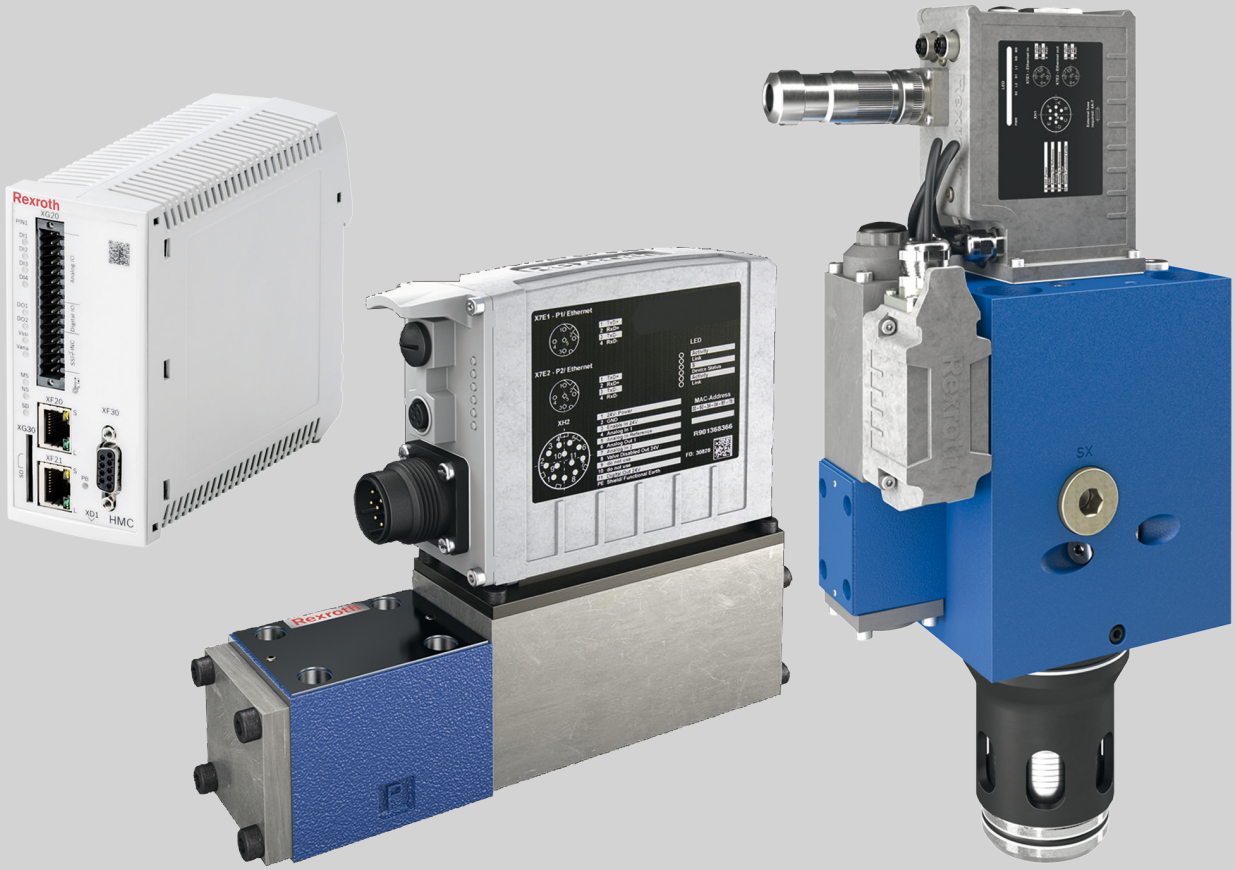
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Rexroth HydraulicDrive

HDx-20
Functions

Application manual
RE 30338-FK/02.2020

Edition 07



Title

Rexroth HydraulicDrive
HDx-20
Functions

Type of Documentation

Application manual

Document Typecode

DOK-HYDRV*-HD*-20VRS**-AP07-DE-P

Internal File Reference

RS-b15370330fe94d1c0a6846a50062aa49-7-en-US-3

Purpose of Documentation

This documentation describes all the functional properties of the HydraulicDrive firmware in the variant HDx-20.

Record of Revision

Edition	Release Date	Notes
DOK-HYDRV*-HD*-20VRS**-AP01-EN-P	02/24/2016	Edition 1
DOK-HYDRV*-HD*-20VRS**-AP02-EN-P	04/07/2016	Edition 2
DOK-HYDRV*-HD*-20VRS**-AP03-EN-P	09/13/2016	Edition 3
DOK-HYDRV*-HD*-20VRS**-AP04-EN-P	03/04/2017	Edition 4
DOK-HYDRV*-HD*-20VRS**-AP05-EN-P	10/04/2018	Edition 5
DOK-HYDRV*-HD*-20VRS**-AP06-EN-P	03/06/2019	Edition 6
DOK-HYDRV*-HD*-20VRS**-AP07-DE-P	02/10/2020	Edition 7

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Published by

Bosch Rexroth AG

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E-mail: my.support@boschrexroth.com

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1 System overview

1.1 General

1.1.1 About this documentation

Means of representation in this documentation

To facilitate reading this documentation, the table below contains the means of representation and notations of recurring terms.

What?	How?	For example...
Important facts which are to be highlighted in the body text	Boldface	Transmission of freely configurable external **process data** (command values and actual values of the external control unit)
Parameter names, diagnostic message names, function designations	Quotation marks	...the function "set/shift coordinate system" for firmware HDx-20...

Tab. 1-1: Conventions of notation

All important notes are highlighted. A symbol tells you what kind of note is used in the text. The symbols have the following significances:

⚠ DANGER ...

In case of non-compliance with this safety instruction, death or serious injury will occur.

⚠ WARNING ...

In case of non-compliance with this safety instruction, death or serious injury could occur.

⚠ CAUTION ...

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE ...

In case of non-compliance with this safety instruction, property damage could occur.

Signal words in accordance with ANSI Z535.6-2006 draw the reader's attention to hazards (see "Explanation of signal words and the safety alert symbol").

This box provides important information which should be taken into consideration.

This symbol highlights useful tips and tricks.

Your feedback

Your experience is important for our improvement processes of products and documentation.

If you discover mistakes in this documentation or suggest changes, you can send your feedback to the following e-mail address:

Dokusupport@boschrexroth.de

We need the following information to handle your feedback:

- The number indicated under "internal file reference".
- The page number.

1.1.2 How to use this documentation

Structure of the Functional Description

The functional descriptions of the HydraulicDrive firmware are subdivided into firmly defined chapters. The individual subjects of the firmware description are assigned to these chapters according to their content.

The description of the respective firmware functionality is basically divided into the following sections:

- Brief description
- Functional description
- Notes on commissioning
- Diagnostic and status messages, monitoring functions

Within one subject, these sections are always contained in the mentioned order, but for practical and formal reasons they are not always existing or may have a different title.

Brief description

The brief description contains an overview of the firmware function or the subject of the section. The brief description can contain, for example, general basics, the most important features of the function, overviews and examples of application. At the end of the brief description you can find, where possible and useful, a list of the parameters and diagnostic messages that are associated with this function.

Functional description

The section "Functional description" explains the operating principle of the respective drive function in an application-oriented way. The relevant parameters of this function are described with regard to their settings and effects. The parameter configuration is only explained in detail where this is necessary for the description of the function. As a basic principle, the functional description contains references to the separate documents for parameters and diagnostic messages.

 The detailed description of the parameters, their function and structure is contained in the separate documentation "Rexroth HydraulicDrive, Parameters".

 The detailed description of the diagnostic messages, their causes and remedies is contained in the separate documentation"Rexroth HydraulicDrive, Diagnostic Messages".

Notes on commissioning

The section "Notes on commissioning" or "Notes on parameterization" provides the user with the steps required for commissioning the function, similar to a checklist. The necessary parameter settings are described in compact form and, if necessary, instructions are given for activating the function, and the diagnostic messages of the immediate functional sequence are mentioned.

Diagnostic and status messages, monitoring functions

The section "Diagnostic and status messages" (also "monitoring functions", if necessary) summarizes the diagnostic messages and possible status displays available for the respective function and describes them briefly. If there are function-specific monitoring functions, they are also described in this section.

Markers and terms

The complete functionality of the HydraulicDrive firmware is subdivided into functional packages (base packages and optional expansion packages). The scope of the available functions does not only depend on the hardware design, but in the majority of cases also on the variant and characteristic of the firmware.

The descriptions of master communication, drive functions and operation modes have a marker containing information on the availability of this functionality in the respective functional package of the firmware, e.g.:



Assignment to functional firmware package, see chapter "Supported operation modes".

Terms

The application-specific scalability of the hardware and firmware provides a multitude of possibilities. For detailed information, the following terms are used in the Functional Description:

- Firmware **family** e.g. HydraulicDrive
- Firmware **design** e.g. single-axis, double-axis
- Firmware **variant** e.g. HD**B**, HD**C**
- Firmware **version** e.g. HDx-**20**VRS
- Firmware **characteristic** e.g. open-loop/closed-loop
- Firmware **performance** e.g. Basic/Economy/Low
- Firmware **type** complete firmware type designation

Cross-references

Many basic subfunctions of the firmware as well as necessary settings and definitions are of multiple use within the overall functionality or have an effect on areas related to the drive functionality. Such subfunctions normally are described only once. Descriptions that are part of other HydraulicDrive documentation (parameter description, description of diagnostic messages, project planning manuals …) are only repeated in detail in exceptional cases. Cross-references indicate the source for more detailed information.

For cross-references to other sections or documents, we make the following distinction:

- References to sections within this documentation are specified by indicating the title of the respective section and the designation of the superordinate topic, if necessary (both can be easily found via the index).
-  References to other documents are additionally signaled by the "info icon", unless contained in a note, in a table or in brackets.

1.1.3 Reference documentations

Only deal with the product when you have the documentation identified with the book symbol 🕮 at hand and have observed it.

All the documents can be downloaded on the Internet at www.boschrexroth.com.

Hardware

	Title	Document number	Document type
🕮	Directional control valve, pilot operated, with integrated digital axis controller (IAC Multi-Ethernet), type 4WRLD	RE 29289	Technical data sheet
🕮	Directional control valve, direct operated, with integrated digital axis controller (IAC Multi-Ethernet), type 4WRPDH	RE 29391	Technical data sheet
🕮	High-response/proportional valve with Multi-Ethernet interface, type 4WRPD(H), type 4WRPQ(H), type 4WRPF(H), type 4WRLD, type 4WRLF, type 4WRLQ, type 5WRPF10, type 5WRPQ10	RE 29391-B	Operating instructions
🕮	Pressure and flow control system, type SYDFED series 2X, 3X, type SYHDFED series 1X	RE 30017-B	Operating instructions
🕮	Pressure and flow control system, type SYDFE1-2X, type SYDFEE-2X, type SYDFEC-2X, type SYDFEn-2X, type SYDFED-2X	RE 30030	Technical data sheet
🕮	Pressure and flow control system, type SYDFE1, type SYDFEE, type SYDFEC, type SYDFEn, type SYDFED, type SYDFEF	RE 30630	Technical data sheet
🕮	Pressure and flow control system, type SYHDFEE-1X, type SYHDFEC-1X, type SYHDFEn-1X, SYHDFED-1X	RE 30035	Technical data sheet
🕮	Digital control electronics for axial piston pumps, type VT-HPC	RE 30237	Technical data sheet Operating instructions
🕮	Digital axis control, type VT-HMC	RE 30239	Technical data sheet Operating instructions
🕮	Pressure and flow control system, type SYDFEF series 2X, 3X, type SYHDFEF series 1X	RE 30013	Operating instructions
🕮	Directional high-response cartridge valve, pilot operated, with integrated electronics and analog or field bus interface, type 2WRCE and 2WRCF	RE 29406	Technical data sheet
🕮	Directional control valve, direct operated, with integrated fieldbus (IFB Multi-Ethernet), type 4WRPFH	RE 29395	Technical data sheet
🕮	Directional control valve, pilot operated, with integrated fieldbus (IFB Multi-Ethernet), type 4WRLF	RE 29293	Technical data sheet
🕮	Control devices HM, HS, HS5 and EO	RE 92076	Technical data sheet
🕮	Axial piston variable pump A4... with HS5E pilot control valve series 10, 11, and series 3x	RE 92076-01-B	Operating instructions

Tab. 1-2: Reference documentations

Software

	Title	Document number	Document type
🕮	Rexroth HydraulicDrive HDS-16, HDx-17 to HDx-20	RE 30330-PA RE 30330-WA	Parameter description Description of diagnostic messages

🕮	Rexroth HydraulicDrive HDx-18	RE 30331-FK	Functional description
🕮	Rexroth HydraulicDrive HDx-19	RE 30337-FK	Functional description
🕮	Rexroth Hydraulic Drive Rexroth IndraMotion MLD (2G) HDx-18	RE 30336-RE RE 30336-AP	Library description Application manual
🕮	Rexroth HydraulicDrive HDS-20	RE 30335-FK	Functional description
🕮	Rexroth HydraulicDrive HDx-20	RE 30338-FK	Functional description
🕮	Rexroth HydraulicDrive HDx-20 pump control	RE 30237-Z	Supplementary information
🕮	Rexroth HydraulicDrive HDx-20VRS Firmware for drive controllers	RE 30330-RN	Firmware Release Notes

Tab. 1-3: Reference documentations

1.1.4 Terms, basic principles

Engineering tool "IndraWorks Ds/D/MLD"

"IndraWorks Ds/D/MLD" is a component of the software family "IndraWorks", which supports parameterization and commissioning of controls and drives from Rexroth. The commissioning tool "IndraWorks Ds/D/MLD" offers the following possibilities and advantages:

- The functions and features made available by the drive are visualized in a structured manner; the associated parameter values are displayed in the functional context
- Parameter values can be changed directly and therefore adjusted to the individual requirements
- The parameter values in the drive can be saved as group (parameter set) outside the drive, e.g. on a PC hard disk, from where they can also be re-loaded
- Diagnostic messages and operating status messages are displayed in a clearly arranged form
- For commissioning purposes, commands can be started
- Via the “easy startup” mode drives can be commissioned and operated

"IndraWorks Ds/D/MLD" is available with different characteristics.

IndraWorks Ds

IndraWorks Ds is sufficient for commissioning a single drive controller without PLC. It is characterized by the following features:

- Only for 1:1 connection between drive and PC
- Does not contain any project administration feature or a possibility of PLC programming
- Download version available on the Internet

IndraWorks D/MLD

Apart from the above IndraWorks Ds functions, IndraWorks D/MLD comprises:

- Project administration
- Integrated PLC programming

IndraWorks D/MLD has to be purchased on a data carrier (DVD).

Master communication

Multi-Ethernet

Term for the support of several Ethernet-based communication types in one drive controller. The desired type of communication is selected by means of parameters.

Drive bus A drive bus transmits command and actual values clock-synchronously with the controller cycle of the drive or a multiple thereof. The time of transmitting these data can be determined with reference to the controller cycle. Typical buses are Sercos, EtherCAT® and VARAN.

Field bus A field bus can transmit cyclic data, but there is no fixed time-based assignment to the controller cycle of the drive.

Profiles With field bus interfaces, profiles can be used to select certain pre-configured data in cyclic communication. Moreover, a specific behavior of the drive can be configured.

Analog master communication Alternatively to command triggering for a drive over a bus system, this can also be effected via an analog interface.

Parameters

With a few exceptions, communication between master and drive takes place with the help of parameters.

Parameters are used for:

- Determining the configuration
- Parameterizing the control loop
- Triggering and controlling drive functions and commands
- Transmitting command values and actual values (according to requirements, cyclically or acyclically)

All operating data are mapped to parameters!

The operating data stored in parameters can be identified by means of the IDN. It can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. The drive firmware checks specific parameter values (operating data) for validity.

Data storage and parameter handling

Data memory Several non-volatile data memories are available in a HydraulicDrive device:

- In the controller
- Optional plug-in SD card (depending on device type)



The SD card is not hot-plug-capable It must be plugged in before the drive is started.

In addition, a volatile data memory (working memory) is available in the controller.

Condition as supplied Condition as supplied of the Rexroth drive components:

- The controller memory contains the drive firmware and the controller-specific parameter values.

Storing the application-specific parameter values The application-specific parameter values are stored in the controller. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can also be stored in the working memory (volatile memory).

Storing parameter values Saving application-specific parameter values is required in the following cases:

- After initial commissioning of the drive
- Before replacing the controller in the case of repairs (if possible)

Application-specific parameter values can be saved using:

- "IndraWorks Ds/D/MLD" commissioning tool
  → Saving parameter values on external data carrier
- Control master
  → Saving parameter values on master-side data carrier

Parameter IDN Lists

The drive supports saving of parameter values on the master side by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer, e.g. list of password-protected parameters.

Loading parameter values

Loading parameter values is required in the following cases:

- Initial commissioning of the drive
  → Loading of default values (factory settings)
- Series commissioning of machine axes in series machines
  → Loading of parameter values saved after initial commissioning
- Restoring of a defined initial state
  → Re-loading of parameter values saved after initial commissioning
- In case a repair is required, change of the drive controller
  → Loading of the current parameter values saved before the repair

Possibilities of loading parameter values to the controller:

- Commissioning tool "IndraWorks Ds/D/MLD"
  → Loading parameter values from an external data carrier
- Control master
  → Loading of parameter values from master-side data carrier

Checksum of parameter values

By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive correspond to the values saved on the master side (see parameter S-0-0326).

Password

HydraulicDrive controllers provide the opportunity to password-protect parameter values against accidental or unauthorized change. With regard to write protection, there are 3 groups of writable parameters:

- Parameters that are generally write-protected, such as hardware code parameters, encoder parameters, error log, etc. ("administration parameters"). The values of these parameters ensure correct functioning and performance of the drive.
- Parameters, which the customer can combine in groups and protect with a so-called customer password. This allows protecting parameter values that are used for adjusting the drive to the axis after their definition.
- All other writable parameters not contained in the above-mentioned groups. They are not write-protected.

Types of passwords

The drive firmware allows activating and deactivating the write protection for parameter values by means of three hierarchically different passwords:

- **Customer password**
  The parameter values of a parameter group set up by the customer can be protected.
- **Control password**

Parameters protected by a customer password are writable; "administration parameters" remain read-only.

- **Master password**

  All writable parameters, including "administration parameters" and parameters protected by a customer password, can be changed.

Commands

Commands are used to activate and control complex functions or monitoring features in the drive. The higher-level master can start, interrupt and clear commands.

Each command is assigned to a parameter by means of which the execution of the command can be controlled.

☞ Each command that was started must be actively cleared again.

All commands available in the drive are stored in parameter "S-0-0025, IDN-list of all procedure commands".

Types of commands

There are 3 different types of commands:

- **Drive control commands**
  - can cause automatic drive motion
  - can be started only when drive enable has been set,
  - deactivate the active operation mode during its execution
- **Monitor commands**
  - activate or deactivate monitoring or other functions in the drive.
- **Administration commands**
  - carry out administration tasks
  - cannot be interrupted.

See also section "Command processing"

Operation modes

The selection of operation modes defines which command values will be processed in which way in order to lead to the desired drive motion. The operation mode does not determine how these command values are transmitted from the master to the drive.

One of the eight operation modes that are defined in parameters is always active if the conditions below are fulfilled:

- Control section and power section are ready for operation
- Drive enable signal sees a positive edge
- Drive follows command value input
- "Drive Halt" function has not been activated
- No drive control command is active
- No error reaction is carried out

☞ All implemented operation modes are stored in parameter "S-0-0292, List of supported operation modes".

See also chapter "Operation modes"

Warnings

Depending on the active operation mode and the parameter settings, many monitoring functions are carried out. When a state is recognized that still allows proper operation, but, if the state persists, will result in the occurrence of a fault or error and thus to the automatic shutdown of the drive, the drive firmware generates a warning message.

☞ Warnings do not cause an automatic shutdown (exception: fatal warnings).

Classes of warnings

Warnings are classified in different warning classes which determine whether or not the drive carries out an automatic reaction when the warning is generated.

☞ The warning class can be recognized by the diagnostic message.

The following classes of warnings are distinguished:

- **Without** drive reaction → diagnostic message no. **E2**xxx, **E3**xxx, **E4**xxx
- **With** drive reaction → diagnostic message no. **E8**xxx

See also description of diagnostic messages

☞ Warnings cannot be cleared. They persist until the condition that activated the warning is no longer fulfilled.

Errors

Depending on the active operation mode and the parameter settings, many monitoring functions are carried out. If a state is detected that affects or prevents correct operation the drive firmware generates an error message.

Error classes

Errors are assigned to various error classes, which differ in different error reactions of the drive.

☞ The error class can be recognized by the diagnostic message number.

Diagnostic message number	Error class
F2xxx	Non-fatal error
F4xxx	Interface error
F6xxx	Travel range error
F8xxx	Fatal error
F9xxx	Fatal system error

Tab. 1-4: Overview of error classes

☞ Apart from the mentioned error classes that can occur during operation, errors can occur when the devices are booted and during firmware download. Boot and firmware download errors are described in a separate "Troubleshooting Guide" documentation (description of diagnostic messages).

Error reactions of the drive

If the drive controller is in closed-loop control and an error state is detected, the execution of a drive error reaction is automatically started.

The drive reaction in the case of F2xxx, F4xxx, F6xxx errors is determined in parameter "P-0-0119, Best possible deceleration". At the end of each error reaction, the drive outputs the standstill value determined in "P-0-2873.000.014, Control disabled offset".

See also "Error reactions"

Clearing an error message

Error messages are not cleared automatically, but according to a procedure that depends on the severity of the error, see separate documentation "Troubleshooting Guide" (description of diagnostic messages).

If the error state persists the error message is immediately generated again.

Clearing error messages when drive enable was set

If a drive error occurs during operation with set controller enable, the drive carries out an error reaction. The drive automatically deactivates itself at the end of each error reaction; in other words, the output stage is switched off and the drive switches from an energized to a de-energized state.

To reactivate the drive:

- clear the error message and
- preset a positive edge for drive enable again.

Error memory

The diagnostic message numbers of occurring errors are written to an error memory. This memory contains the diagnostic message numbers of the last 50 errors that occurred and the time when they occurred.

The diagnostic message numbers in the error memory are mapped in parameter "P-0-0192, Error memory of diagnostic numbers". The "IndraWorks Ds/D/MLD" commissioning tool allows displaying the diagnostic message numbers and the respective times when the errors occurred.

Reclassifying errors as warning

The user can reclassify some error cases as warning. After an error has been reclassified, no error reaction takes place, but a warning is issued upon the occurrence of such an error.



When an error has been reclassified, only a warning is output instead of the error message; the warning signals the control master that there is a problem. It is the user's responsibility to react to the diagnostic warning messages in an appropriate way. If this is not the case, the machine or installation can be damaged.

1.2 HydraulicDrive product family

1.2.1 Overview of devices

HydraulicDrive product family

The HydraulicDrive product family consists of product lines that are based on common platforms and technologies.

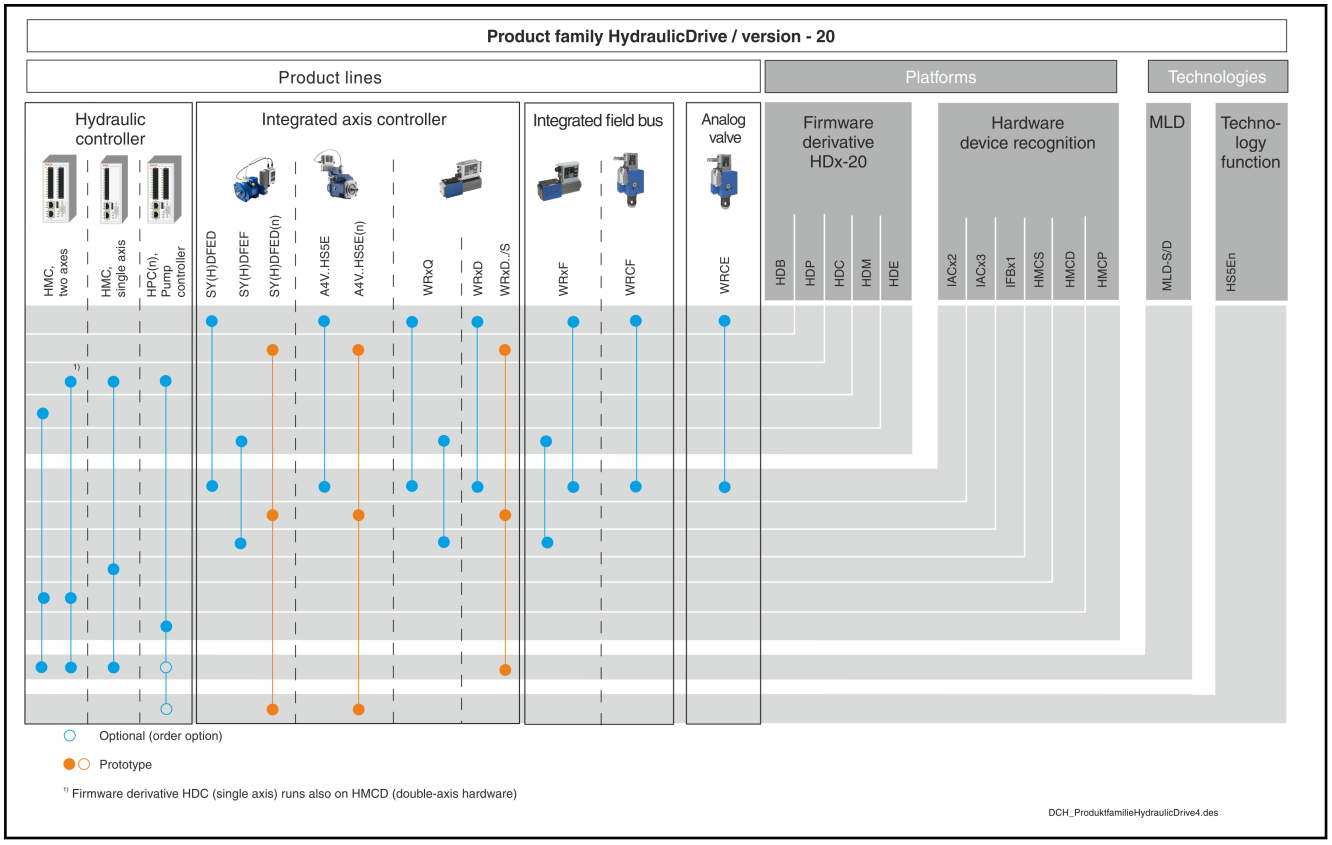


Fig. 1-1: Overview of HydraulicDrive product family

Product lines

The product lines differ by devices with different scopes of functions. The devices are subdivided into those featuring type of protection IP20, which are to be installed in the control cabinet, and devices of type of protection IP67, which are mounted directly to the relevant hydraulic component.

Firmware derivatives

The "Hydraulic Drive" firmware platform can be subdivided into various derivatives. These are usually determined by the individual hardware and can only be used in conjunction with this hardware.

See also Firmware derivatives

Hardware device identification

Depending on the application (control cabinet installation or mounted to hydraulic component), the required scope of functions and the required performance, different hardware characteristics are available, which are represented in "P-0-1520.0.0, Control section type" (first five characters).

Hardware device identification	Control section type (P-0-1520.0.0)	Description of hardware characteristic	Product examples
IACx2	IACF2	Integrated axis controller with bus interface, I/O (optional), no position encoder interface	WRPF, series 2X WRLF, series 4X
	IACQ2	Integrated axis controller with bus interface, I/O for p/Q control, no position encoder interface	WRPQ, series 2X
	IACP2	Integrated axis controller with bus interface, I/O for pump control, no position encoder interface	SY(H)DFED
	IACD2	Integrated axis controller with bus interface, I/O and position encoder interface	WRPD, series 2X
IACx3	IACP3	IACP2 with extended memory	
	IACD3	IACD2 with extended memory	
IFBx1	IFBF2	Integrated analog connection	WRCE, series 4X
	IFBF2	Integrated field bus connection	WRPF, series 3X WRCF, series 4X
	IFBQ2	Integrated field bus connection with I/O for p/Q control	WRPQ, series 3X
	IFBP2	Integrated field bus connection with I/O for pump control	SY(H)DFEF
HMCS1	HMCS1	HMC without extension card as single-axis version	VT-HMC-1-1X
HMCD1	HMCD1	HMC with extension card as double-axis version	VT-HMC-2-1X
HMCP1	HMCP1	HMC with extension card for pump control → HPC	VT-HPC-1-1X

Tab. 1-5: Hardware device identification

For describing analog and digital inputs and outputs (I/O)

See also Inputs/outputs, including assignments and Inputs and outputs of hardware

Functional packages / technology functions

Functional packages determine and scale the scope of functions of a firmware derivative. The base package essentially determines the device function. Depending on the device package, additional alternative or additive functional packages are possible, see also Functional packages.

Operation modes

The operation modes determine the scope of functions of the device with regard to open and/or closed-loop drive control and the associated command value generators and/or interpolators, see also "Operation modes".

Overview of devices

The following table provides an overview of:

- the individual device types

- the required firmware derivatives
- possible functional packages
- supported operation modes

			Supported operation modes												
Device types	Required firmware derivative	Possible functional packages (base package)	Direct valve control	Closed-loop torque/ force control/direct valve control	Closed-loop pressure control/direct valve control	Flow (open/closed-loop control)	Torque/force control Flow (open/closed-loop control)	Closed-loop pressure control/(open/closed-loop) flow control (open/closed-loop)	Torque/force control	Velocity (open/closed-loop) control	Cyclic position control	Drive-controlled positioning	Drive-internal interpolation	Positioning block mode	Closed-loop pressure/swivel angle control
WRCE	HDE	IFB	■			■				■					
WRxF	HDE	IFB	■			■				■					
WRxF	HDB HDE	IFB	■			■				■					
WRxQ	HDB HDE	p/Q	■		■	■	■	■							
WRxD	HDB	AXR OL[1)]	■	■	■	■	■	■	■	■					
	HDP	AXR CL[1)]	■	■	■	■	■	■	■	■	■	■	■	■	
SY(H)DFED	HDB	DFE	■					■							■
SY(H)DFEn	HDP	DFE	■					■							■
SY(H)DFEF	HDE	DFE	■					■							■
A4V..HS5E	HDB	DFE	■					■							■
A4V..HS5En	HDP	DFE	■					■							■

			Supported operation modes												
Device types	Required firmware derivative	Possible functional packages (base package)	Direct valve control	Closed-loop torque/ force control/direct valve control	Closed-loop pressure control/direct valve control	Flow (open/closed-loop control)	Torque/force control Flow (open/closed-loop control)	Closed-loop pressure control/(open/closed-loop) flow control (open/closed-loop)	Torque/force control	Velocity (open/closed-loop) control	Cyclic position control	Drive-controlled positioning	Drive-internal interpolation	Positioning block mode	Closed-loop pressure/swivel angle control
HMC	HDC	AXR OL[1)]	■	■	■	■	■	■	■	■					
	HDM [2)]	AXR CL[1)]	■	■	■	■	■	■	■	■	■	■	■	■	
	HDM [2)]	SYN CL[3)]							■	■		■		■	
HPC	HDC	DFE	■					■							■

1) The functional packages can be activated alternatively in a device.
2) Firmware derivative for double-axis controller
3) The functional package “synchronization controller” can only be used with the synchronization axis of the HMC. For utilizing the synchronization functionality, SD card VT-SD-HMC-SYNC-000-001-000-000 (R90151246) is required.

Tab. 1-6: Overview of devices

Brief description of the individual device types

WRCE, analog directional high-response cartridge valve with digital parameterization

The electronics is mounted directly on the hydraulic valve. It extends the analog valve function by digital parameterization.

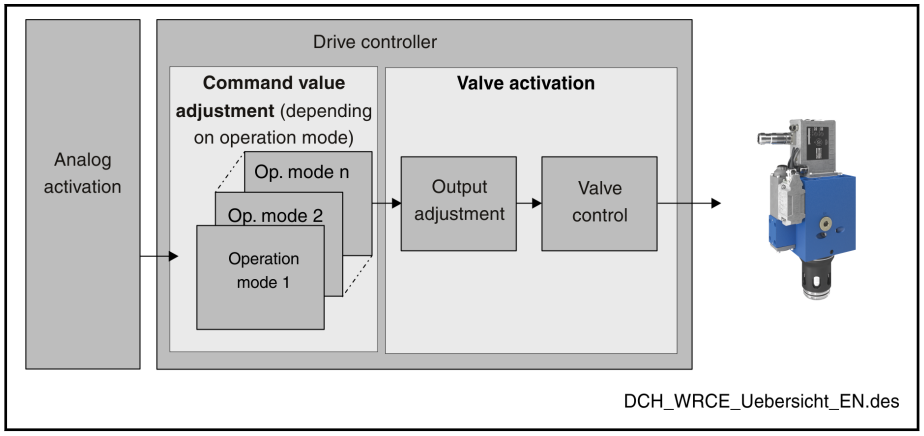


Fig. 1-2: Overview of analog directional high-response cartridge valve

WRCF, directional high-response valve as bus valve (IFB function = Integrated Field Bus)

The electronics is mounted directly on the hydraulic valve. It extends the directional high-response control function by a field bus interface.

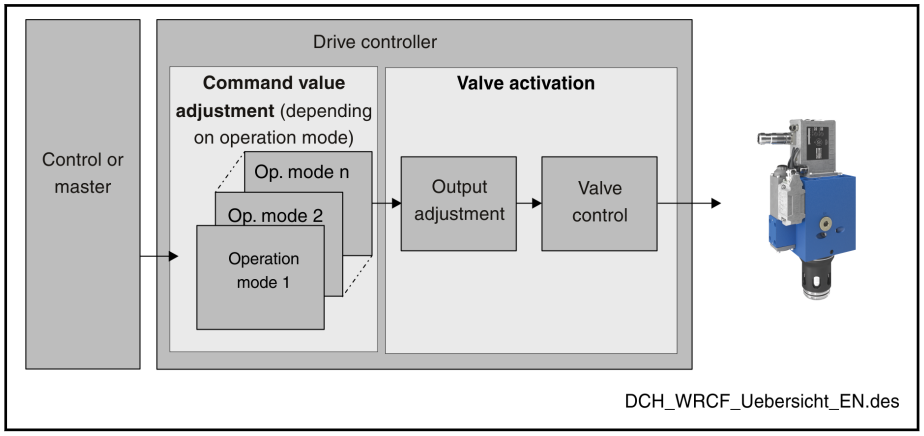


Fig. 1-3: Overview of directional high-response cartridge valve as bus valve

WRxF, proportional valve as bus valve (IFB function = Integrated Field Bus)

The electronics is mounted directly on the hydraulic valve. It extends the proportional valve function by a field bus interface.

In addition, pressure sensors can be read in via the inputs at the device. The sensed pressures can be made available over the bus or, in the operation mode of "open-loop velocity control", used for calculating the actual force for "active damping".

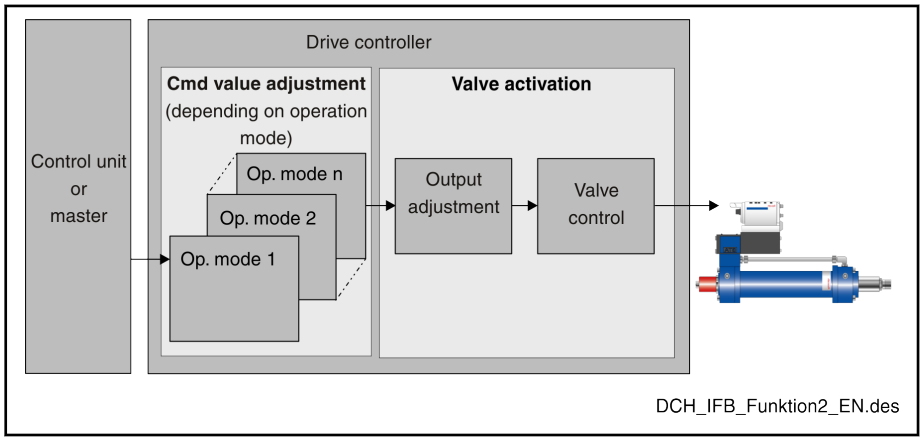


Fig. 1-4: Overview of bus valve

WRxQ, proportional valve as p/Q valve

The electronics is mounted directly on the hydraulic valve. Pressure sensors for measuring pressures are integrated in the valve chambers. This device

can generate a constant flow (electronic pressure compensator) by establishing the pressure drop across a control land and using a stored, normalized flow characteristic curve. In addition, pressure or force can also be closed-loop-controlled.

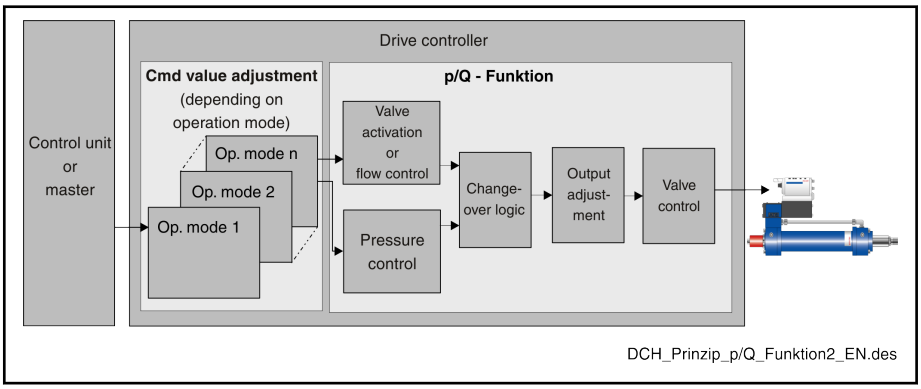


Fig. 1-5: Overview of high-response valve as p/Q valve

WRxD, high-response valve as axis controller (IAC function = Integrated Axis Control)

The electronics is mounted directly on the hydraulic valve. Position encoders and pressure or force sensors can be read in via inputs at the device.

The functional package "Axis Controller Closed Loop (AXR CL)" allows closed-loop position control of a hydraulic drive. For applications in continuous path controls a velocity controller can be used additionally.

The functional package "Axis Controller Open Loop (AXR OL)" allows only open-loop controlled operation. Irrespective of the functional package used, closed-loop torque/force control can be activated additionally.

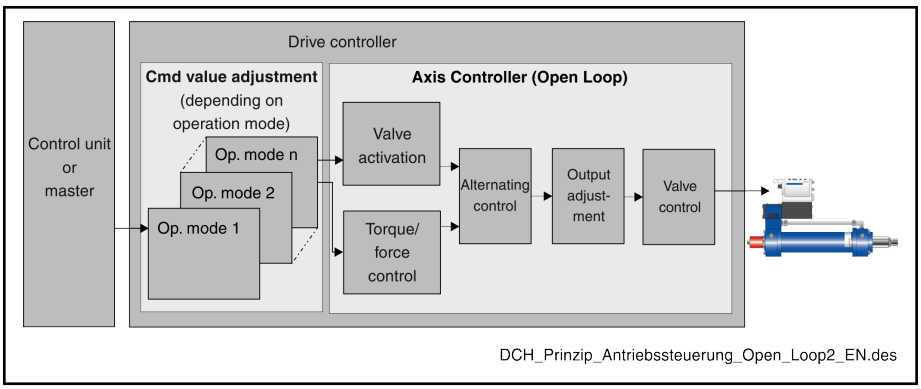


Fig. 1-6: Overview of proportional valve as axis controller with functional package Open Loop.

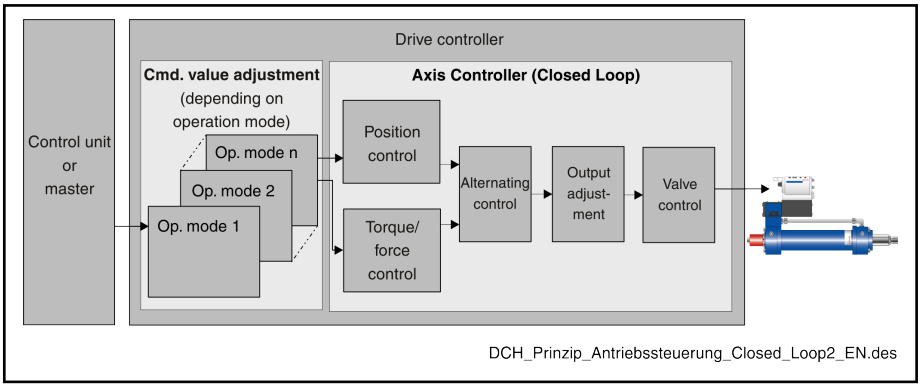


Fig. 1-7: Overview of proportional valve as axis controller with functional package Closed Loop.

SY(H)DFED, SY(H)DFEF and A4V..HS5E

The electronics is mounted together with the pilot valve to a hydraulic variable displacement pump. This allows closed-loop controlling of the swivel angle and pressure of this pump unit. The controller structure can be switched between parallel and cascade structure.

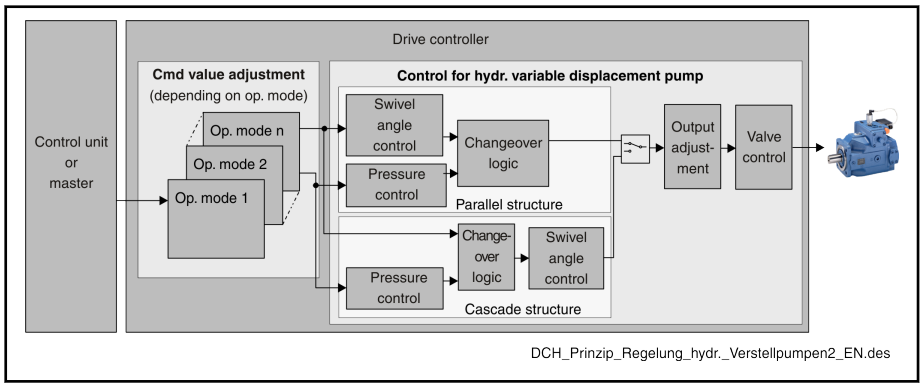


Fig. 1-8: Hydraulic variable displacement pumps with DFE function

HMC (Hydraulic Motion Controller)

The electronics is provided for installation in a control cabinet. Position encoders and pressure or force sensors can be read in via inputs at the device.

This device is available in the characteristic "single-axis" or "double-axis controller". The functional package "Axis Controller Closed Loop (AXR CL)" allows closed-loop position control of a hydraulic drive. For applications in continuous path controls a velocity controller can be used additionally.

The functional package "Axis Controller Open Loop (AXR OL)" allows only open-loop controlled operation. Irrespective of the functional package used, closed-loop torque/force control can be activated additionally.

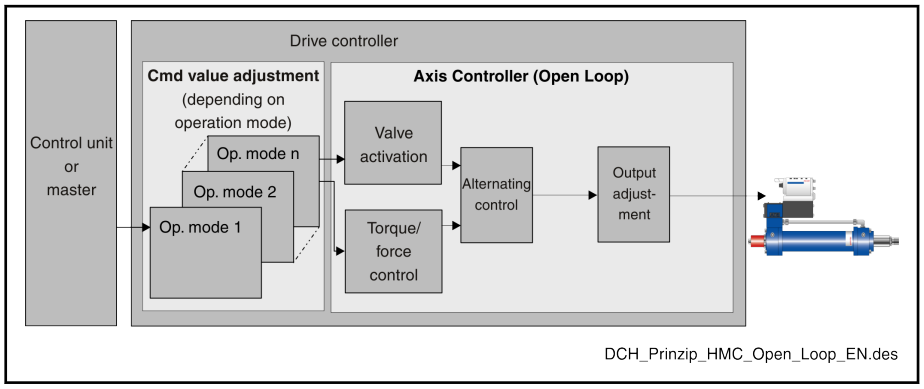


Fig. 1-9: Overview of HMC with functional package Open Loop

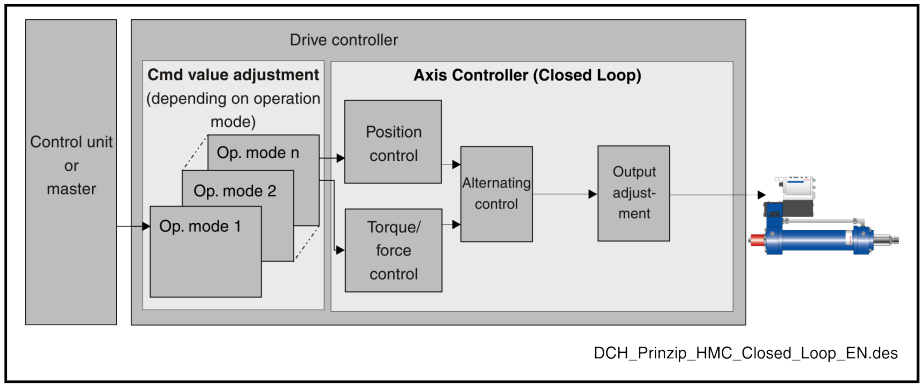


Fig. 1-10: Overview of HMC with functional package Closed Loop

HPC (Hydraulic Pump Controller)

The electronics is provided for installation in a control cabinet. This device allows closed-loop controlling of the swivel angle and pressure of this pump

unit. The controller structure can be switched between parallel and cascade structure.

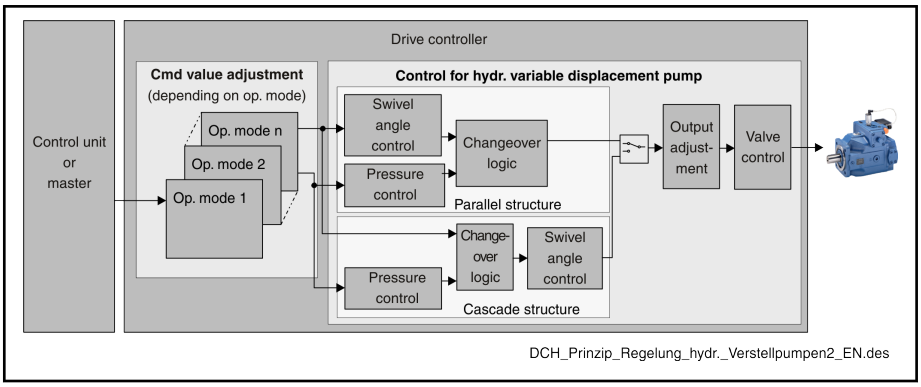


Fig. 1-11: Overview of hydraulic pump controller HPC

1.3 Firmware derivatives

1.3.1 General information

The functionality available for the HydraulicDrive is basically defined by the following:

- The basic hardware characteristic as well as hardware options
- The firmware derivative used
- The functional packages activated for the firmware used

1.3.2 Overview of firmware derivatives

Model variants

The basic characteristic of the firmware version **HDx** means:

HD: "HydraulicDrive": Drives for general automation (including machine tool applications) with Multi-Ethernet interface (Sercos III, EtherCAT®, PROFINET®, EtherNet/IP, VARAN, Ethernet POWERLINK), field bus interface (e.g. PROFIBUS DP) and Analog Interface

"x“ stands for the various derivatives.

At present, the following firmware derivatives are available:

- **HDE** devices with Multi-Ethernet interface without axis control for IFB devices (Integrated Field Bus), which are mounted directly to the hydraulic actuator.

  Compatible devices: High-response valves of series WRxF...., WRxQ... and variable displacement pumps of type SY(H)DFEF
- **HDB**: Single-axis function for IAC devices (Integrated Axis Control) in IP67 design, which are mounted directly to the hydraulic actuator.

  Compatible devices: High-response valves of series WRxD... and variable displacement pumps of type SY(H)DFED and A4V..HS5E systems
- **HDP**: Single-axis function for IAC devices (Integrated Axis Control) in IP67 protection class, which are mounted directly to the hydraulic actuator, with PLC function integrated in the drive (MLD).

  Compatible devices: High-response valves of series WRxD... and variable displacement pumps of type SY(H)DFEDn
- **HDC**: Single-axis function for hydraulic controllers in IP20 design for control cabinet installation.

  Compatible devices: VT-HMC... and VT-HPC...

- **HDM**: Double-axis function for hydraulic controllers in IP20 design for control cabinet installation.

  Compatible devices: VT-HMC

The designation **HDS** is used for the central hydraulic controller in the MLC control unit (HydrControl library).

This results in the following firmware derivative designations

- • FWA-HYDRV*-HDE-20VRS
- • FWA-HYDRV*-HDB-20VRS
- • FWA-HYDRV*-HDP-20VRS
- • FWA-HYDRV*-HDC-20VRS
- • FWA-HYDRV*-HDM-20VRS

The firmware designation can also be read via parameter S-0-1300.0.9 or S-0-0030.

Functionality of firmware derivatives

The scope of functions of the individual firmware derivatives is determined by the definition of “derivative-specific firmware projects" from the entirety of the HydraulicDrive firmware functionality ("module library”) at the time of compilation.

When booting a firmware derivative, the finally available functionality is first determined at runtime by identification of existing hardware and the functional package selection (P-0-2003).

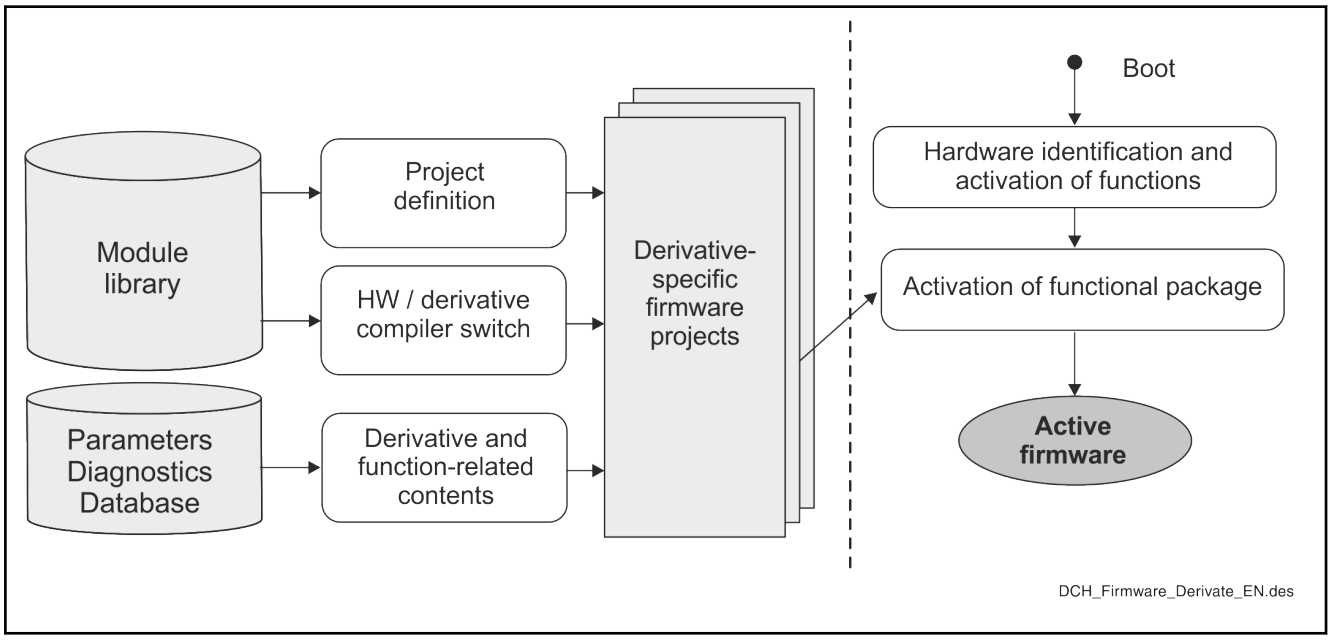


Fig. 1-12: Functionality in firmware variants

See also Hardware enabling, functional packages

1.4 Functional packages

1.4.1 Overview

Overview of functional packages

With the help of functional packages it is possible to extend the scope of functions of the firmware to suit your individual requirements and, if necessary, also to reduce the complexity.

The scope of functionality of the HydraulicDrive firmware depends on:

- The available device function
- The activated functional packages

The following functional packages are currently supported:

	Bus valve	p/Q function	Pump control	Axis controller Open Loop	Axis controller Closed Loop	Synchronization controller Closed Loop
Base package	IFB	p/Q	DFE	AXR OL	AXR CL	SYN CL
Alternative functional packages (only 1 possible out of n)	--	--	--	--	SRV (Servo)	--
Additive functional packages	--	--	TF (DFEn)	ML (IndraMotion MLD)	ML (IndraMotion MLD)	ML (IndraMotion MLD)

Tab. 1-7: Overview of base package, alternative and additive functional packages

See also:

- Functional package enabling
- Supported devices, general
- Hardware enabling

Description of the functional packages

Base package IFB bus valve

The base package "bus valve" merely provides the functionality for direct valve control.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, ...)
- Functions for valve activation
- Active damping (optional)
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling settings
- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup mode, command value generator)

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-0-**IFB**-NN

Base package p/Q function

The base package "p/Q function" provides the functionality for closed-loop flow control with outer-loop pressure or force control.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, etc.)
- Functions for valve activation, closed-loop control of pressure, flow and force
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling settings (except for position scaling)
- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup mode, command value generator)

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-0-**p_Q**-NN

Base package DFE pump control

The base package "pump control" provides the functionality for closed-loop flow control (swivel angle) with outer-loop pressure control and power limitation.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, etc.)
- Functions for closed-loop pressure/swivel angle control
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling setting (except for position and force scaling)
- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup mode, command value generator)

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-0-**DFE**-NN

Base package AXR OL - Axis Control Open Loop

The base package "Axis Controller Open Loop" provides the minimal basic functionality for traversing an axis. With this package, only open-loop controlled operation is possible, there is no position encoder provided.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, etc.)
- Functions for valve activation, closed-loop pressure and force control
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling settings

- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup mode, command value generator)

☞ With regard to encoder evaluation, the functional package merely contains the Encoder Basic profile (raw data), but no complete encoder evaluation. As a consequence, no position control modes are provided.

Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-**0**-**AXR**-NN

Base package AXR CL - Axis Controller Closed Loop

In addition to "Axis Control Open Loop" the base package "Axis Controller Closed Loop" provides encoder evaluation and thus position evaluation as well as related functions and operation modes.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, etc.)
- Functions for valve activation, closed-loop position, velocity, pressure and force control
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling settings
- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup, command value generator, initial commissioning wizard, axis optimization)

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-**1**-**AXR**-NN

Basic package SYN - Synchronization Control Closed Loop

The base package “Synchronization Control Closed Loop” contains the functions required for hydraulic synchronization.

The available basic functionality consists of:

- Basic functions of device control (operation mode handling, error reactions, etc.)
- Functions for position, velocity and force synchronization
- Master communication with all associated functions
- Monitoring and limitation functions
- Scaling settings
- Diagnostic functions (oscilloscope, generation of diagnostic messages, diagnostic classes, error memory)
- Commissioning functions (easy startup, command value generator, initial commissioning wizard, axis optimization)

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-**1**-**SYN**-NN

☞ The overview of operation modes supported by the individual base packages is shown in Supported devices, general.

Alternative functional packages (only one package may be selected):

- SRV - servo package

  In addition to the scope of the base package, the following functions are provided:

  – Error reaction return movement
  – Axis error correction
  – Quadrant error correction

  Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-**1**-**SRV**-NN

Additive functional packages:

- ML - IndraMotion MLD

  In addition to the base package, functions are provided for the integrated Motion Logic Control MLD (PLC function).

☞ This functional package can be selected additionally depending on the device characteristic.

Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-x-xxx-**ML**

- TF - technology function

  In addition to the base package, functions with a fixed functionality are provided on the basis of the integrated PLC

  DFEn: Variable-speed pump control

☞ This functional package can be selected additionally depending on the device characteristic.

Representation in firmware string: FWA-HYDRV*-HDx20-Vxx-D5-x-xxx-**TF**

Representation of functional packages in the firmware string

Firmware	Derivative	Version	Release	Language	OL/CL	Base package including alternative functional package	Additive functional package
FWA-HYDRV*	-xxx-	20	Vxx-	D5-	x-	xxx-	xx
Example: Axis Controller Closed Loop with servo package for device WRxD							
FWA-HYDRV*	-HDB-	20	V06-	D5-	1-	SRV-	NN
Example: Axis Controller Open Loop with MLD for device HMC							
FWA-HYDRV*	-HDC-	20	V06-	D5-	0-	AXR-	ML
Example: Field bus for device WRxF							
FWA-HYDRV*	-HDE-	20	V06-	D5-	0-	IFB-	NN

Firmware	Derivative	Version	Release	Language	OL/CL	Base package including alternative functional package	Additive functional package
Example: Axis Controller Closed Loop with MLD for device WRxD							
FWA-HYDRV*	-HDP-	20	V10-	D5-	1-	AXR-	ML
Example: Axis Controller Closed Loop with MLD for synchronization							
FWA-HYDRV*	-HDM-	20	V18-	D5-	1-	SYN-	ML

Tab. 1-8: Representation in firmware string

☞ The firmware string is always valid per axis!

1.4.2 Commissioning, parameters, diagnostic and status messages

In the parameter description, the relation of a parameter to a functional package is represented as follows in the assignment:

Code	Designation in parameter description	Description
OL	"Open loop"	"Open loop" characteristic without position encoder
CL	"Closed loop"	"Closed loop" characteristic with position encoder
IFB	"valve"	Device function for bus valve
p_Q	"p/Q"	Device function for p/Q function of a high-response or proportional valve
DFE	"pump"	Device function for hydraulic variable displacement pump
AXR	"Axis control"	Device function for open and/or closed-loop axis control
SRV	"Servo (compensation)"	Device function for axis control with servo extension package
SYN	"Synchron control"	Device function for the synchronization control of several axes
ML	"Motion logic"	Extension package with drive-integrated PLC
TF	"Tech function"	Extension package with fixed functionality on the basis of the drive-integrated PLC

Tab. 1-9: Overview of functional package codes

1.4.3 Functional package enabling

General information

Enabling and activation of the functional packages is indicated as follows:

- Activation/deactivation of functional packages via parameter "P-0-2003, Selection of functional packages"

- Activated functional packages displayed in parameter "P-0-2004, Active functional packages"
- Dynamic adjustment of firmware type designation in parameter "S-0-0030, Manufacturer version" on the basis of the value in "P-0-2004, Active functional packages"
- Count of operating hours counter at last change of access enable is stored
- After the functional package selection was changed, rebooting is required.

Changing the active functional package selection

Generally, the drive functionality can subsequently be scaled in the following ways:

- Reducing the already licensed scope of functions in order to reduce the complexity of the firmware
- Expanding the scope of functions originally ordered (re-licensing)

Parameter "P-0-2003, Selection of functional packages" is available for selecting the functional packages.

Parameters "P-0-2004, Active functional packages" as well as "S-0-0030, Manufacturer version" show the activated packages.

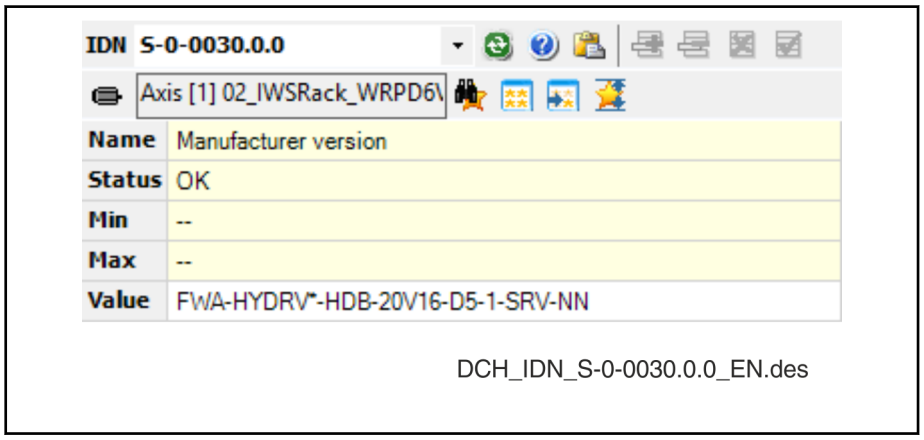


Fig. 1-13: Changing the active functional package selection

If you have to determine at runtime, which functional package is active, you always have to use parameter "P-0-2004, Active functional packages".

The following assignment applies:

Bit no.	Name of package (Bit = 1 → package is selected)
0 - 1	00: Reserved 01: Base package Open Loop (OL) 10: Base package Closed Loop (CL) 11: Reserved
2 - 3	Reserved

Bit no.	Name of package (Bit = 1 → package is selected)
4 - 7	0001: Extension package "Servo function" (SRV) 0010: Reserved 0100: Extension package "main spindle" (MSP) All other combinations: reserved
8 - 11	0010: Additional package "IndraMotion" (MLD) 0100: Additional package "technology function" (TF) All other combinations: reserved
12 - 15	Reserved
16	Base package "bus valve" (IFB)
17	Base package "p/Q function" (p_Q)
18	Base package "pump control" (DFE)
19	Base package "axis controller" (AXR)
20	Base package "synchronization controller" (SYN)
21 - 31	Reserved

Tab. 1-10: Selection of functional packages via parameter "P-0-2003, Selection of functional packages"

Enabling the base package "Closed Loop" and the extension package "servo function", for example, requires the following setting in "P-0-2003, Selection of functional packages":

- Bit 1 = 1 for the base package "closed loop"
- Bit 4 = 1 for the extension package "servo function"

Consequently: Set P-0-2003 = 0x0012.

The settings in parameter "P-0-2003, Selection of functional packages" are accepted by "P-0-2004, Active functional packages" during next booting. The selected functional packages are also activated only upon booting.

The figure below illustrates the interaction of the parameters involved in enabling of functional packages.

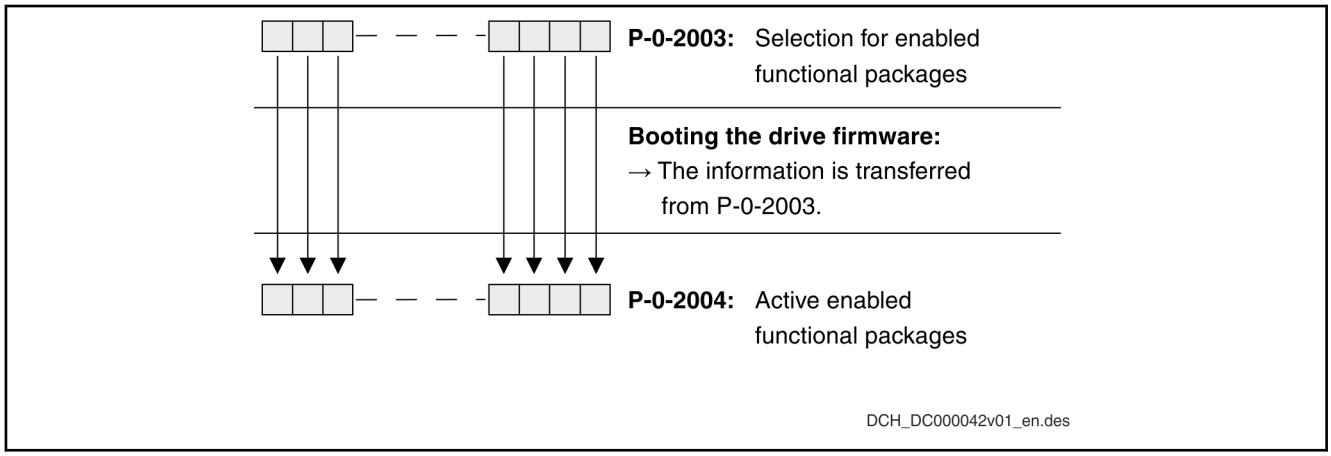


Fig. 1-14: Interaction of parameters for functional package selection

Every change in the selection of functional packages is stored via an entry of the current count of the operating hours counter in parameter "P-0-2002,

Oper. hours of contr. sect. at change of functional packages". The change in the functional package is thus documented.

As long as the values of "P-0-2003, Selection of functional packages" and "P-0-2004, Active functional packages" are different, it is impossible to switch over to OM. The transition command is terminated with command error "C0299Configuration changed. Restart".

The table below shows the currently possible combinations for entry in parameter "P-0-2003, Selection of functional packages". Whether the respective combination can be used depends on the available hardware variant.

HydraulicDrive packages with open-loop drive control

Base package/extension package(s)	Content of P-0-2003	Possible with this FWA				
		HDB	HDC	HDE	HDM	HDP
Bus valve (IFB)	0x0001 0001	X		X		
p/Q function (p_Q)	0x0002 0001	X		X		
Pump control (DFE)	0x0004 0001	X	X	X		X
Axis controller Open Loop (AXR)	0x0008 0001	X	X		X	X
Axis Controller Open Loop (AXR) + IndraMotion MLD (ML)	0x0008 0201		X		X	X

Tab. 1-11: HydraulicDrive packages with open-loop drive control

HydraulicDrive packages with closed-loop drive control

Base package/extension package(s)	Content of P-0-2003	Possible with this FWA			
		HDB	HDC	HDM	HDP
Axis Controller Closed Loop (AXR)	0x0008 0002	X	X	X	X
Axis Controller Closed Loop (AXR) + IndraMotion MLD (ML)	0x0008 0202		X	X	X
Axis Controller Closed Loop (AXR) + servo function (SRV)	0x0008 0012	X	X	X	X
Axis Controller Closed Loop (AXR) + servo function (SRV) + IndraMotion MLD (ML)	0x0008 0212		X	X	X
Synchronization Control Closed Loop (SYN)	0x0010 0002			X	
Synchronization Control Closed Loop (SYN) + IndraMotion MLD (ML)	0x0010 0202			X	

Tab. 1-12: HydraulicDrive packages with closed-loop drive control

☞ Changes in parameter "P-0-2003, Selection of functional packages" are only accepted by the drive after rebooting.

Reducing the active functional packages

The user can at any time reduce the scope of functions of the firmware by deactivating individual functional packages. To do this, reset the bits assigned to the functional packages, which are not required, in parameter "P-0-2003, Selection of functional packages".

Subsequent extension for HydraulicDrive

Functions required additionally can be activated by enabling further functional packages. Re-licensing is not provided. The available functional packages depend on the individual hardware variant.

Pertinent parameters

- P-0-2002, Oper. hours of contr. sect. at change of functional packages
- P-0-2003, Selection of functional packages
- P-0-2004, Active functional packages

Pertinent diagnostic messages

- C0299, Configuration changed. Restart

1.5 Hardware enabling

1.5.1 General information

Depending on existing hardware options, associated functionalities are enabled and relevant parameters made visible. To this end, optional hardware, which can be operated with the relevant firmware derivative, is identified during the booting process. Parameters of hardware, which are not available in the current device configuration, are also always hidden in PM (exception: “reconfigurable hardware”).

1.5.2 Reconfigurable hardware

There are hardware modules, which use different parameters depending on their parameterization. These packages can be marked as “reconfigurable hardware”. Such parameters are then visible in PM, even if the current configuration does not use these parameters.

1.5.3 Existing hardware packages

At present, the following packages can be enabled in dependence on the hardware:

- Analog peripherals
- Main connector type
- Bus system Sercos III
- Bus systems PROFINET, EtherNet/IP or POWERLINK
- Bus systems PROFIBUS
- Communication profile Servodrive
- Communication profile CANopen profile
- Communication profile CiA402
- Communication profile CiA408
- Real engineering

  (A separate “engineering port“ is available on the drive or master communication is not active)
- Virtual engineering

  (The engineering is transmitted in parallel to active master communication)
- Offline mode

1.6 Overview of master communication

1.6.1 General information

Master communication is used for communication of the drive with a higher-level control. It basically offers the following:

- Cyclic process data channels (“connections“) with pre-configurable data contents and monitoring mechanisms
- Acyclic process data channels with largely freely selectable access to all parameters

At present, the following master communication variants are supported

- Sercos III
- Servodrive profile over EtherCAT (SoE)
- CAN application protocol over EtherCAT (CoE)
- PROFINET (RT)
- EtherNet/IP
- PROFIBUS
- Servodrive over VARAN (SoV)
- Ethernet POWERLINK

Selected master communication

With the help of parameter “P-0-4089.0.1, Master communication: Protocol“ you can select the master communication protocol that is supported by the hardware.

Selection of master communication		Associated number	Description
No master communication hardware available		1	Appears, when no master communication hardware is available
Master communication not active		2	Can be selected by the customer to deactivate master communication. By deactivation of master communication, analog master communication is activated.
Ethernet-based field buses	EtherNet/IP	3	In the case of Multi-Ethernet HW the "Ethernet-based field bus derivative" can be selected.
	PROFINET (RT)	4	
	Servodrive over EtherCAT (SoE)	5	
	Sercos III	6	
	Servodrive over VARAN (SoV)	7	
	CAN application protocol over EtherCAT (CoE)	8	
	Ethernet POWERLINK	9	

Selection of master communication		Associated number	Description
Classic field buses	PROFIBUS DP	16	You can only switch to "master communication" **not active**. Although the hardware is available, it is not possible to switch to an "Ethernet-based field bus derivative".
	Reserved	17	
	Reserved	18	
Reserved range (range of numbers 256-...)	Reserved	256	-

Availability of buses for the individual derivatives

Interfaces for master communication

	Firmware derivative				
Master communication	HDB	HDC	HDE	HDM	HDP
EtherNET/IP	■	■	-	■	■
PROFINET	■	■	-	■	■
Servodrive over EtherCAT	■	■	■	■	■
Sercos	■	■	■	■	■
Servodrive over VARAN	■	-	■	-	■
PROFIBUS	-	■	-	■	-
CoE (CAN application protocol over EtherCAT)	■	■	■	■	■
Ethernet POWERLINK	■	■	-	■	■

Tab. 1-13: Supported interfaces for master communication

1.6.2 Configuration of master communication interface

The master communication interface can be configured with the help of parameters "P-0-4088, Master communication: Drive configuration" and "P-0-4089.0.5, Master communication: Configuration".

In parameter P-0-4088, the configuration is executed per axis, in parameter P-0-4089.0.5, the configuration refers to the complete device.

P-0-4088, Master communication: Drive configuration

Here, the following settings are configured:

1. The booting behavior of the subdevice state machine in relation to the master communication state machine
2. Behavior of the device in the event of a bus failure, see also "Operation modes of master communication"

P-0-4089.0.5, Master communication: Configuration

Name	Master communication: Configuration		
Structure	Bit	Designation/function	Comment
	0	PLL synchronization for POWERLINK 0: PLL is synchronized by the Sync signal of master communication 1: PLL is not synchronized by the Sync signal of master communication (PLL deactivated)	
	2/1	Selection of PLL algorithm for synchronous master communication 00: Hard-synchronous PLL control, (Sercos II, EtherCAT) 01: Soft-synchronous PLL control (Sercos, CANopen) 10: Very soft-synchronous PLL control (Sercos, Softmaster) 11: Reserved	For “non-clock-synchronized master communication” it has no effect, e.g. EtherCAT FreeRun
	3	Reserved	
	4	Activation of DirectAccess for ServoDrive over VARAN 0: DirectAccess telegrams are not processed 1: DirectAccess telegrams are processed	
	5-8	Reserved	
	9	Multicast TTL for EtherNet/IP 0: TTL takes the value 1 (default) 1: TTL takes the value 64 (Multicast telegrams are routed)	Change in configuration requires rebooting of the drive
Function	This parameter contains configuration bits of master communication. It is used to configure the functions and the behavior of the master communication interface. Configuration bits, which are valid per axis (i.e. not for the complete device), are configured in parameter P-0-4089.0.5. A change in the configuration becomes effective upon a restart. Without a restart, with transition command C0200 “Exit parameterization level procedure command”, command error “C0299 Configuration changed. Restart“ is issued.		

Tab. 1-14: Configuration P-0-4089.0.5

The protocol is selected or deactivated via "P-0-4089.0.1, Master communication: Protocol" (e.g. using the IndraWorks dialog “Master Communication”). The change will only take effect after the device has been restarted.

IP engineering is carried out via the Multi-Ethernet interface. IP engineering cannot be carried out when the EtherCAT® protocol has been activated, because EtherCAT® does not support IP engineering; EoE (Ethernet over EtherCAT) for EtherCAT® can be used instead. When the VARAN protocol is activated, IP engineering can also not be carried out; in this case, engineering can be accessed via the Foreign Package mechanism.

1.6.3 Device model

The basic structure of the HydraulicDrive as field bus slave device is illustrated in the graphic below. It consists of two essential components:

- Application (typical drive)
- (Master) communication

While the type of communication may vary, the (drive) application is always identical. The application is always based on the Sercos specification.

This means, even with master communication variants other than Sercos, the application is always based on the Sercos specification. This refers to functions such as parameter model and administration, diagnostic system, scaling system, device initialization, complete drive section, etc.

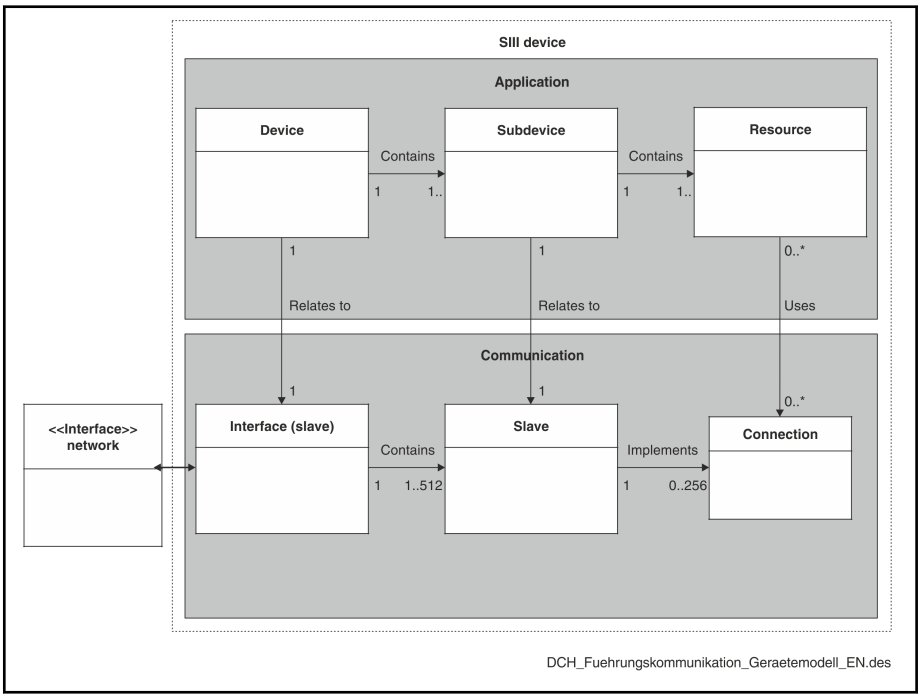


Fig. 1-15: Device model

Fundamental device control

A drive with master communication is largely controlled by 2 state machines:

- Communication state machine: State control according to the state at the bus system
- Device state machine: Consisting of the general main states of the subdevice such as
  - PM "parameterization level 1 active"
  - OM operating mode

1.6.4 Transmission mode or time-based application and communication relationships (synchronicity)

General information

Synchronicity and type of data transmission according to the criteria mentioned below are initially independent of each other. Interrelationships may result from implementations.

Synchronicity (time-based relation) in general

Synchronous

- Properties
  - Distributed clocks are coupled with regard to the relative time (directly or indirectly such as, for example, PLL), but they are not necessarily absolutely coupled. In the absolute case: Absolute-synchronous
  - Between distributed clocks, there is a restricted inaccuracy (jitter).
  - An explicit clock or a corresponding counter does not necessarily exist in all devices. The synchronization can also be based on directly transmitted events.

- Consequences
  - Exceeding of inaccuracy (timing errors) does not occur in normal operation.
  - Distributed clocks do not diverge.

Asynchronous

- Properties
  - Distributed clocks (if available) run completely independently of each other
- Consequences
  - Timing errors may occur
  - Distributed clocks may permanently diverge

Data transmission in general

Cyclic

- Data exchange within a fixed time base

Acyclic without request

- Data exchange without a fixed time base
- Data are sent not upon request, but, for example, upon an event in the network node.

Acyclic on request / polling

- Data exchange without a fixed time base
- Data are sent on request of the communication counter-node.

Communication view

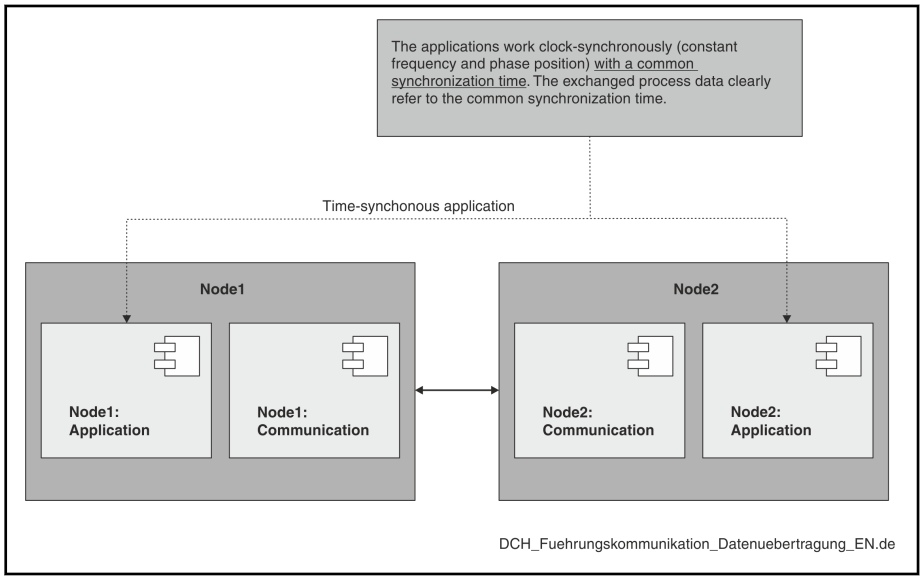


Fig. 1-16: Master communication data transmission

The communication view consists of the complete communication chain. This is shown in the figure, see fig. 1-16 "Master communication data transmission" on page 33.

Synchronicity

- Complete communication chains may be synchronous (synchronous with regard to communication) or asynchronous.
- The "weakest link" of the complete chain determines the synchronicity of the complete chain:

  If an element is asynchronous, the complete communication chain is asynchronous. Jitters add up. If the "weakest link" is the field bus, the synchronicity of the complete communication chain corresponds to the synchronicity of the field bus:

- The application needs not necessarily to utilize this synchronization, if communication-related synchronization is available. It may also be asynchronous, see the following sections.

Data transmission

- Complete communication chains can offer some or all of the data transmission methods listed under "node 1".

Also here, the synchronicity initially depends on the data transmission. Depending on the implementation of communication there may, however, exist a dependency, e.g. synchronicity only in conjunction with cyclic transmission.

A matrix can be set up for every field bus. Based on the field bus mechanisms, you can derive from this matrix, which combinations are possible.

Application view

Synchronicity

Applications may be synchronous (synchronous with regard to the application) or require synchronicity. This is possible through:

- Synchronization via a synchronous complete communication chain
- Realization at application level. This is possible by using, for example, a time stamp together with a reference clock. This, in turn, usually results in demands made on communication. However, these demands do not refer to the transmission of data, but to signaling in order to realize the reference clock.

Data transmission

The applications can require all the various types of data transmission. These have to be offered by the complete communication chain in the respective combination with the required type of synchronization.

Overview of cases, general

Synchronization

		Application	
		Application-synchronous	Application-asynchronous
Complete communication chain	**Communication-synchronous**	**Case 1** Implementation: • Synchronization through communication **(case 1.1)** • Synchronization through application-based procedure **(case 1.2)**	**Case 2** Asynchronous (despite communication synchronicity)
	Communication-asynchronous	**Case 3** Implementation: Synchronization is only possible through application-based procedure	**Case 4** Asynchronous

Tab. 1-15: Overview of cases, general / synchronization

All cases of synchronization can be combined with all cases of data transmission, such as, for example, cyclic, as far as this is useful for the application at hand and possible with regard to the implementation.

1.6.5 Mapping to field buses

In the following, the cases listed in the section before are mapped to the various field buses.

Case 1.1: Communication & application-synchronous; implementation with Sync. through communication

	Case 1.1 a) Cyclic	Case 1.1 b) Acyclic without request	Case 1.1 b) Acyclic with request
PROFIBUS	Isochronous	-	SYNC/FREEZE
PROFIBUS RT	-	-	-
PROFIBUS IRT	Isochronous	-	-
Sercos III	Clock-synchronous (cyclic data)	Only indirectly via clock-synchronous cyclic data	-
EtherNet/IP	CIPsync, CIPmotion	-	-
EtherCAT (SoE + CoE)	Clock-synchronous (cyclic data)	-	-
VARAN (SoV + CoV)	Clock-synchronous (cyclic data)	-	-
Ethernet POWERLINK	Clock-synchronous (cyclic data)	-	-

Tab. 1-16: Case 1.1

Case 1.2: Communication-synchronous & application-synchronous; implementation with Sync. by application

In this case, synchronizing is (largely) independent of the field bus, for this reason, no mapping to field bus mechanisms possible.

Case 2: Communication-synchronous & application-synchronous; implementation with Sync. by application

	Case 2 a) Cyclic	Case 2 b) Acyclic without request	Case 2 b) Acyclic with request
PROFIBUS	Isochronous	-	SYNC/FREEZE
PROFIBUS RT	-	-	-
PROFIBUS IRT	Isochronous	-	-
Sercos III	Asynchronous cyclic data with watchdog	Only indirectly via asynchronous cyclic data without watchdog	-
EtherNet/IP	CIPsync, CIPmotion	-	-
EtherCAT (SoE + CoE)	-	-	-
VARAN (SoV + CoV)	-	-	-
Ethernet POWERLINK	-	-	-

Tab. 1-17: Case 2

Case 3: Communication & application-synchronous

In this case, synchronizing is (largely) independent of the field bus, for this reason, no mapping to field bus mechanisms possible.

Case 4: Communication & application-asynchronous

	Case 4 **a) Cyclic**	**Case 4** **b) Acyclic** **without request**	**Case 4** **b) Acyclic** **with request**
PROFIBUS	Cyclic	-	-
PROFIBUS RT	Cyclic	-	-
PROFIBUS IRT		-	-
Sercos III	Cyclic data (asynchronous), Mux channel SMP, SIP	SMP, (SIP)	SVC, SIP
EtherNet/IP	Cyclic	ChangeofState	-
EtherCAT **(SoE + CoE)**	-	-	-
VARAN **(SoV + CoV)**	-	-	-
Ethernet POWERLINK	-	-	-

Tab. 1-18: Case 4

2 Important Directions for Use

2.1 Appropriate Use

2.1.1 Introduction

Rexroth products reflect state of the art in their development and manufacture. They are tested prior to delivery to ensure operating safety and reliability.

⚠ WARNING **Personal injury and property damage caused by incorrect use of the products!**

The products have been designed for use in industrial environments and may only be used in the appropriate way. If they are not used in the appropriate way, situations resulting in property damage and personal injury can occur.

☞ Rexroth as manufacturer is not liable for any damage resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone bears responsibility for the risks.

Before using Rexroth products, the following pre-requisites must be met to ensure appropriate use of the products:

- Personnel who use our products in any way or form must first read and understand the relevant safety instructions and be familiar with their appropriate use.
- If the products take the form of hardware, then they must remain in their original state, in other words, no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Damaged or faulty products may not be installed or put into operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

2.1.2 Areas of Use and Application

Drive controllers made by Rexroth are designed to control hydraulic drives and monitor their operation.

Control and monitoring of the drive controllers may require the connection of additional sensors and actuators.

☞ The drive controllers may only be used with the accessories and parts specified in this documentation. If a component has not been specifically named, then it may neither be mounted nor connected. The same applies to cables and lines.

Operation is only permitted in the specified configurations and combinations of components using the software and firmware as specified in the relevant Functional Description.

Drive controllers have to be programmed before commissioning to ensure that the drive executes the specific functions of an application.

Drive controllers of the HydraulicDrive line have been developed for use in single- and multiple-axis drive and control tasks.

To ensure the application-specific use of drive controllers, device types of different drive powers and different interfaces are available.

Typical applications include, for example:

- Plastics machines,
- Presses,
- Printing and paper processing machines and
- Machine tools.

Drive controllers may only be operated under the assembly and installation conditions described in this documentation, in the specified position of normal use and under the ambient conditions described (temperature, protection class, humidity, EMC, etc.).

2.2 Inappropriate Use

Using the drive controllers outside the operating conditions described in this documentation and outside the technical data and specifications given is defined as "inappropriate use".

Drive controllers may not be used, if...

- they are exposed to operating conditions that do not meet the prescribed ambient conditions. This includes, for example, operation under water, under extreme temperature fluctuations or extremely high maximum temperatures.
- Furthermore, drive controllers may not be used in applications which have not been expressly authorized by Rexroth. Please strictly observe the specifications outlined in the general Safety Instructions!

3 Safety Instructions for Electric and Hydraulic Drives and Controls

3.1 Definitions of Terms

Installation An installation consists of several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.

Electric Drive System An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the associated lines and cables.

Hydraulic Drive System A hydraulic drive system comprises all components, starting with the pressure supply through to the actual drive. This includes, for example, hydraulic cylinders, hydraulic motors, hydraulic valves, hydraulic pumps, transducers and associated lines and cables.

User A user is a person installing, commissioning or using a product which has been placed on the market.

Application Documentation Application documentation comprises the entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: User Guide, Operation Manual, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Manual, etc.

Electrical Equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Manufacturer The manufacturer is a natural or legal person bearing responsibility for the design and manufacture of a product which is placed on the market in his or her name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Component A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric or hydraulic drive and control system are, for example, supply units, controllers, valves, motors, cables, etc.

Machine A machine is the entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, machining, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project Planning Manual A project planning manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified Persons The activities described in this documentation require knowledge of the electrical installation, the control technology, programming and hydraulics as well as knowledge of the associated technical terms. To ensure safe usage, these activities may therefore only be carried out by qualified personnel or under the direction and supervision of qualified personnel. Qualified personnel are those who can recognize possible hazards and institute the appropriate safety measures due to their professional training, knowledge and experience, as well as their understanding of the relevant regulations pertaining to the work to be done. Qualified personnel must observe the rules relevant to the subject area.

Control System A control system comprises several interconnected control components placed on the market as a single functional unit.

3.2 General Information

3.2.1 Using the Safety Instructions and Passing Them on to Others

Do not isntall or operate the product unless you have thoroughly read all enclosed documents. Read and understand these safety instructions and all user information prior to working with these components. If you do not have the user documentation for the components, contact your responsible Bosch Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.

Improper use of these components, failure to observe the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, injury, electric shock or even death in the worst case.

3.2.2 Requirements for Safe Use

Read the following instructions before initial commissioning of the product components in order to eliminate the risk of injury and/or property damage. You must comply with these safety instructions.

- Bosch Rexroth is not liable for damage resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified personnel are authorized to work on the product components or in their vicinity.
- Only use accessories and spare parts approved by Bosch Rexroth.
- Observe the safety regulations and stipulations of the country in which the components of the electric drive and control system are operated.
- Only use the product according to the intended use. See chapter "Appropriate Use".

- The ambient and operating conditions given in the available application documentation must be adhered to.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technology". If this is not the case, they are excluded. Functional safety includes parts of the overall safety concept, in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.
- The information given in the application documentation with regard to the use of the delivered components contains only application examples and suggestions.

  The machine and installation manufacturers must

  – make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,
  – make sure that the individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application at hand are complied with.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the relevant application documentation.

  The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in national regulations.
- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be strictly observed at all times.
- Observe safety-relevant information and information on risks in the operating instructions of the manufacturer of the connected hydraulic system before you commission a control in conjunction with a hydraulic system.

National regulations which the user must take into account

- European countries: In accordance with European EN standards
- United States of America (USA):
  – National Electrical Code (NEC)
  – National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  – Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  – International Organization for Standardization (ISO)
  – International Electrotechnical Commission (IEC)

3.2.3 Hazards by Improper Use

- High electrical voltage and high operating current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or damage to property due to unintended movements of the drive resulting from misuse or incorrect actuation!
- Health hazard for persons with cardiac pacemakers, metal implants and hearing aids in close proximity to electric drive systems!
- Risk of burns by hot housing surfaces!
- Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines and components!

3.3 Instructions with Regard to Specific Hazards

3.3.1 Protection Against Contact With Electrical Parts and Housings

☞ This section is related to components of the electric drive and control system with voltages of **more than 50 volt**.

Contact with parts conducting voltages above 50 volt can be dangerous and lead to electric shock. When operating components of the electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!

- Only qualified personnel are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Observe the general installation and safety regulations when working on high-voltage units.
- Before switching the machine on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component against reconnection.
- For electric components, observe the following:

  Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.
- Install covers and guards provided for this purpose before switching on.
- Never touch electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component is connected to the power supply.
- Under certain conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- For built-in devices, ensure protection against the ingress of foreign bodies and water as well as against direct contact by providing an external housing, for example a control cabinet.

High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!

- Before switching on and before commissioning, ground or connect the components of the electric drive and control system to the equipment grounding conductor at the grounding points.

- Connect the equipment grounding conductor of the components of the electric drive and control system permanently to the main power supply. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross-section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross-section as the external conductors.

Cross-section of the external conductor	Minimum cross-section of grounding conductor Leakage current ≥ 3.5 mA	
	1 protective earth conductor	2 protective earth conductors
1.5 mm^2 (AWG 16)	10 mm^2 (AWG 8)	2 × 1.5 mm^2 (AWG 16)
2.5 mm^2 (AWG 14)		2 × 2.5 mm^2 (AWG 14)
4 mm^2 (AWG 12)		2 × 4 mm^2 (AWG 12)
6 mm^2 (AWG 10)		2 × 6 mm^2 (AWG 10)
10 mm^2 (AWG 8)		-
16 mm^2 (AWG 6)	16 mm^2 (AWG 6)	-
25 mm^2 (AWG 4)		-
35 mm^2 (AWG 2)		-
50 mm^2 (AWG 1/0)	25 mm^2 (AWG 4)	-
70 mm^2 (AWG 2/0)	35 mm^2 (AWG 2)	-
...	...	...

Tab. 3-1: Minimum Cross-Section of the Grounding Conductor Connection

3.3.2 Protective Extra-Low Voltage as Protection Against Electric Shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

All connections and terminals with voltages between 5 and 50 volt at the components of the drive and control systems from Bosch Rexroth are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections.

Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volt (e.g., the mains connection) are connected to products from Bosch Rexroth, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

3.3.3 Protection Against Dangerous Movements

Dangerous movements can be caused by incorrect actuation of connected drives. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Errors in transducers and signal generators
- Defective components
- Software or firmware errors

These errors can occur immediately after the equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the electric drive and control system will normally be sufficient to avoid malfunction in the connected drives. With regard to personal safety, especially the risk of injury and/or property damage, it is critical to rely on these monitoring functions alone to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that incorrect drive movements will occur. The extent of incorrect drive movements depends on the type of control and the operating state.

Dangerous movements! Danger to life, risk of injury, serious injury or property damage!

A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the electric drive and control system are to be installed.

Based on the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

In case of malfunction imparing safety, immediately shut down the product and inform responsible personnel about the malfunction.

To avoid accidents, injury and/or property damage:

- Controls alone do not include safety functions for personnel safety and are not safety-relevant components
- Keep away from the machine’s range of motion and moving machine parts. Prevent personnel from accidentally entering the machine’s range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective covers
  - Light barriers
- Ensure a sufficient stability of safety fences and protective covers against the maximum possible kinetic energy.
- Mount emergency stop switches in the immediate reach of the operator. Before commissioning, verify that the emergency stop equipment works. Do not operate the machine if the emergency stop switch is not working.

- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons, depressurize the hydraulic system or use a safety interlock.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- Additionally, secure vertical axes against falling or lowering after switching off the motor by, for example,
  - mechanical locking of the vertical axes,
  - an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterbalancing of the vertical axes.
- The **motor holding brake**, which is part of the standard electric drive system, or an external holding brake activated by the drive controller is **not sufficient to guarantee personal safety**!
- Disconnect all relevant system parts via the main switch from the power supply, depressurize hydraulic systems and protect them against restarting in the case of:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long service interruptions
- Avoid the operation of high-frequency, remote control and radio equipment in the direct vicinity of components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation at initial commissioning of the electric drive and control system for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. A special EMC test might be required.

3.3.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors or permanent magnets of electric motors can represent a serious risk to persons with cardiac pacemakers, metal implants and hearing aids.

Health hazard for persons with cardiac pacemakers, metal implants and hearing aids in the direct proximity to electric components!

- Persons with carediac pacemakers and metal implants are not allowed to enter the following areas:
  - Areas in which components of the electric drive and control systems are mounted, commissioned and operated.
  - Areas in which parts of motors with permanent magnets are stored, repaired or mounted.
- If it is necessary for somebody with a cardiac pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of implanted cardiac pacemakers varies so widely that no general rules can be given.
- Pesons with metal implants or metal fragments in their body or who use hearing aids must consult a doctor before they enter the areas described above.

3.3.5 Protection Against Contact With Hot Parts

Hot surfaces of components of the electric or hydraulic drive and control system. Risk of burns!

- Avoid touching hot surfaces! Depending on the operating conditions, temperatures of the surfaces can be **higher than 60 °C** (140 °F) during or after operation.
- Before touching motors after having switched them off, let them cool down sufficiently. Cooling down can take **up to 140 minutes**!
- Before touching components after having switched them off, wait **15 minutes** to allow them to cool down.
- Wear safety gloves or do not work on hot surfaces.
- For certain applications, measures to prevent burns in the final application have to be taken by the machine or system manufacturer in accordance with the safety regulations. These measures can be, for example: Warnings on the machine or installation, guards (shielding or barriers) or safety instructions in the application documentation.

3.3.6 Protection During Handling and Mounting

Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!

- Observe the relevant statutory regulations of accident prevention.
- Use suitable equipment for mounting and transport.
- Avoid jamming and crushing by taking appropriate measures.
- Always use suitable tools. Use special tools if mandatory.
- Use lifting gear and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under suspended loads.
- Immediately clean up any spilled liquids from the floor due to risk of slipping!

3.3.7 Battery Safety

Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage.

Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not attempt to recharge the batteries as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle batteries.
- When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
- Only use the battery types specified for the product.

☞ Environmental protection and disposal! The batteries contained in the product are considered hazardous goods in case of overlland, air, or marine transport (risk of explosion) in the sense of legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

3.3.8 Protection Against Pressurized Lines

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air as well as hydraulic components can be supplied with externally provided pressurized media such as compressed air, hydraulic oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of ejecting oil jet).
- Observe the relevant manufacturer's operating instructions.
- Before disconnecting lines, depressurize the relevant system section and let the medium drain.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to risk of slipping!

☞ Environmental protection and disposal! The media used for the operation of the product might not be environmentally friendly. Dispose of environmentally harmful media separately from other waste. Observe the national regulations of your country.

3.4 Explanation of signal words and the Safety alert symbol

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is meant to draw the reader's attention to the safety instruction and identifies the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 Master communication

4.1 Basic functions of master communication

4.1.1 Brief description

General information



You can find a general description of master communication in chapter "Overview of master communication"

Note on parameter access

For control units that are not able to access 4-byte EIDN parameters, the following mechanisms are available:

- 4-byte EIDNs available in the drive with Sercos element and Sercos instance = 0 can be accessed as 2-byte IDNs. Example: Parameter P-0-4006.0.0 via P-0-4006
- The 4-byte EIDNs below with Sercos element or Sercos instance unequal to 0 are mapped to the assigned 2-byte IDN parameters.

4-byte EIDN parameters	2-byte IDN parameters
P-0-4089.0.1, Master communication: Protocol	P-0-2310, Master communication: Protocol
P-0-4089.0.2, Master communication: Device name	P-0-2311, Master communication: Device name
P-0-4098.0.5, Master communication: Configuration	P-0-2318, Master communication: Configuration
P-0-4089.0.6, Sync failures monitoring threshold	P-0-2728, Sync failures monitoring threshold
P-0-4089.0.10, Master communication: MAC address device	P-0-2312, Master communication: MAC address device
P-0-4089.0.11, Master communication: MAC address Port1	P-0-2313, Master communication: MAC address Port1
P-0-4089.0.12, Master communication: MAC address Port2	P-0-2314, Master communication: MAC address Port2
P-0-4089.0.13, Master communication: IP address	P-0-2315, Master communication: IP address
P-0-4089.0.14, Master communication: Network mask	P-0-2316, Master communication: Network mask
P-0-4089.0.15, Master communication: Gateway address	P-0-2317, Master communication: Gateway address

Tab. 4-1: Parameters for configuring master communication

Features

- Protocol selection via "P-0-4089.0.1, Master communication: Protocol"
- IP engineering is supported depending on the protocol
- Master communication engineering is supported depending on the protocol
- **Command processing**

→ Drive commands that can be externally activated (via master communication and "Engineering over IP")

- **Device control** (state machine)

  → Individual state machines for master communication and the device

  – Depending on the variant of master communication, the master communication state machine has different functionalities and complexities. The communication-specific states are distinguished and mapped to the status words of the corresponding master communication (e.g., for Sercos: "S-0-0135, Drive status word"; "S-0-1045, Sercos: Device Status (S-Dev)".

  – The device state machine is independent of the variant of master communication and maps the device-specific states to parameter "S-0-0424, Status parameterization level". We always distinguish between the operating mode (OM) and the parameter mode (PM).

- **Extended possibilities of control**

  – Signal control word (S-0-0145) and signal status word (S-0-0144)

  – Multiplex channel

  See chapter "Control options / additional functions".



The state machine of the master communications is briefly outlined in this section; it will be described in detail, i.e. including the individual status transitions, in the main chapter of the relevant master communication.

Pertinent parameters

The following parameters are used independently of the variant of master communication:

Parameters for state machine and phase switching

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, Class 3 diagnostics
- S-0-0014, Interface status
- S-0-0420, C0400 Activate parameterization level procedure command
- S-0-0422, C0200 Exit parameterization level procedure command
- S-0-0423, IDN-list of invalid data for parameterization levels
- S-0-0424, Status parameterization level
- P-0-4086, Master communication status
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.1, Master communication: Protocol
- P-0-4089.0.5, Master communication: Configuration
- P-0-4089.0.6, Sync failures monitoring threshold

Operation mode parameters

- S-0-0032, Primary operation mode
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5

- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

Sercos-specific control and status words

For the "Sercos" interface, the following **additional** parameters are used:

- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-1044, Sercos: Device Control (C-Dev)
- S-0-1045, Sercos: Device Status (S-Dev)

Field bus-specific parameters

The following **additional** parameters are used for field buses:

- P-0-1901.0.1, CiA402: Controlword
- P-0-1901.0.2, CiA402: Statusword
- P-0-4068, Field bus: Control word IO
- P-0-4077, Field bus: Control word
- P-0-4078, Field bus: Status word
- P-0-4094.0.1, Field bus: control word fluid power
- P-0-4094.0.2, Field bus: status word fluid power

Specific parameters for analog interface

For the analog interface, the following **additional** parameters are used:

- P-0-4028, Device control word
- P-0-0115, Device control: Status word

Pertinent diagnostic messages

- C0100, Communication phase 3 transition check
- C5200, Communication phase 4 transition check
- C0200, Exit parameterization level procedure command
- C0400, Activate parameterization level 1 procedure command

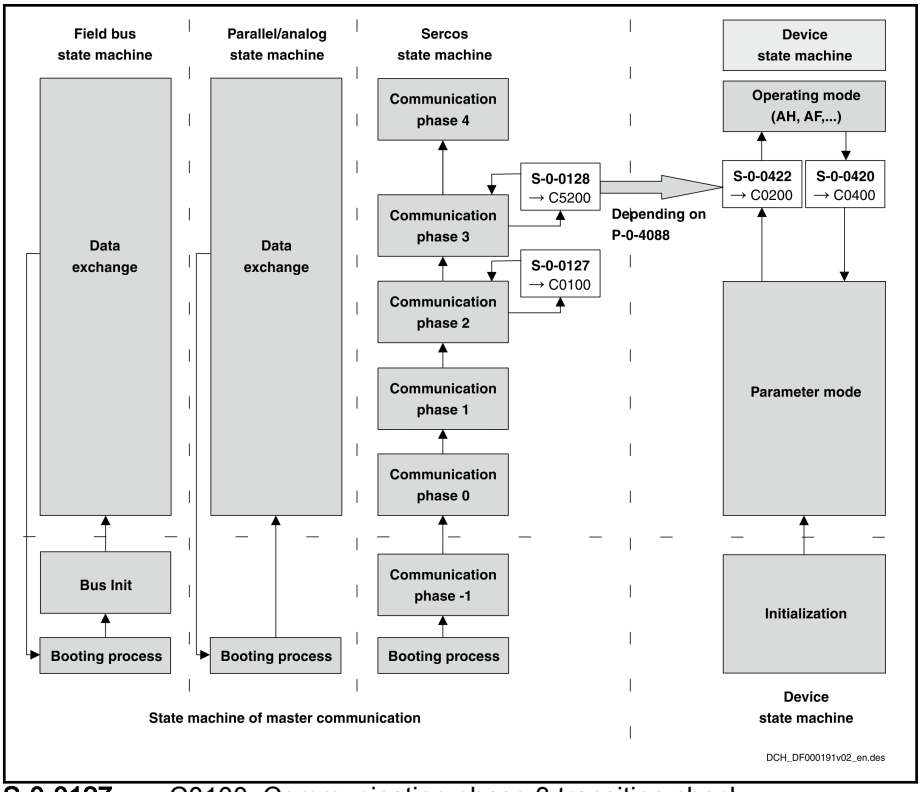
4.1.2 Device control and state machines

Overview

A drive state (e.g. Drive Halt, drive error) represents a specific internal and external behavior of the drive. The state can be exited as a result of defined events (e.g. drive commands, switching of operation modes). Corresponding state transitions are assigned to these events. The status transitions or the interaction of control and status bits are called state machine.

We distinguish between:

- Device-internal state machine (defines the device-specific states which determine the behavior of the device) and
- State machine of master communication



S-0-0127, C0100, Communication phase 3 transition check
S-0-0128, C5200, Communication phase 4 transition check
S-0-0420, C0400 Activate parameterization level 1 procedure command
S-0-0422, C0200, Exit parameterization level procedure command
P-0-4088, Master communication: Drive configuration

Fig. 4-1: Overview: State machines of master communications and device

Device-internal state machine

Parameter mode/operating mode

For the device-internal state machine we distinguish the following states:

- **Parameter mode (PM)**

  → Allows write access to all drive parameters which are not password-protected

- **Operating mode (OM)**

  → Only allows write access to all drive parameters which can be changed during operation and preferably can be cyclically transmitted

Switching

Switching between these two states can be performed using the following commands:

- S-0-0420, C0400 Activate parameterization level procedure command
- S-0-0422, C0200 Exit parameterization level procedure command

Observe the following aspects for switching:

- Switching is generally possible by direct execution of the transition commands S-0-0420 or S-0-0422.
- For field bus devices, switching can additionally take place in the freely configurable operating mode (P-0-4084 = 0xFFFE or 0xFFFD) by presetting the desired mode via bit 1 in "P-0-4077, Field bus: Control word".
- In the case of the Multi-Ethernet interface, the state machine of master communication is connected to the device-internal state machine. This

means that when master communication is switched (communication phase 2 → communication phase 4 or back), the device-internal state machine is switched, too. Via parameter "P-0-4088, Master communication: Drive configuration", this dependence can be deactivated.

Control word and status word

The device-specific states are mapped to the following parameters:

- S-0-0424, Status parameterization level
- P-0-0115, Device control: Status word
- P-0-0116, Device control: Control word

State machine of master communication

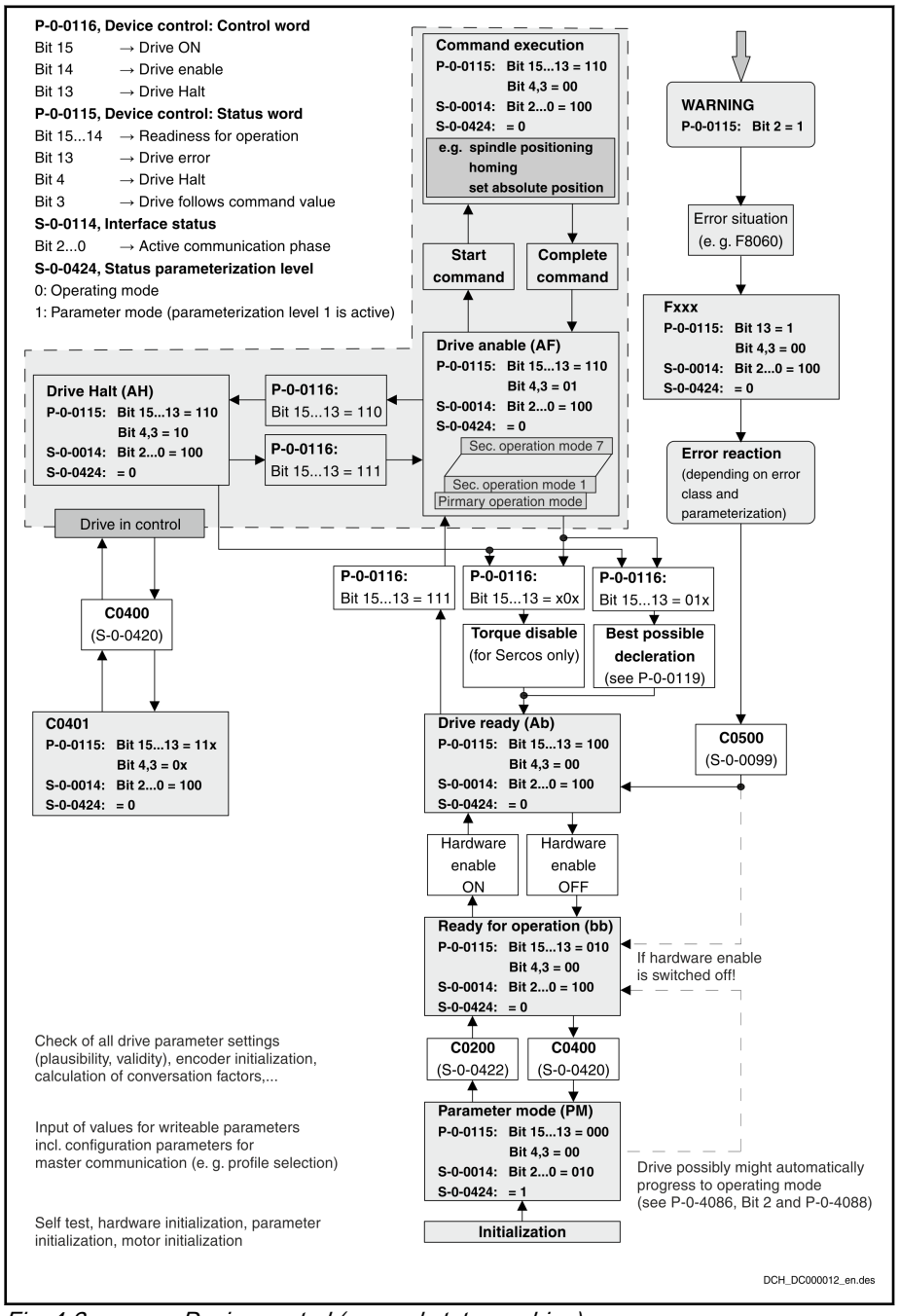


Fig. 4-2: Device control (general state machine)

For the state machine of master communication, we distinguish 3 characteristics which differ with regard to functionality and complexity:

- Sercos state machine
- Field bus state machine
- Analog state machine



The following sections only describe the most important states; more details can be found in the section of the respective master communication.

Sercos state machine

For the "Sercos" master communication, we distinguish the following states specific to this type of communication:

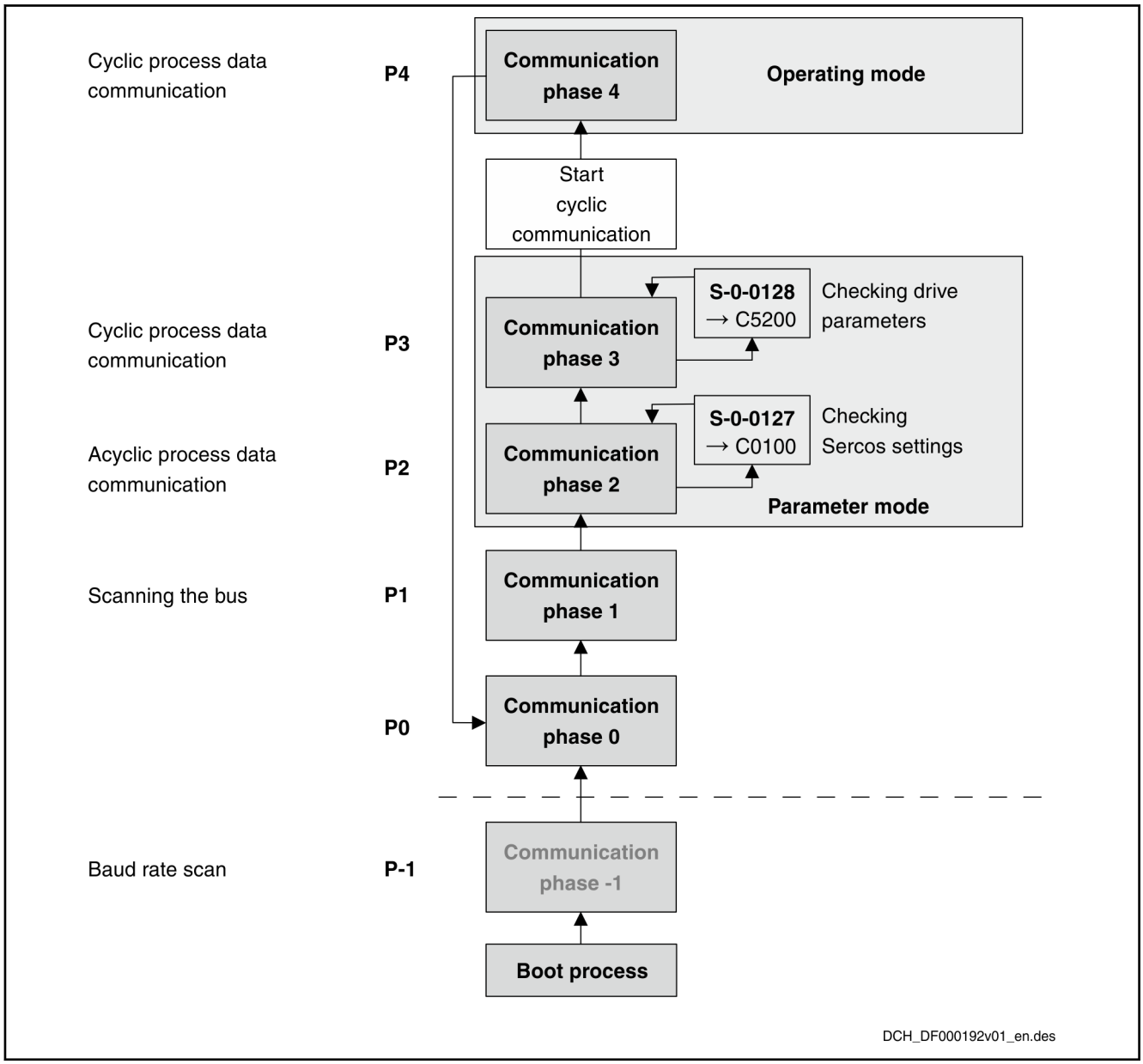


Fig. 4-3: State machine of the communication phases of the drive according to Sercos specification

See also chapter "Sercos".

The currently valid communication phase is contained in parameter "S-0-0014, Interface status" (bit 0...2).

Field bus state machine

For field bus master communication, we distinguish the following states specific to this kind of communication:

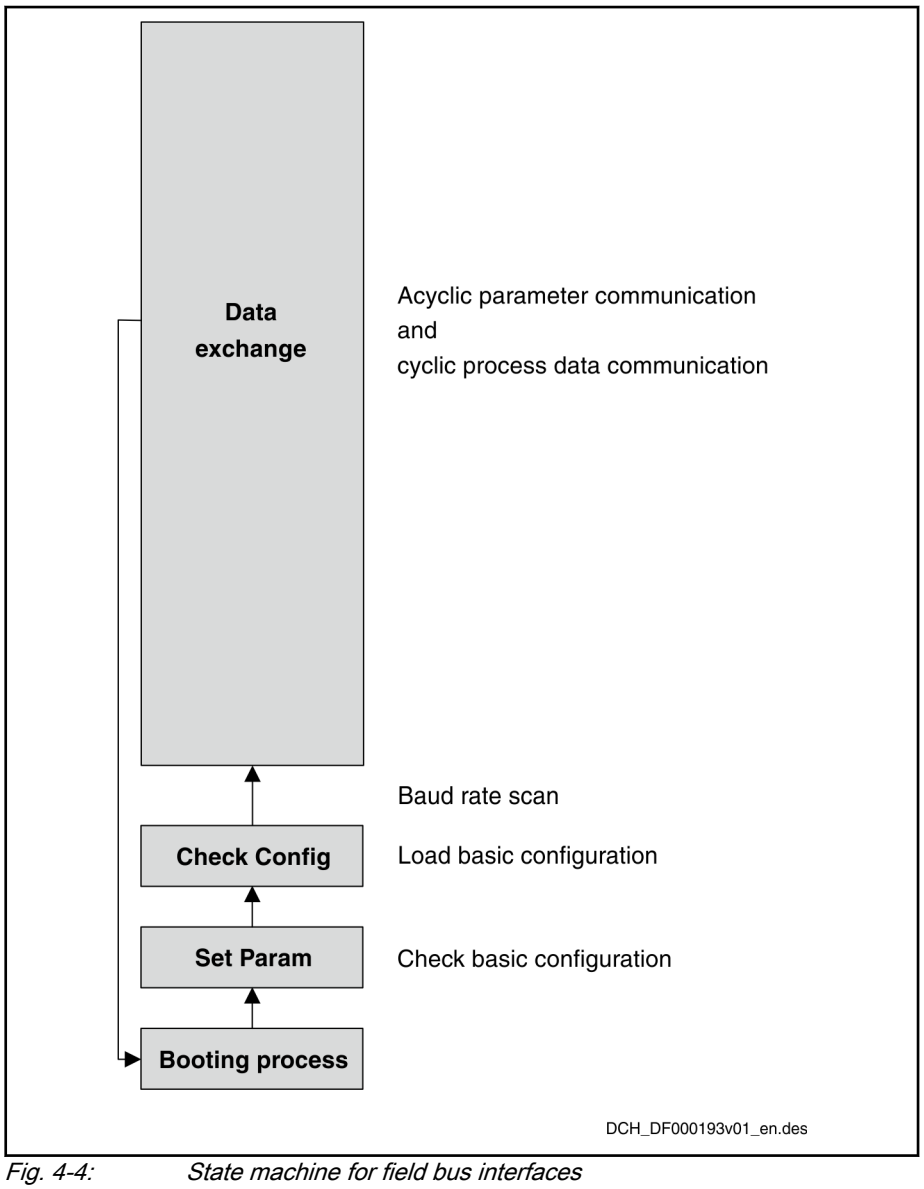


Fig. 4-4: State machine for field bus interfaces

See also sections on the respective variants of field bus master communication.

Communication phases of master communication

The supported communication phases as well as the handling of switching between the communication phases (e.g. parameter and operating mode) depend on the master communication used.

Communication phases according to Sercos specification

According to **Sercos specification**, the individual communication phases (states) have the following significances:

- **P-1**: In this phase, the drive can communicate via standard Ethernet mechanisms.

- **P0**: In P0, the master determines the topology (ring/line). The slaves determine their topology addresses and transmit them to the master, together with the respective Sercos address which has been set. At the end of P0, the master knows the Sercos addresses used and their positions in the topology.
- **P1**: In P1, the service channels of the connected slaves are initialized by the master.
- **P2**: In phase 2, the drive can be parameterized completely.

  The following types of parameters **can only be changed in phase 2**:
  - Communication parameters (according to Sercos)
  - Configuration of axis control (sampling times)
  - All factory-specific settings (can only be changed via master password)
- **P3**: When changing from P2 → P3, only the parameters that can be changed in phase 2 (see above) are checked.

  In phase 3, the following parameters can be changed:
  - Parameters for operation mode configuration
  - Error reaction settings
  - Encoder configuration parameters
  - Mechanical transmission elements (gear, feed constant)
  - Scaling and polarity parameters, position data format, modulo value
  - Configuration of analog and digital inputs/outputs
  - Configuration of the controller enable, on/off sequence (delays, …)

☞ According to Sercos specification the parameter mode is divided into phases 2 and 3. In phase 3, the limit values for all scaling-dependent parameters are not yet known. When these parameters are written in phase 3, the extreme value check is only carried out during phase switch to phase 4.

- **P4**: In phase 4, the so-called "operating mode", only the cyclic data can be changed, the configuration parameters cannot. Switching to the operating mode always causes a re-initialization of all functions available in the drive.

The following aspects have to be observed for **phase switching**:

- After the controller has been switched on, it does not automatically go to the operating mode, but has to be switched to this mode by the master.
- This switching of the drive controller to the operating mode is closely connected to establishing the readiness for operation.
- The procedure comprises several steps and is controlled by the master by presetting communication phases -1 to 4 and starting/completing the following commands:
  - S-0-0127, C0100 Communication phase 3 transition check
  - S-0-0128, C5200 Communication phase 4 transition check

☞ For Sercos devices, **all 5 communication phases** are supported. According to Sercos specification, switching takes place by the master setting the communication phase.

Communication phases for field bus interface

For devices with **field bus interface**, there is only the "Data Exchange" state, apart from basic initialization. In the "Data Exchange" state, we distinguish the following device states:

- Parameter mode
- Operating mode

Communication phases for analog interface

Basically, the same communication phases as for devices with field bus interface apply to devices with **analog interface**.

Switching always takes place when the transition check commands are executed.

☞ After the drive controller has been switched on, it automatically changes to the operating mode!

Control words and status words of master communication

The control word and status word of the respective master communication are an essential part of the communication between the master communication master and the drive.

Depending on the master communication, different parameters are used:

- EtherCAT® and VARAN (servo drive profile)
  - S-0-0134, Master control word
  - S-0-0135, Drive status word
- Field bus interface (e.g. PROFIBUS®, PROFINET®, EtherNet/IP™)
  - P-0-4077, Field bus: Control word

    - or -

    P-0-4068, Field bus: Control word IO

    - or -

    P-0-4094.0.1, Field bus: control word Fluid Power
  - P-0-4078, Field bus: Status word

    - or -

    S-0-0144, Signal status word

    - or -

    P-0-4094.0.2, Field bus: status word Fluid Power
- Analog interface (analog mode)
  - P-0-4028, Device control word
  - P-0-0115, Device control: Status word

The following device-specific parameters are used drive-internally:

- P-0-0115, Device control: Status word
- P-0-0116, Device control: Control word

The figure below illustrates the interaction of the above control and status words:

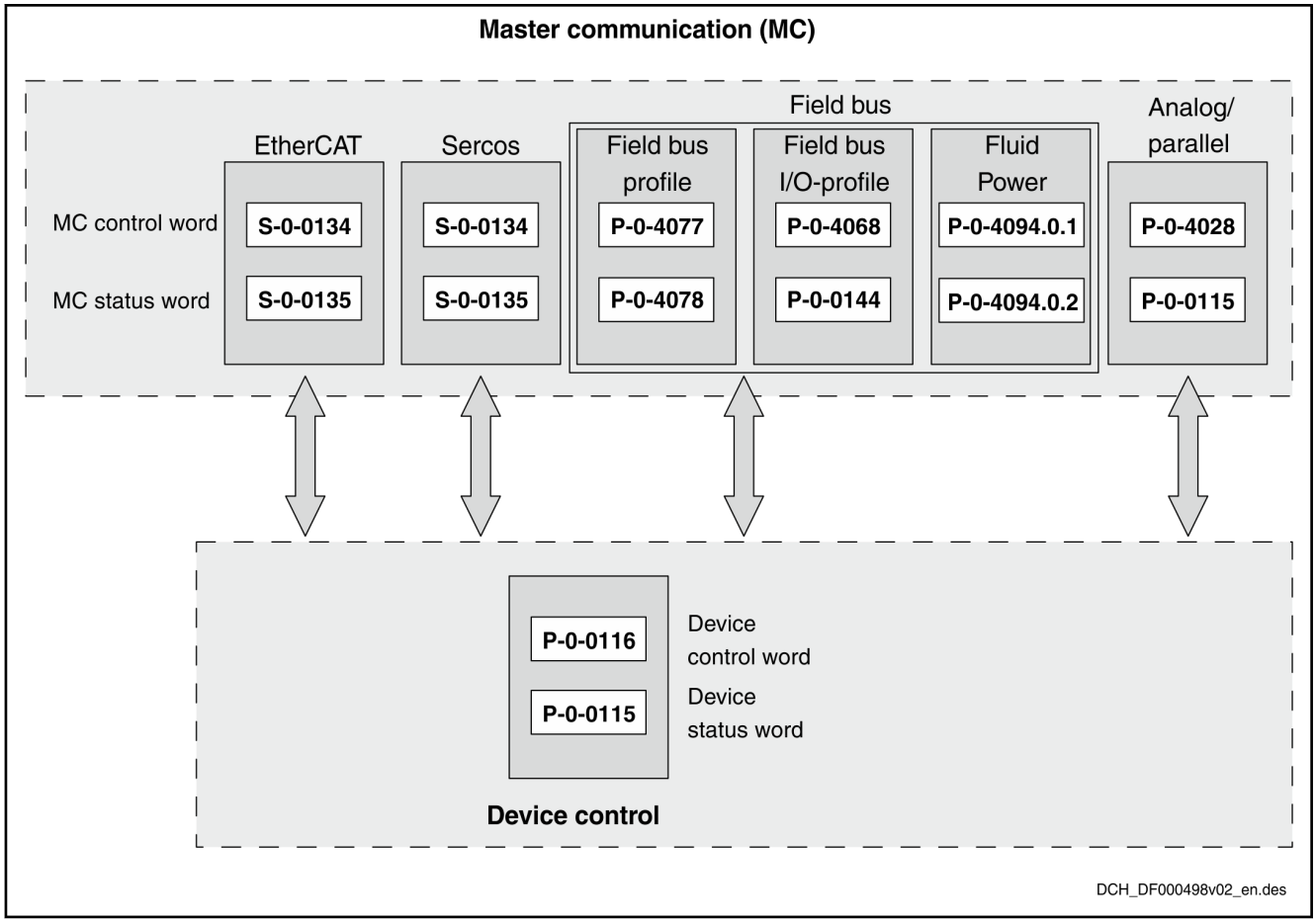


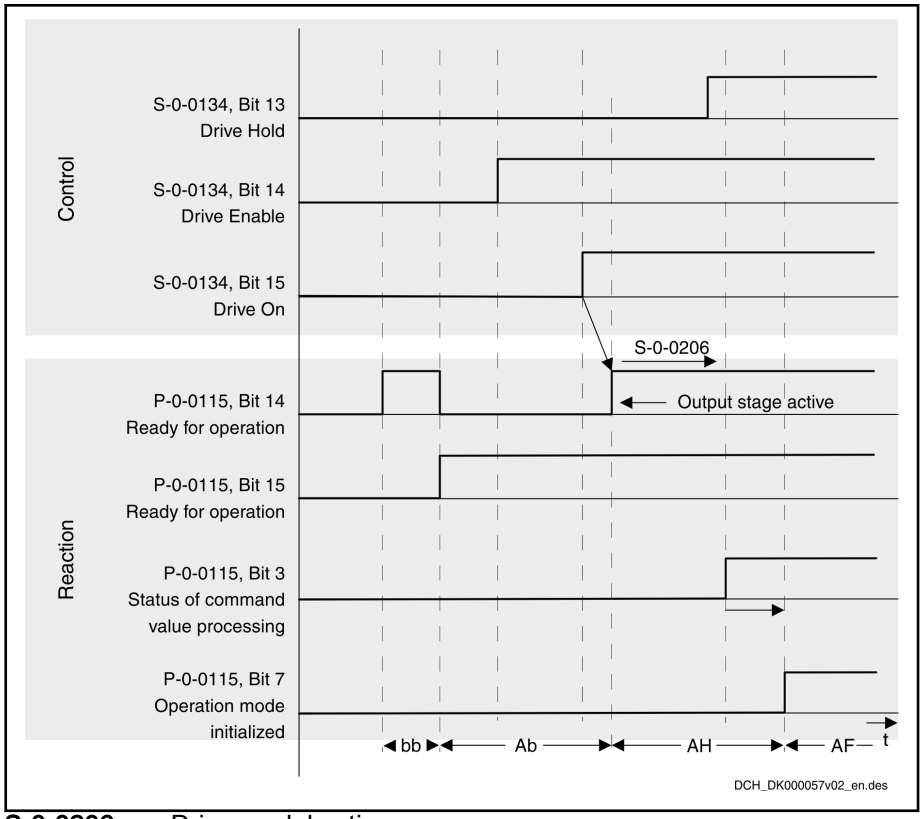
Fig. 4-5: Interaction of the available control and status words

Timing diagrams for device control

☞ The control bits in the parameter "S-0-0134, Master control word" are input externally via the master communication (the following examples apply to Sercos)!

☞ It is assumed that the drive is already in the operating mode and the hardware enable (if available) is set.

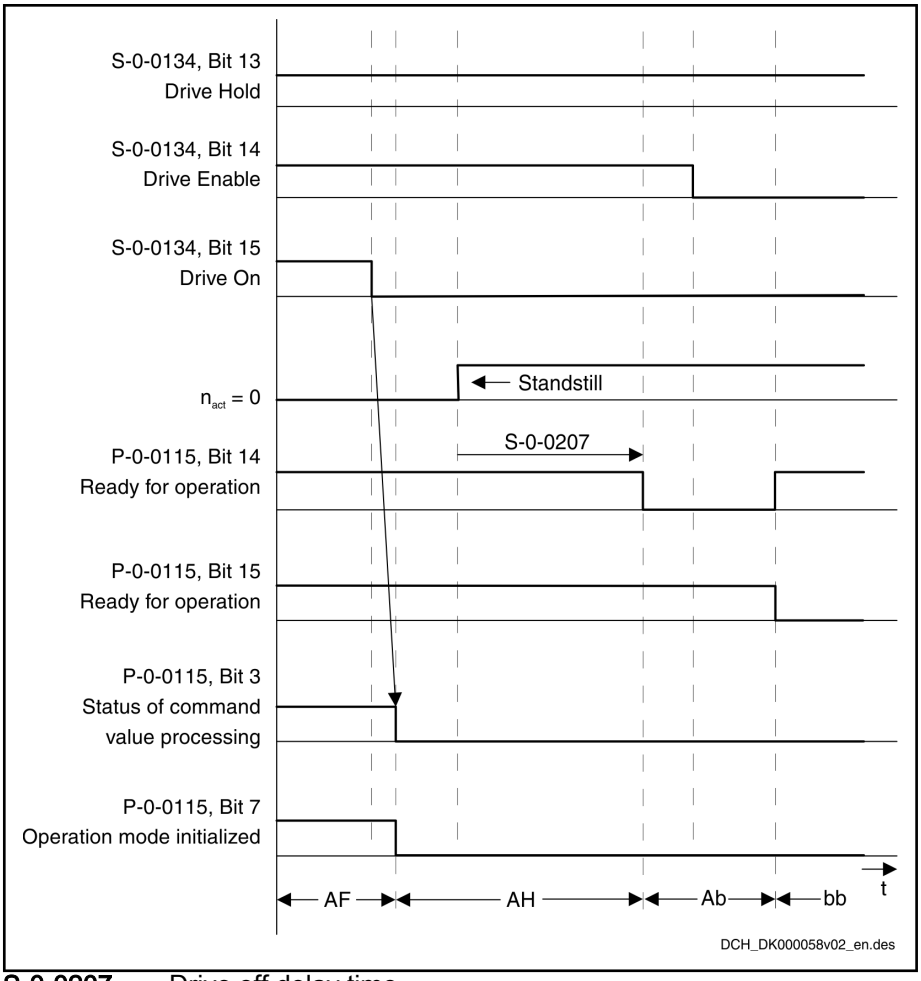
Bit sequence during switch-on process



S-0-0206 Drive on delay time

Fig. 4-6: Bit sequence during switch-on process

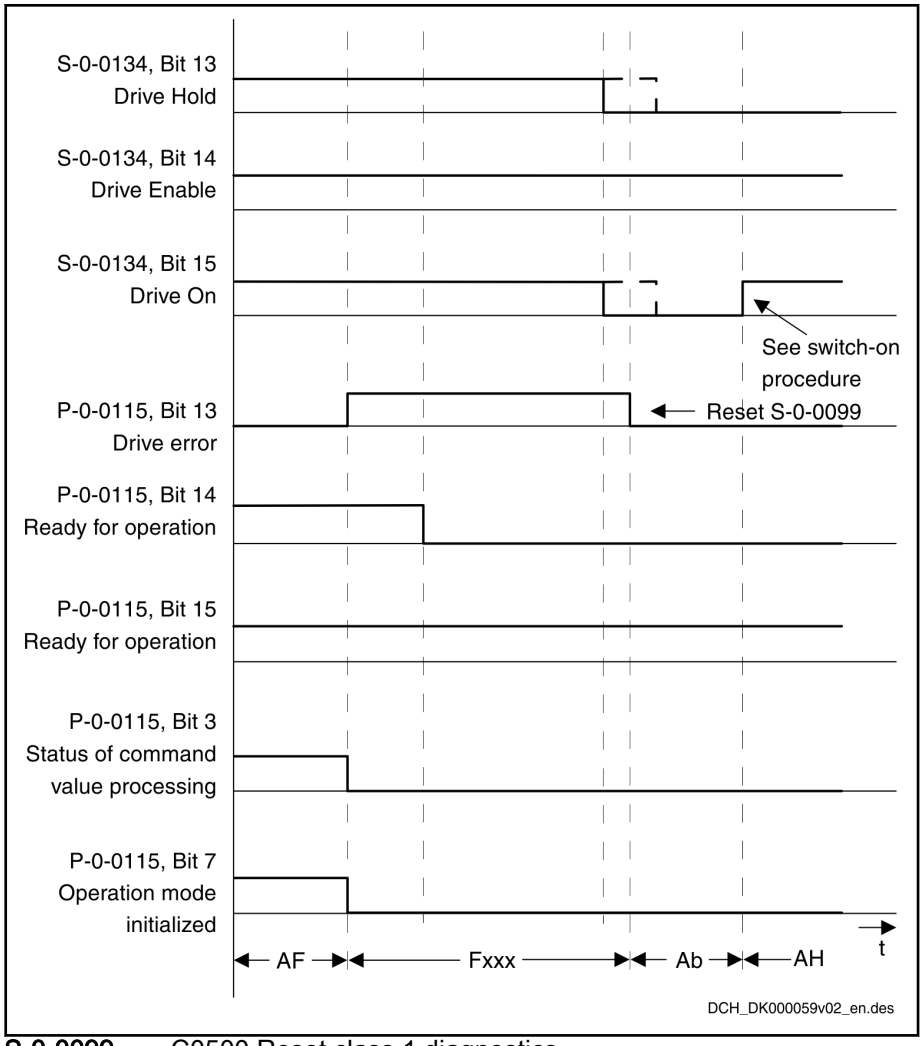
Bit sequence during switch-off process



S-0-0207 Drive off delay time

Fig. 4-7: Bit sequence during switch-off process

Bit sequence during error reaction



S-0-0099 C0500 Reset class 1 diagnostics

Fig. 4-8: Bit sequence during error reaction

Bit sequence during change of operation modes

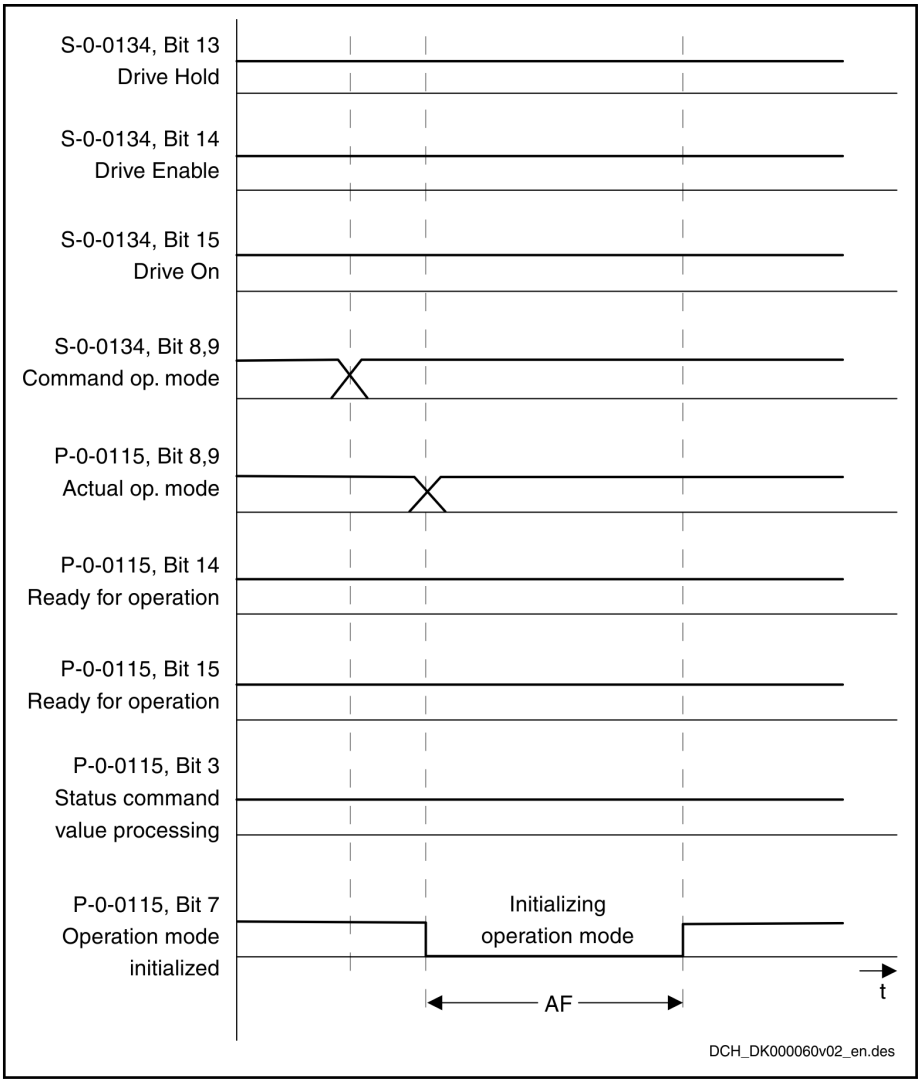


Fig. 4-9: Bit sequence during change of operation modes

Commands and diagnostic messages for mode change and phase switching

Distinguishing the commands

According to the desired action, the commands are related to the following groups:

- Commands for changing between parameter mode and operating mode:
  - S-0-0420, C0400 Activate parameterization level procedure command
  - S-0-0422, C0200 Exit parameterization level procedure command
- Commands for transition check to communication phases 3 and 4 (with Sercos only):
  - S-0-0127, C0100 Communication phase 3 transition check
  - S-0-0128, C5200 Communication phase 4 transition check

☞ With Sercos, command C0200 (S-0-0422) is automatically called during the execution of command C5200 (S-0-0128). This is why a diagnostic command message C02xx can be displayed after the command C5200 has been started.

Communication phase 3 transition check

By executing the command "S-0-0127, C0100 Communication phase 3 transition check", a number of checks and parameter conversions are carried out that can possibly cause the listed diagnostic command messages:

- Checking the validity of parameters required for switching to phase 3

  If one of these parameters has never been written or the backup was carried out incorrectly, the error message "C0101, Invalid parameters (-> S-0-0021)" is generated. The IDNs of the incorrect parameters are listed in parameter "S-0-0021, IDN-list of invalid operation data for CP2". These parameters have to be set valid by writing correct values to them.
- Checking the device configuration
- Checking the telegram configuration, especially in the case of configured telegrams

  In this case a check is run to find out whether the parameters selected for the configurable data block in the cyclic command value channel (MDT) or actual value channel (AT) may be configured and whether the allowed length of the configurable data blocks is complied with.
- If necessary, checking of timing parameters for Sercos communication in phases 3 and 4 for plausibility and compliance with requirements
- Limit value check of communication parameters and system

Communication phase 4 transition check or "exit parameterization level procedure" command

With the command "S-0-0128, C5200 Communication phase 4 transition check" or "S-0-0422, C0200 Exit parameterization level procedure command", the following checks and initializations are carried out that can possibly cause the listed command errors:

- Checking whether functional package selection was changed
  - C0299, Configuration changed. Restart

    → Drive has to be rebooted before it is possible to switch to the operating mode (OM)
- Checking the validity of parameters required for subsequent initializations
  - C0201, Invalid parameters (->S-0-0423)
  - C0212, Invalid control section data (->S-0-0423)
- Checking the device configuration
  - C0223, Invalid settings for controller cycle times
- If necessary, checking parameters for field bus communication for validity and compliance with requirements
  - C0229, Field bus: IDN for cycl. command val. not configurable
  - C0230, Field bus: Max. length for cycl. command val. exceeded
  - C0231, Field bus: IDN for cycl. actual val. not configurable
  - C0232, Field bus: Length for cycl. actual values exceeded
  - C0233, Field bus: Tcyc (P-0-4076) incorrect
  - C0234, Field bus: P-0-4077 missing for cycl. command values
- Checking the configuration of the multiplex channel
  - C0238, Order of cyclic command value configuration incorrect
  - C0239, IDN for command value data container not allowed
  - C0240, IDN for actual value data container not allowed
- Checking the encoder configuration

  - C0219, Max. travel range too large
  - C0271, Incorrect encoder 1 parameterization
  - C0272, Incorrect encoder 1 parameterization (mechanics)
  - C0273, Modulo value for encoder 1 cannot be displayed
  - C0274, Encoder 1 unknown
  - C0280, Maximum travel range cannot be displayed internally
  - C0288, Rotary scaling not allowed
- Checks during encoder initialization
  - C0220, Error when initializing position of encoder 1
  - C0221, Initialization velocity encoder 1 too high
- Limit value check
  - C0202, Parameter limit error (->S-0-0423)
  - C0203, Parameter conversion error (->S-0-0423)
- General system checks
  - C0245, Operation mode configuration (->S-0-0423) not allowed
- Initializing the fine interpolator
  - C0258, Error in relation TNcyc (S-0-0001) to fine interpol.
- Checking the interface configuration
  - C0242, Multiple configuration of a parameter (->S-0-0423)
- Checking master communication
  - C0251, Error during synchronization to master communication
- Checking whether a boot error is present or firmware download has been carried out
  - C0298, Impossible to exit parameterization level

"Error-free" message

When the drive has reached communication phase 4 without error, the display reads "bb". The corresponding diagnostic message is:

- A0013, Ready for operation

4.2 Control options/additional functions

4.2.1 Configurable signal control word

Brief description

The signal control word allows writing individual control bits, which are available in different parameters, by a freely configurable collective parameter. The configurable signal status word is used to accept a maximum of 16 copies of bits from other drive parameters.

Examples of use

This functionality can be used, for example,

- for freely configuring the digital inputs
- for setting-up mode via digital inputs
- for setting bits in drive parameters and for starting commands via the cyclic channel (master communication)



For Sercos and field bus interfaces, the parameter "S-0-0145, Signal control word" is to be configured accordingly in the cyclic data so that the configured control bits are evaluated.

Pertinent parameters

- S-0-0027, Configuration list for signal control word
- S-0-0145, Signal control word
- S-0-0329, Assign list signal control word
- S-0-0399, IDN-list of configurable data in signal control word

Notes on commissioning on the signal control word

Selection list

Only parameters that are contained in "S-0-0399, IDN-list of configurable data in signal control word" can be assigned to parameter "S-0-0027, Configuration list for signal control word".

Configuring the IDNs

In parameter "S-0-0027, Configuration list for signal control word", the IDNs of those parameters are indicated that are to be configured by means of the signal control word (= targets).

The position of an IDN in this list defines which bit is assigned to which IDN (targets) in the signal control word. For example, the 1st list element determines the parameter to which bit 0 of the signal control word is assigned.

Configuring the bit numbers

Which bit of the selected parameters (= targets in parameter S-0-0027) is set (or cleared) by the signal control word, has to be defined in parameter "S-0-0329, Assign list signal control word".

☞ If this list remains empty, bit 0 of the mentioned parameters is automatically influenced. Otherwise the bit that is to be assigned to the target parameter is entered in this list.

Bit numbers from "0" (LSB) to "31" (MSB) can be entered.

☞ A maximum of 16 bits can be configured. Configuration always has to be carried out from the least significant to the most significant bit; in other words, the position of the bit copy in the signal control word results from the continuous configuration in parameter "S-0-0027, Configuration list for signal control word".

Exceptions

- If the assigned parameter is a command, the bit number in parameter "S-0-0329, Assign list signal control word" is irrelevant.
- If the parameter assigned is parameter "S-0-0346, Positioning control word", a positive edge in the respective bit of the control word causes toggling of parameter S-0-0346.

Diagnostic messages and error messages

When entering data in the parameters "S-0-0027, Configuration list for signal control word" and "S-0-0329, Assign list signal control word", the following checks are run:

- If an IDN specified in parameter S-0-0027 is not contained in parameter "S-0-0399, IDN-list of configurable data in signal control word", the error message "0x7008 Invalid data" is generated.

☞ In this case, only those inputs up to the faulty element are accepted!

4.2.2 Configurable signal status word

Brief description

The configurable signal status word is used to accept a maximum of 16 copies of bits from other drive parameters. The user can thereby freely configure

a bit list of status bits. This allows defining a bit list which contains all important status information of the drive for the control unit.

☞ The bits in the signal status word are configured in every master communication cycle at the point of time defined in parameter "S-0-0007, Feedback acquisition starting time (T4)".

Pertinent parameters

- S-0-0026, Configuration list for signal status word
- S-0-0144, Signal status word
- S-0-0328, Assign list signal status word
- S-0-0398, IDN-list of configurable data in signal status word

Notes on commissioning on the signal status word

Configuring the IDNs

In parameter "S-0-0026, Configuration list for signal status word", the IDNs of those parameters are indicated that contain the original bits (sources). The parameters that can be entered into the configuration list are contained in parameter "S-0-0398, IDN-list of configurable data in signal status word". The position of an IDN in the list determines the bit in the signal status word to which the IDN applies. For example, the 1st list element determines from which parameter bit 0 of the signal status word is taken.

Configuring the bit numbers

Which bit of the parameters selected in "S-0-0026, Configuration list for signal status word" is copied to the signal status word has to be determined in "S-0-0328, Assign list signal status word".

☞ If this list remains empty, bit 0 of the mentioned parameters is automatically copied. Otherwise, the bit to be taken from the source parameter is specified in the list.

Bit numbers from "0" (LSB) to "31" (MSB) can be entered.

The signal status word can have the following configuration, for example:

Bit no. in the signal status word (S-0-0144)	IDN of original parameter in S-0-0026	Bit no. of original parameter in S-0-0328	Significance
0	S-0-0403	0	Position status

Tab. 4-2: Example of configuration of signal status word

☞ A maximum of 16 bits can be configured. Configuration always has to be carried out from the least significant to the most significant bit; in other words, the position of the bit copy in the signal control word results from the configuration in parameter "S-0-0026, Configuration list for signal status word".

Diagnostic messages and error messages

When entering data in the parameters "S-0-0328, Assign list signal status word" and "S-0-0026, Configuration list for signal status word", the following checks are run:

- Check whether the IDN specified in S-0-0026 has variable data length (list parameter) or a so-called online read function. If yes, the service channel error message "0x7008 Invalid datum" is generated.

  Parameters with online read functions generally are parameters with physical units (position, velocities, accelerations and currents), as well

as the parameters "S-0-0135, Drive status word" and "S-0-0011, Class 1 diagnostics".

☞ In this case, only those inputs up to the faulty element are accepted!

4.2.3 Multiplex channel

Brief description

The multiplex channel is an expansion of the limited cyclic data channel. By means of index assignment and switching, cyclic access to list elements is possible for the multiplex channel, too.

☞ To use the "multiplex channel" mechanism, it is necessary to use master communication via Sercos or field bus and configure the multiplex parameters in the cyclic real-time channel.

Features

- 8 multiplex containers with 4 bytes each are available for cyclic command value data (MDT) and cyclic actual value data (AT)
- Multiplex datum to be transmitted is addressed via parameter "S-0-0368, Data container A: Addressing" (L-byte for MDT; H-byte for AT)
- Interpolation of the command value via S-0-0362, and S-0-0366,
- Multiplex data are transmitted in communication cycle

Possible applications

By means of the multiplex channel it is possible:

- to increase the number of transmittable bytes in the cyclic real-time channel (command and actual values) by multiplexing data
- to transmit the multiplex data at a cycle time of "T_{scyc} x number of multiplex data" by incrementing the addressing index (S-0-0368)
- to achieve an operation mode-dependent configuration of the cyclic data by index switching in case the operation mode is changed

☞ When IndraMotion MLC is used, the multiplex channel is used for communication between MLC and drive and therefore cannot be freely used any more!

Pertinent parameters

Parameters for command value channel:

- S-0-0362, Data container A: List index command values
- S-0-0368, Data container A: Addressing
- S-0-0360, Data container A: Command value 1
- S-0-0450, Data container A: Command value 2

  - to -

  S-0-0456, Data container A: Command value 8

Parameters for actual value channel:

- S-0-0366, Data container A: List index feedback values
- S-0-0364, Data container A: Feedback value 1
- S-0-0480, Data container A: Feedback value 2

  - to -

  S-0-0486, Data container A: Feedback value 8

Configuration lists of the command value data containers:

- S-0-0370, Data container A: Configuration list command value-1
- S-0-0490, Data container A: Configuration list command value 2

  - to -

  S-0-0496, Data container A: Configuration list command value 8

Configuration lists of the actual value data containers:

- S-0-0371, Data container A: Configuration list feedback value-1
- S-0-0500, Data container A: Configuration list feedback value 2

  - to -

  S-0-0506, Data container A: Configuration list feedback value 8

Pertinent diagnostic messages

- C0238, Order of cyclic command value configuration incorrect
- E4008, Invalid addressing command value data container A
- E4009, Invalid addressing actual value data container A

Functional description

General information

Possible multiplex data

In the multiplex channel it is possible to configure all parameters that can be transmitted in the cyclic real-time channel. The possible multiplex data are contained in the list parameters for the command value and actual value channel:

- S-0-0188, List of configurable data in the MDT
- S-0-0187, List of configurable data in the AT

Data containers

For data exchange between master and drive there is a total of 8 data containers available. For each container the following distinction is made according to its content or direction of data transfer:

- Master → drive: Data container A: Command value-x
- Drive → master: Data container A: Actual value-x

☞ "x" represents a command/actual value from 1 to 8.

Configuration lists

The 8 multiplex channels are configured via 2 configuration lists (command value and actual value) per channel:

- In the "configuration list command value-x" lists (S-0-0370, …), the IDNs of those parameters are entered, the data of which are to be transmitted, depending on the setting in parameter "S-0-0368, Data container A: Addressing" (L-byte), to the "Data container A: Command value-x" (S-0-0360, …).
- In the "configuration list actual value-x" lists (S-0-0371, …), the IDNs of those parameters are entered, the data of which are to be transmitted, depending on the setting in parameter "S-0-0368, Data container A: Addressing" (H-byte), to the "Data container A: Command value-x" (S-0-0364, …).

☞ It is possible to define a maximum of 32 parameter IDNs in the configuration lists; but these lists can only be changed in communication phase 2 (parameter mode).

Addressing the data containers

Addressing the parameters to be transmitted

Parameter "S-0-0368, Data container A: Addressing" contains the indices for the selection of the parameters from the configuration lists, whose values are to be transmitted to the data containers (command values and actual values).

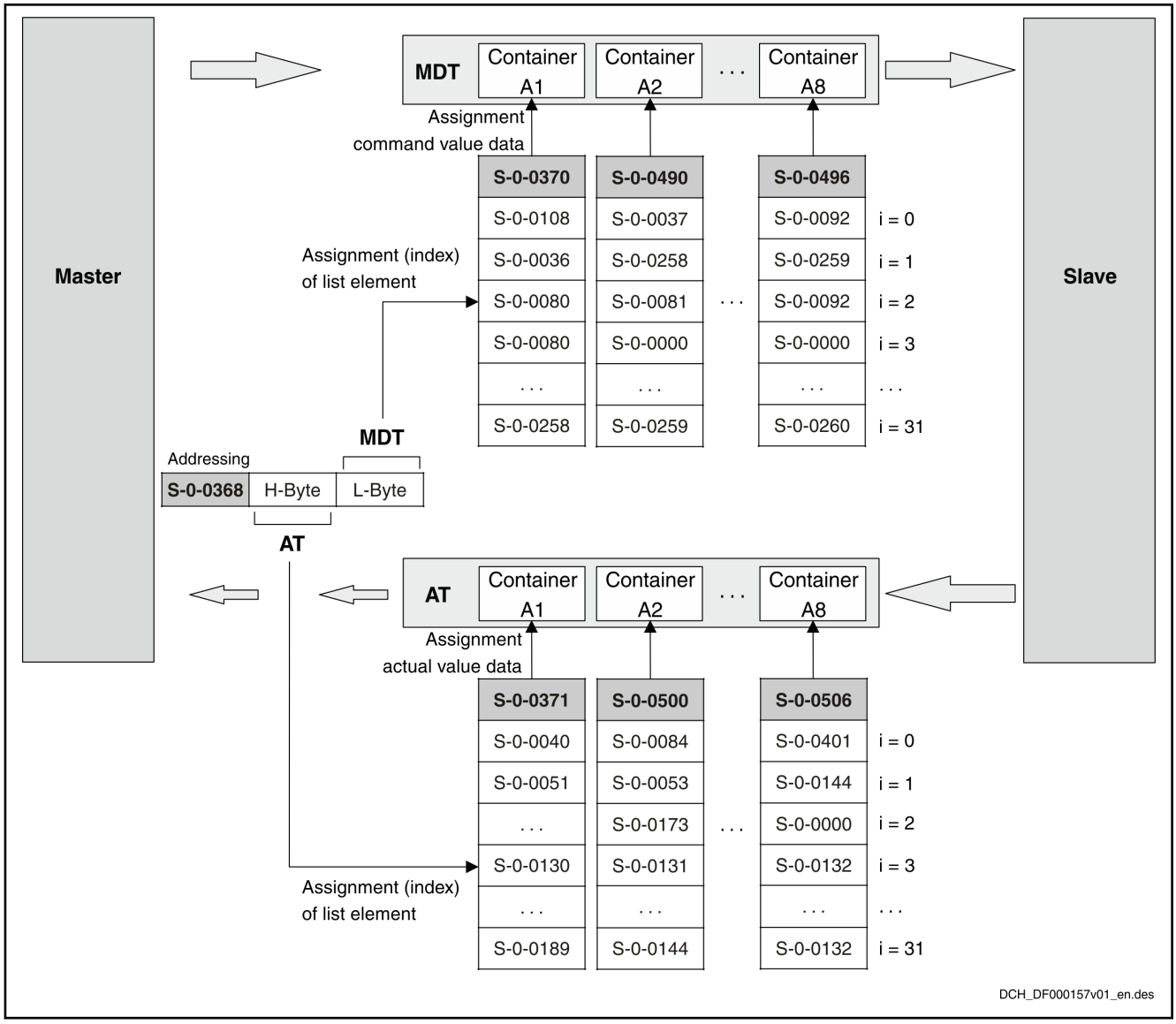
The following assignment applies to S-0-0368:

- Bit 0…4 → addressing for all data containers configured in the cyclic command value telegram (MDT)
- Bit 8…12 → addressing for all data containers configured in the cyclic actual value telegram (AT)



Only bits 0...4 (for MDT) and bits 8...12 (for AT) are used for addressing via parameter S-0-0368. The other bits are ignored. This is why no value greater than 31 can be set for addressing!

The figure below illustrates the relationship between addressing and assignment of parameter values to the data containers of the multiplex channel.



i	index (= list element no.)
S-0-0368	Data container A: Addressing
S-0-0370	Data container A: Configuration list command value-1
S-0-0490	Data container A: Configuration list command value 2
S-0-0496	Data container A: Configuration list command value 8
S-0-0371	Data container A: Configuration list actual value-1
S-0-0500	Data container A: Configuration list actual value 2
S-0-0506	Data container A: Configuration list actual value 8

Fig. 4-10: Addressing and assignment for multiplex channel

☞ The parameter "S-0-0368, Data container A: Addressing" can, depending on the requirements, be configured in the cyclic command value telegram or write-accessed via the non-cyclic data channel or some other interface.

Assigning individual list elements

The value (datum) transmitted in the data container is written to the determined target parameter; in this case we distinguish between single and list parameters.

In order to allow cyclic transmission or change of single elements in the case of list parameters, there are two more addressing parameters available:

- S-0-0362, Data container A: List index command values

  → Addressing elements of list parameters that have been entered as target for the content of command value data containers (for **write access**)

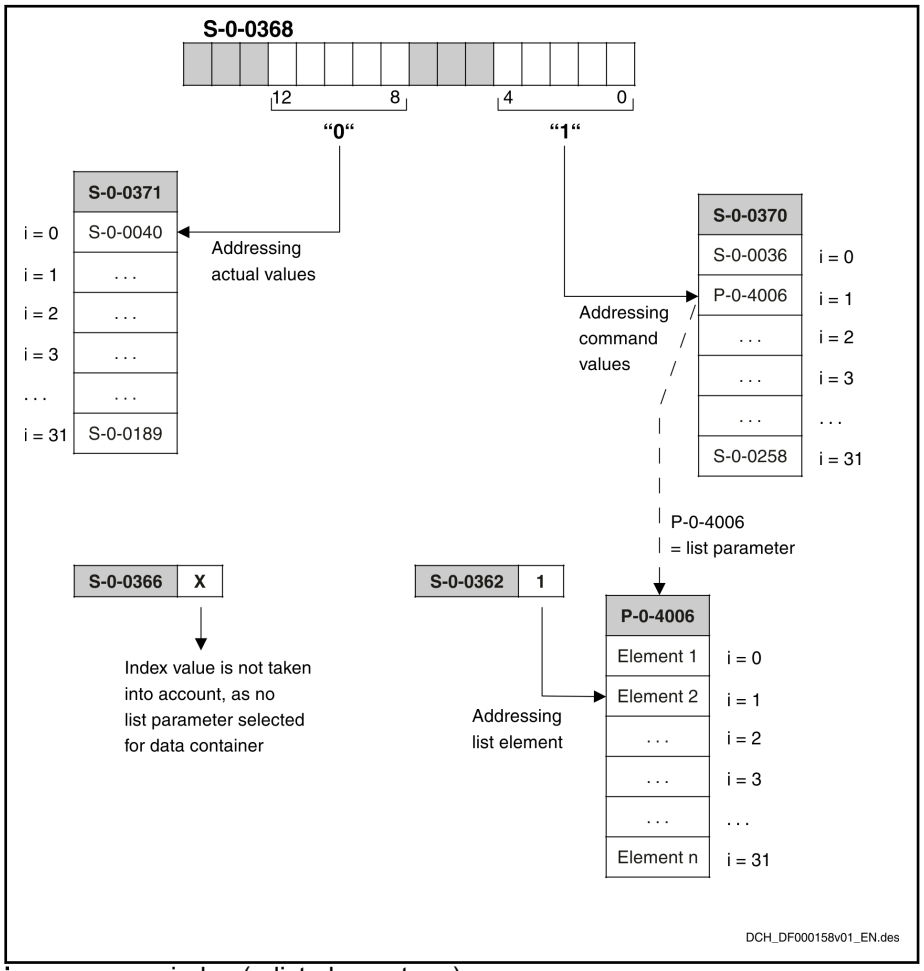
- S-0-0366, Data container A: List index feedback values

  → Addressing elements of list parameters that have been entered as source for the content of actual value data containers (for **read access**)



The parameters S-0-0362 and S-0-0366 only take effect when a list parameter is addressed as target/source for the content of the data container.

The figure below illustrates the access to an element of a list parameter for the multiplex channel.



i index (= list element no.)
S-0-0368 Data container A: Addressing
S-0-0362 Data container A: List index command values
S-0-0366 Data container A: List index actual values
S-0-0370 Data container A: Configuration list command value-1
S-0-0371 Data container A: Configuration list actual value-1
P-0-4006 Positioning block target position

Fig. 4-11: Access to elements of a list parameter via multiplex channel (example of command values → MDT data container)

Notes on commissioning

Activation

To use the function of the multiplex channel it is not necessary to take any measures for activation.

Data container A: Command value-x

For determining the target parameter to which the content (datum) of "data container A: Command value-x" (S-0-0360, …) is to be written, we distinguish between single and list parameters:

- **Single parameters**

  → The target parameter is determined by addressing (S-0-0368) in the relevant configuration list (S-0-0370, S-0-0490 to S-0-0496).

- **List parameters**

  → The element of the target parameter is determined by addressing (S-0-0368) in the relevant configuration list (S-0-0370, S-0-0490 to S-0-0496) and parameter "S-0-0362, Data container A: List index command values".

☞ The display format is hexadecimal without decimal places.

If the configuration list contains 16-bit parameters, only the lower 16 bits from the data container are used when a 16-bit parameter is addressed.

Data container A: Actual value-x

For determining the source parameter, the content (datum) of which is to be copied to the "data container A: Actual value-x" (S-0-0364, …), we also distinguish between single and list parameters:

- **Single parameters**

  → The source parameter is determined by addressing (S-0-0368) in the relevant configuration list (S-0-0371, S-0-0500 to S-0-0506).

- **List parameters**

  → The element of the source parameter is determined by addressing (S-0-0368) in the relevant configuration list (S-0-0371, S-0-0500 to S-0-0506) and parameter "S-0-0366, Data container A: List index feedback values".

☞ The display format is hexadecimal without decimal places.

If the configuration list contains 16-bit parameters, only the lower 16 bits are copied into the data container when a 16-bit parameter is addressed.

Diagnostic and status messages

In conjunction with the multiplex channel, various checks are carried out.

Checking the configured IDN order

The chronology of processing of cyclic command value data in the drive has the order in which the parameter IDNs of the configured list have been entered in parameter "S-0-0024, Configuration list of MDT".

If the parameters "data container A, command value-x" (S-0-0360, S-0-0450 to S-0-0456) and the parameter "S-0-0368, Data container A: Addressing" were configured in the cyclic command value telegram, the MDT data container is only processed correctly when addressing had been processed before.

To make sure the correct order is followed when configuring the cyclic command values, the drive, during the execution of "S-0-0127, C0100 Communication phase 3 transition check", checks whether IDN S-0-0368 was configured before the IDNs S-0-0360 or S-0-0450 to S-0-0456. If this is

not the case, the drive generates the error message "C0118, Order of cyclic command value configuration incorrect".

Checking the configuration lists

It has to be ensured that the IDN contained in the configuration lists are existing and the corresponding parameters can be cyclically configured.

Therefore, when "S-0-0127, C0100 Communication phase 3 transition check" is executed, a check is run to find out whether the entered IDNs are contained in the lists "S-0-0187, List of configurable data in the AT" or "S-0-0188, List of configurable data in the MDT".

There are the following possible error messages:

- If a **command value configuration list** contains one or several IDNs, which are not available or are not contained in "S-0-0188, List of configurable data in the MDT", the following error message is generated:
  - C0151, IDN for command value data container not allowed
- If a **command value configuration list** contains one or several IDNs, which are not available or are not contained in "S-0-0187, List of configurable data in the AT", the following error message is generated:
  - C0152, IDN for actual value data container not allowed

Checking the index

During the runtime, the drive monitors whether the index in parameter "S-0-0368, Data container A: Addressing" points to a non-initialized place in the MDT data containers or AT data containers.

According to the case that occurred, one of the following warning messages is generated:

- E4008, Invalid addressing command value data container A
- E4009, Invalid addressing actual value data container A

☞ These warning messages can only occur if fewer IDNs than possible at maximum are entered in the configuration lists.

4.3 Operation modes of master communication

4.3.1 Introduction and overview

Overview of operation modes and possibilities of command triggering

Command triggering for the drive can be carried out by an external control master (remote mode) or via the available inputs/outputs (local mode).

The figure below shows an overview of the various possibilities of drive command triggering.

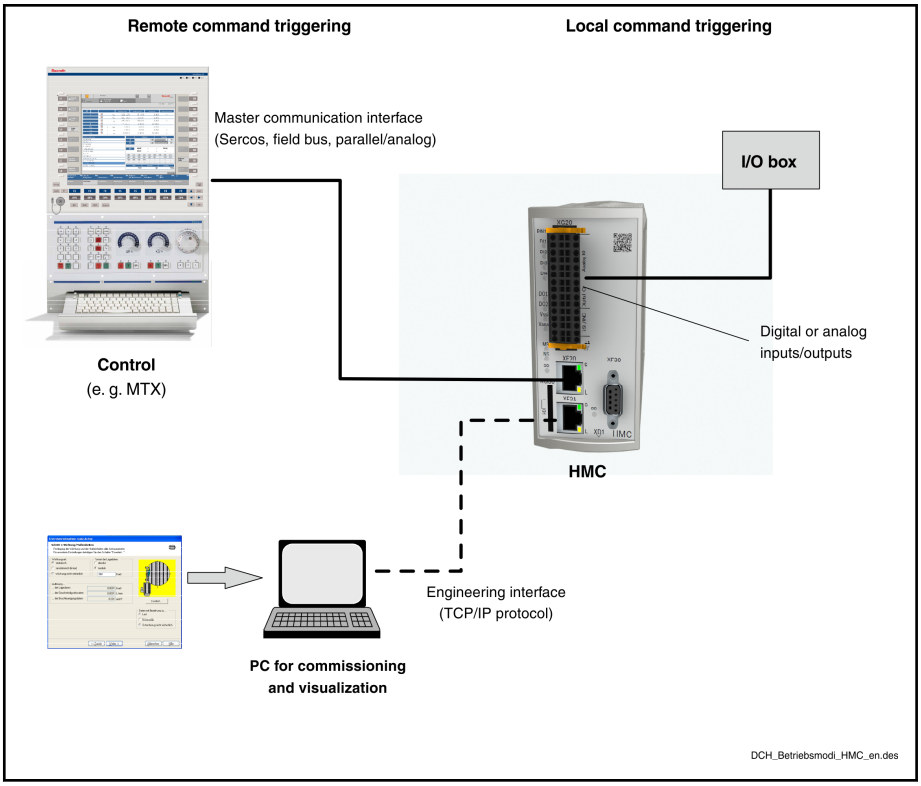


Fig. 4-12: Overview of possibilities of command triggering for an HMC control

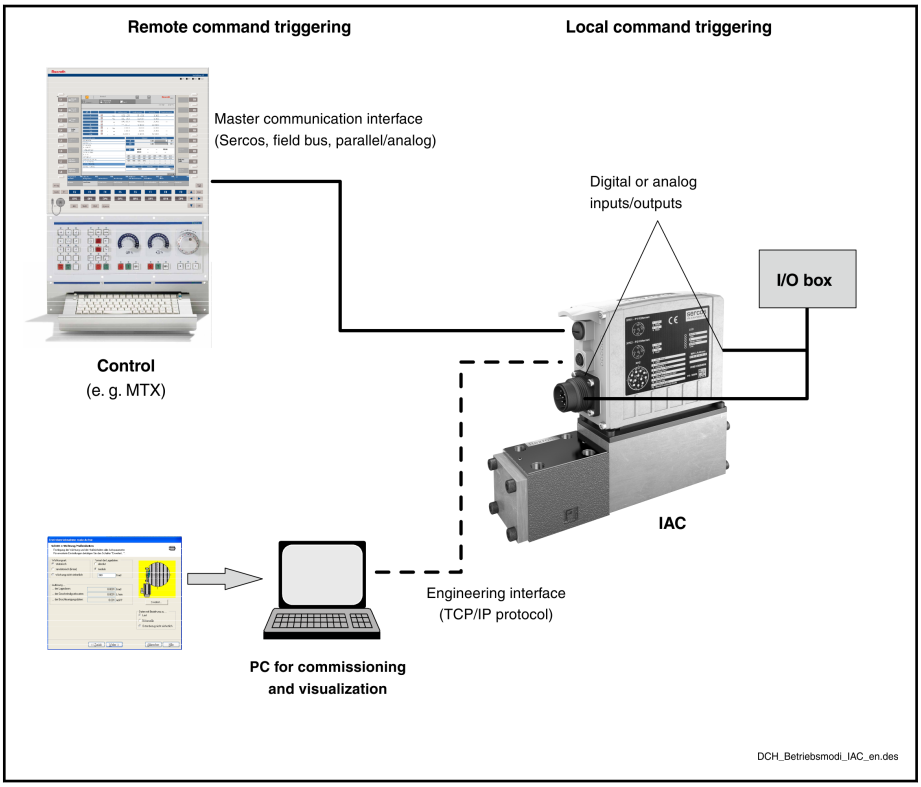


Fig. 4-13: Overview of possibilities of command triggering for an IAC control

Operation modes and changes of state

The overview below shows the basically possible operating states and the actions required for change/transition from one operation mode to the other.

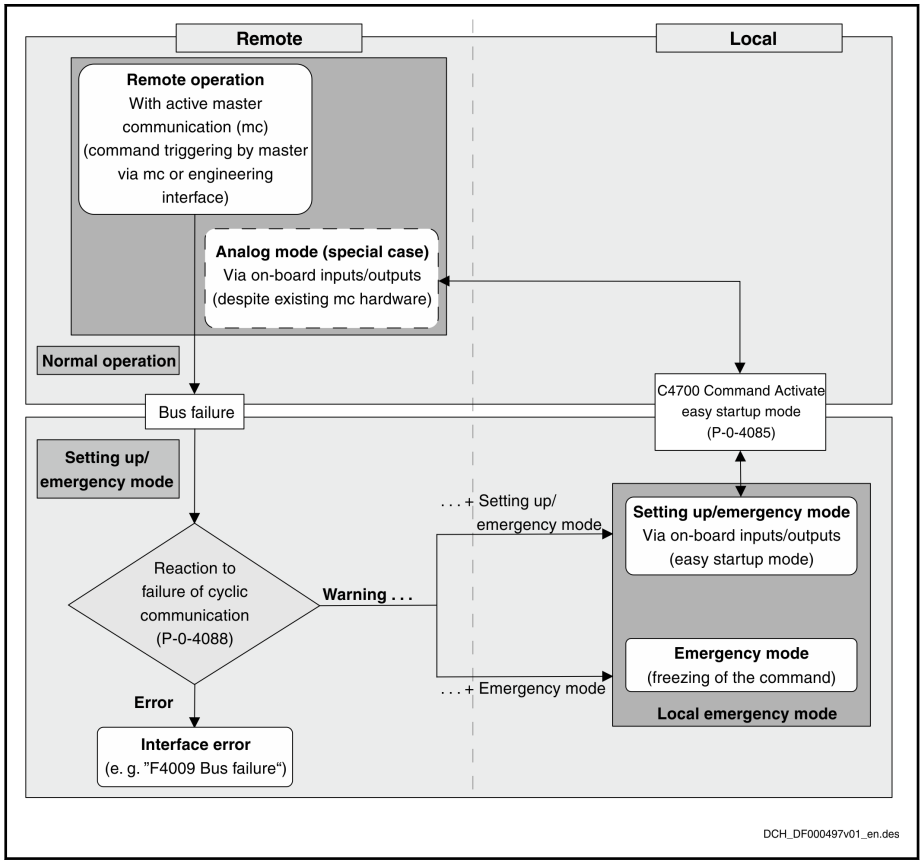


Fig. 4-14: Operating states and operation modes of master communication

Device control and state machine

Depending on the kind of master communication or setting of the device control, different control words take effect. Internally, however, all relevant control bits are always displayed in parameter "P-0-0116, Device control: Control word".



The actual state machines of master communication are described in the section "Device control and state machines"!

Normal operation (via internal or external control unit)

In so-called normal operation, command triggering for the drive takes place via an external control unit (e.g. IndraMotion MTX or MLC), with the following cases having to be distinguished:

- **Remote mode** with active master communication (standard case)

  → The axis is commanded via the master communication (Sercos, field bus, analog).

Local setting-up mode/emergency mode (easy startup mode)

During operation, the drive can, **situationally**, change to a local mode for setting up or for remedying an emergency (e.g. bus failure). We distinguish the following operating modes:

- **Setting-up mode** (easy startup mode)

  → For commissioning or the setting-up procedure, the drive can temporarily be moved via the inputs/outputs (digital and analog), independently of the external master.

- **Emergency mode** in the case of bus failure (freezing the last command values)

→ Even if the master communication fails, it is possible to continue operating the drive in an emergency mode via the (local) inputs/outputs at the device.

☞ For using the emergency mode, parameter "P-0-4088, Master communication: Drive configuration" has to be configured accordingly; the automatic activation of the easy startup mode can also be set in this parameter, if necessary.

4.3.2 Normal operation (remote or local)

Remote mode with external control unit and active master communication

In the standard case, command triggering for the axis takes place externally via the master communication ("remote"). In this case, command values and actual values are exchanged with the external control unit via the master communication interface (incl. control word and status word).

See description of the respective master communication:

- Sercos
- EtherCAT®
- VARAN
- EtherNet/IP(TM)
- PROFINET
- PROFIBUS-DP

When using field bus interfaces, also take the profile types for this type of master communication into account [see "Profile types (with field bus interfaces)"].

4.3.3 Setting-up mode (easy startup mode)

Brief description of easy startup mode

The setting-up mode as so-called easy startup mode allows moving the drive without connected or active control unit (or master communication master) or external command value box.

Fields of application

The easy startup mode is particularly suited for

- **initial commissioning** of individual axes without active master communication,
- maintaining a configurable **emergency mode** (local mode) when the internal or external control unit (or master communication) has failed

  See also section "Introduction and overview: Local setting-up mode/ emergency mode (easy startup mode)"

Features

The easy startup mode is characterized by the following features:

- **Activation/deactivation** of the easy startup mode:
  - by writing parameter "P-0-4085, C4700 Command Activate easy startup mode"
- **Command triggering** (axis control) via digital inputs/outputs by
  - predefined digital I/O configuration in operation mode "**direct valve control**" with a command value (default) that can be parameterized
  - freely configurable I/O configuration and operation mode with active Easy Startup Mode

  - selecting the **travel direction** (positive/negative) via digital input signals

- **Deactivating command triggering** by the master communication interface (see "P-0-4077, Field bus: Control word", "S-0-0134, Master control word")

Pertinent parameters

- S-0-0014, Interface status
- P-0-0120, Control word easy startup
- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-4085, C4700 Command Activate easy startup mode
- P-0-4086, Master communication status
- P-0-4088, Master communication: Drive configuration

Functional description of easy startup mode

In the setting-up mode (easy startup mode), the drive can be controlled either via the digital and analog inputs or via the engineering interface. Direct valve control is the default operation mode for easy startup. Depending on the derivative und functional packages, further secondary operation modes are available.

Control via digital or analog inputs

If the drive is to be controlled via the digital or analog inputs, the inputs are to be configured accordingly. The form and point of time of the configuration are set in parameter "P-0-4088, Master communication: Drive configuration":

- Automatically by activating the easy startup mode

- or -

- Manually before or after the easy startup mode is activated

Automatic configuration of the inputs

With automatic configuration of the inputs, the following actions are carried out:

- Deactivation of master communication interface and activation of drive enable in parameter "P-0-0120, Control word easy startup"
- Assignment of allocation of inputs

Manual configuration of the inputs

Necessary manual configuration of the digital/analog inputs (see also "Digital inputs/outputs" or "Analog inputs"):

- Connect 24 V/0 V voltage supply to respective terminals
- +24 V for activation of drive enable (P-0-0120, bit 15)

Alternatively, the following manual configurations can be set additionally:

- Direct valve control
- Presetting of the valve command value (P-0-1468)

Operating the drive via the engineering interface

The drive can also be controlled via the engineering interface over which it is possible to write command values apart from the control word.

The following has to be taken into account:

- "P-0-1468, PLC/setting-up mode, valve command value" must not have been assigned to an analog input
- Drive enable must not have been assigned to any digital input ("P-0-0120, Control word easy startup").

Notes on commissioning for easy startup mode

Requirements

The following requirements and conditions are to be fulfilled for using the easy startup mode:

- Master communication should not be active, as the easy startup mode switches off any possibly active command triggering via master communication!
- No error message may be present in the drive, not even a transition command error (C01xx, C02xx).
- The drive is to be ready for operation ("bb").
  - In the case of conventional field bus interfaces (e.g. PROFIBUS®), the drive is automatically ready for operation ("bb") after run-up, even if master communication is not active. In this way, the requirements for manual mode basically are always fulfilled!
  - With Sercos, EtherNet//IP™ interface, …, after run-up, the drive is **not ready for operation** if master communication is not active (e.g., communication phase "P-1" with Sercos).

Possibilities of activation

The easy startup mode is activated by starting "P-0-4085, C4700 Command Activate easy startup mode" in one of the following ways:

- **By setting a digital input** to which the command parameter "P-0-4085, C4700 Command Activate easy startup mode" has been configured
- **By writing the parameter "P-0-4085, C4700 Command Activate easy startup mode"** via master communication or via engineering interface
- **Automatically by internal command start** in the case of a bus failure, if configured accordingly (see "P-0-4088, Master communication: Drive configuration")

Activation via digital input

To activate the easy startup mode via a digital input, bit 0 of parameter P-0-4085 has to be assigned to a digital input.

See "Digital inputs/outputs"

Activation via engineering interface

To activate the easy startup mode via the engineering interface, parameter P-0-4085 is written via SIS telegrams.

☞ Parameter P-0-4085 can also be directly written via the master communication (e.g. Sercos or field bus), but this would cause the master to deactivate itself!

Acknowledgment of activation

The activation of the easy startup mode is acknowledged by:

- Setting bit 8 in parameter "P-0-4086, Master communication status"
- Clearing the bit "drive follows (ext.) command value input" in parameter P-0-0115 (bit 3)

☞ With active easy startup mode, the active operation mode is not acknowledged in the status word (see P-0-0115)!

Deactivating/exiting the easy startup mode

The easy startup mode is deactivated by completing the command execution. The command can be completed by writing parameter P-0-4085.

☞ After exiting the easy startup mode, the previously active status becomes active again. Command triggering for the drive again takes place via master communication (see P-0-4077, S-0-0134, …) and the originally active operation modes are executed.

Control parameter P-0-0120

Control parameter "P-0-0120, Control word easy startup" active in the easy startup mode can be changed or influenced in the following ways:

- Via digital inputs, if these were configured accordingly before

- Via the engineering interface by direct writing to parameter P-0-0120

  → In this case, the parameter has to be actively written at least every 2 s, otherwise the drive will automatically clear the controller enable!

Invalid commands

The commands for the backup of the working memory ("C2200 Backup working memory procedure command" and "C2400 Selectively backup working memory procedure command") are not to be triggered in the easy startup mode, because otherwise the settings of the easy startup mode will be stored in the non-volatile memory and active again when the drive is switched on the next time!

NOTICE

Risk of property damage during initial start in the easy startup mode caused by incorrect parameter values!

Before initial start in easy startup mode, the required controller parameters are to be checked!

Recommissioning

In the easy startup mode, recommissioning (after initial commissioning was carried out before) of drives is possible without any problem, because the correct values of the drive parameters are already available.

4.3.4 Local mode

Overview

During operation it is possible to change **situationally** to **digital and analog inputs/outputs of the controller** in a setting up or emergency operation mode:

- **Emergency operation (local mode)** in the case of bus failure → With the corresponding configuration, operation of the drive can be continued in an emergency mode, even if the master communication (field bus, Sercos …) has failed.

Emergency mode (when master communication has failed)

Behavior in case of bus failure

For bus failure (line interruption), bus stop or PLC stop, the reaction of the drive can be set in parameter "P-0-4088, Master communication: Drive configuration":

- **Bus failure as error**

  → The drive normally switches off, generates an interface error message (e.g. "F4009, Bus failure") and carries out the defined **error reaction** ("best possible deceleration").

- **Bus failure as warning**

  → In the case of bus failure, the drive does **not** react by switching off and generating an error message, but the state of last command triggering is maintained (command value and control word are "frozen") or the easy startup mode is automatically activated and the warning "E4005, No command value input via master communication" is output.

See also section "Setting-up mode (easy startup mode)"

See also parameter description "P-0-4088, Master communication: Drive configuration"

NOTICE **Property damage caused by errors when activating drives and moving parts!**

If bus failure has been configured as a warning, the E-Stop input is to be wired on the drive. Deactivating the drive via master communication is no longer possible.

Status display Parameter "S-0-0014, Interface status" displays the current status of the master communication interface.

4.3.5 Notes on commissioning and utilization

Using the operating mode

The table below summarizes the different operation modes of master communication, their operation criteria and activation.

Place of command triggering	Mode	Use	Execution of command triggering	Activation	Operation modes	Note
Control unit (remote)	**Master comm. mode** (remote)	Field bus or Sercos device is operated as usual via existing interface of master communication	Via external control unit (bus or inputs/ outputs)	Not required	Standard operation modes 0...7 take effect and can be selected	Standard case
	Special case: Analog mode	Field bus device can be permanently operated as analog drive, if master comm. option is deactivated (for use of obsolete electronics or emergency mode without master)	Only via digital onboard inputs/ outputs and analog inputs	Configuration of parameter P-0-4088 **Note:** Activation requires complete booting process	Standard operation modes 0...7 take effect and can be defined as required according to the specific application	Special case in which master communication option exists, but is not active
Local	**Setting-up mode**	Setting-up and commissioning of axes, even without running master	Via digital inputs/outputs or acyclic channel with "IndraWorks Ds /D/MLD"	Command "Easy startup mode"	Internal operation modes 8…12 take effect **Note:** Operation modes 8…12 have been permanently configured	
	Emergency mode	Moving of the axes when master communication fails	Via digital inputs/outputs or acyclic channel with "IndraWorks Ds /D/MLD"	"Easy startup mode" command, can be manually started in the case of bus failure	The operation modes last active take effect (0...7)	Control via activation of easy startup mode is possible

Master comm. option Hardware option for master communication

Tab. 4-3: Criteria for use of the operation modes

Control words of the operation modes and master communications

Depending on the operation mode or master communication used, different control words take effect; they are shown in the figure below.

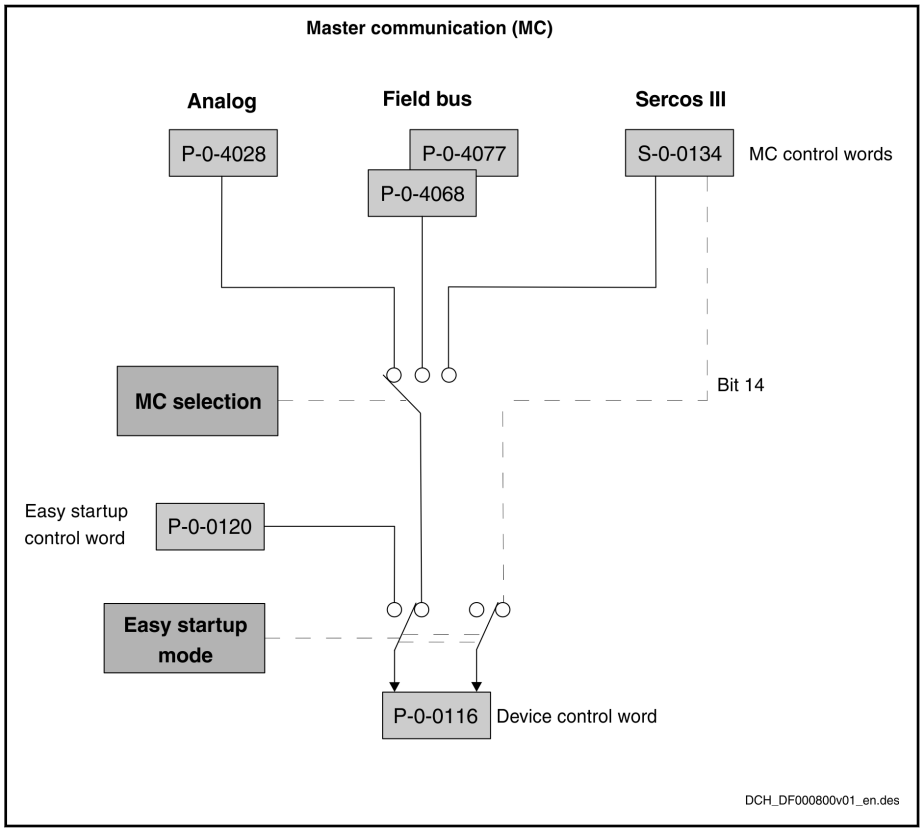


Fig. 4-15: Overview of control words of operation modes and master communication

Special cases of operation with external control unit

For operation via external master communication, the following special case exists:

- EtherNet/IP™ communication via the engineering interface

Observe the following aspects for **commissioning and utilization**:

- Deactivation of master communication and activation of the analog mode take place in the parameter "P-0-4088, Master communication: Drive configuration".
- The configuration will only take effect after re-booting, i.e. the control voltage of the drive controller must be switched off and on again.
- In order to control the device via the digital inputs, the drive enable signal, among others, needs to be assigned (see parameter description "P-0-0120, Control word easy startup") to a digital input of the control section.

  See "Digital inputs/outputs"
- The operation mode of the axis can be freely selected, but in the analog mode only the operation modes "velocity control" and "positioning block mode" can be practically used.

  See "Velocity control" and "Positioning block mode"

4.4 Profile types (with field bus interfaces)

4.4.1 Brief description

Supported profile types, overview

When a field bus interface is used for master communication, HydraulicDrives support the following profile types (modes):

- "No profile"
- Analog
- I/O mode positioning
- I/O mode preset velocity
- Freely configurable mode
- Fluid Power CiA408
- Servodrive profile
- Drives and motion control device profile CiA402

Profile type: "No profile"			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0x0000	PROFIBUS® PROFINET® EtherNet/IP™ EtherCAT (CoE) Ethernet POWERLINK	• With the profile type "No profile", all settings relevant to the profile type are deactivated • The profile type "No profile" is mainly relevant to MLD applications with "permanent control" on the axis	• Profile type without field bus control word and field bus status word • Real-time data can be freely configured • Operation mode can be freely selected

Tab. 4-4: Profile type "No profile"

Profile type: "Analog"			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xFF00	Master communication inactive PROFIBUS® PROFINET® EtherNet/IP™ EtherCAT (CoE) Ethernet POWERLINK	• Profile type "analog" is mainly relevant for operation without master communication	• Use of control word P-0-4028 • Command values via analog assignments or via master communication

Tab. 4-5: Profile type "analog"

Profile type: "I/O mode positioning"			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xFF82	PROFIBUS® PROFINET® EtherNet/IP™ EtherCAT (CoE) Ethernet POWERLINK	• I/O mode positioning (Positioning block mode, encoder 1, lagless)	• Up to 64 positioning blocks can be controlled over field bus • Further real-time data can be configured (in P-0-4080 and P-0-4081) besides control and status words • Bits can be freely defined in signal status word via "configurable signal status word" function

Tab. 4-6: Profile type "I/O mode positioning"

Profile type: I/O mode preset velocity			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xFF92	PROFIBUS® PROFINET® EtherNet/IP™ EtherCAT (CoE) Ethernet POWERLINK	• I/O mode preset velocity	• Fixed velocity command values can be controlled and ramp generator can be operated via field bus • Apart from control and status word, other real-time data can be configured (in P-0-4080 and P-0-4081) • Bits can be freely defined in signal status word via "configurable signal status word" function

Tab. 4-7: Profile type "I/O mode preset velocity"

Profile type: Freely configurable mode			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xFFFE	PROFIBUS® PROFINET® EtherNet/IP™ EtherCAT (CoE) Ethernet POWERLINK	Freely configurable mode (Default assignment is "drive-controlled positioning" with cyclic data required accordingly)	• Possible use of complete drive functionality by free configuration of real-time data and operation mode selection • Control word and status word have a Rexroth-specific structure • Selection suited for operation with analog command values in commissioning phase

Tab. 4-8: Profile type "freely configurable mode"

Profile type: Freely configurable mode operation mode neutral			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xFFFD	Like profile 0xFFFE, but reduced field bus control word		

Tab. 4-9: Profile type "freely configurable mode "operation mode neutral""

Profile type: Fluid Power CiA408			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0x0113	EtherCAT (CoE) Ethernet POWERLINK	• Profile type "Fluid Power" for use of CANopen-based bus systems • Only available with functional package "Open Loop" • All "Open Loop" operation modes possible	• Use of the individual Fluid Power control and status words P-0-4094.0.1 and P-0-4094.0.2 • Free configuration of cyclic data

Tab. 4-10: Profile type "Fluid Power CiA408"

Profile type: Servodrive			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0x0114	VARAN EtherCAT (SoE) Ethernet POWERLINK	• Profile type "Servo drive profile" for use of Servodrive profile over EtherCAT and VARAN	• Use of control and status words S-0-0134 and S-0-0135 • Free configuration of cyclic data

Tab. 4-11: Profile type "Servodrive"

Profile type: Servodrive without evaluation of "drive enable" bit			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xF002	Device behavior, status and control word as with profile 0x0114. **S-0-0134, bit 14 (enable) is not evaluated!**		

Tab. 4-12: Profile type "Servodrive without evaluation bit "drive enable""

Profile type: Drives and motion control device profile CiA402			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0x0402	EtherCAT (CoE) Ethernet POWERLINK	• Profile type CiA402 for use of CANopen-based bus systems	• Use of objects 0x6040 / 0x6041 according to CiA402

Tab. 4-13: Profile type "Drives and motion control device profile CiA402"

Profile type: FSP Drive (Sercos-III profile)			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0x0102	Sercos	Profile type "FSP Drive"	• Use of control and status words S-0-0134 and S-0-0135 • Free configuration of cyclic data

Tab. 4-14: Profile type "FSP Drive (Sercos-III profile)"

Profile type: FSP Drive without evaluation bit "drive enable"			
Content of "P-0-4084, Application: Profile type"	**Master communication**	**Field bus or drive operation mode**	**Features**
0xF102	Device behavior, status and control word as with profile 0x0102. **S-0-0134, bit 14 (enable) is not evaluated!**		

Tab. 4-15: Profile type "FSP Drive without evaluation bit "drive enable""

Change profile type of the axis

Drive profile

To change the profile type of the axis, the value of the requested profile has to be written to parameter "P-0-4084".

Parameter "P-0-4084.0.1, List of available profile types" shows, which profiles are available in the current configuration of the drive. The default profile can be read from the drive by means of "P-0-4084.0.2, Default profile".

If a profile type is selected, which is not permitted for the active master communication, error "C0203, Parameter conversion error (->S-0-0423)" occurs when changing over from PM → OM takes place.

If profiles are switched, which forces the activation of new parameters and deactivation of current parameters, the drive needs to be restarted. An attempt to switch to "OM" without a restart causes command error "C0299, Configuration changed. Restart".

Example:

Switching from profile type "I/O modus positioning" to"freely configurable mode"

→ no restart required

Switching from profile type "freely configurable mode" to "CiA402 DrivePro-file"

→ restart required

Pertinent parameters

- P-0-4083.0.2, Application: Allocation of object ID to Sercos EIDN
- P-0-4083.0.3, Master communication: Allocation object ID to Sercos EIDN
- P-0-4084, Application: Profile type
- P-0-4084.0.1, List of available profile types
- P-0-4084.0.2, Default profile

4.4.2 Profile type “no profile”

I/O mode (positioning and preset velocity)

Brief description

We distinguish the following variants of the "I/O mode" profile type:

- I/O mode positioning
- I/O mode preset velocity (e.g. for open-loop applications)

General features

The I/O mode is characterized by the following features:

- Optional parameter channel can be activated, if required, via "P-0-4083, Parameter channel: Length", (max. 8 words)

  Default: P-0-4083 = 0 → without parameter channel
- Real-time channel consists of at least one word (16 bits), the field bus control word (P-0-4068) and the signal status word (S-0-0144)
- Freely expandable real-time channel by configuration of real-time data:
  - **Master → slave** (drive)

    → Configuration of "P-0-4081, Field bus: Config. list of cyclic command value data ch."
  - **Slave → master** (drive)

    → Configuration of "P-0-4080, Field bus: Config. list of cyclic actual value data ch."
- Freely configurable field bus status word (cf. S-0-0144)
- Relationship between profile type selection and effective operation mode
  - In the **I/O modes**, there is a determined relationship between profile type (P-0-4084) and predefined primary operation mode (S-0-0032).
  - The **freely configurable mode** allows free selection of the operation modes (S-0-0032, S-0-0033, …).

☞ The respective default settings are activated by selecting the profile type and subsequent action "load default communication parameters" (see also P-0-4090 and S-0-0262).

Structure of the real-time channel

Data direction	Word1	Format
Master → slave	P-0-4068, Field bus: Control word IO	u16 (1 word)
Slave → master	S-0-0144, Signal status word	u16 (1 word)

Tab. 4-16: Structure of the real-time channel for the I/O modes

Features "I/O mode positioning"

Specific features of "I/O mode positioning":

- The drive is operated in the "positioning block mode, lagless, encoder 1" (see also description of the operation mode "Positioning block mode").
- In this operation mode, 64 programmable positioning blocks can be selected and started via 6 bits (in the 16-bit wide control word).
- The jog function can be activated in "P-0-4068, Field bus: Control word IO". "Drive-controlled positioning" was set as the 1st secondary operation mode (see also description of the operation mode "Drive-controlled positioning").

Features "I/O mode preset velocity"

Specific features of "I/O mode preset velocity":

- The drive is operated in the "velocity control" mode (see also description of the operation mode "Velocity control").
- In this operation mode, for example, 5 programmable fixed velocity command values (in the 16-bit wide control word) can be selected and started, and the function of the ramp generator can be operated.

State machine in I/O mode

Interaction of control and status bits (state machine):

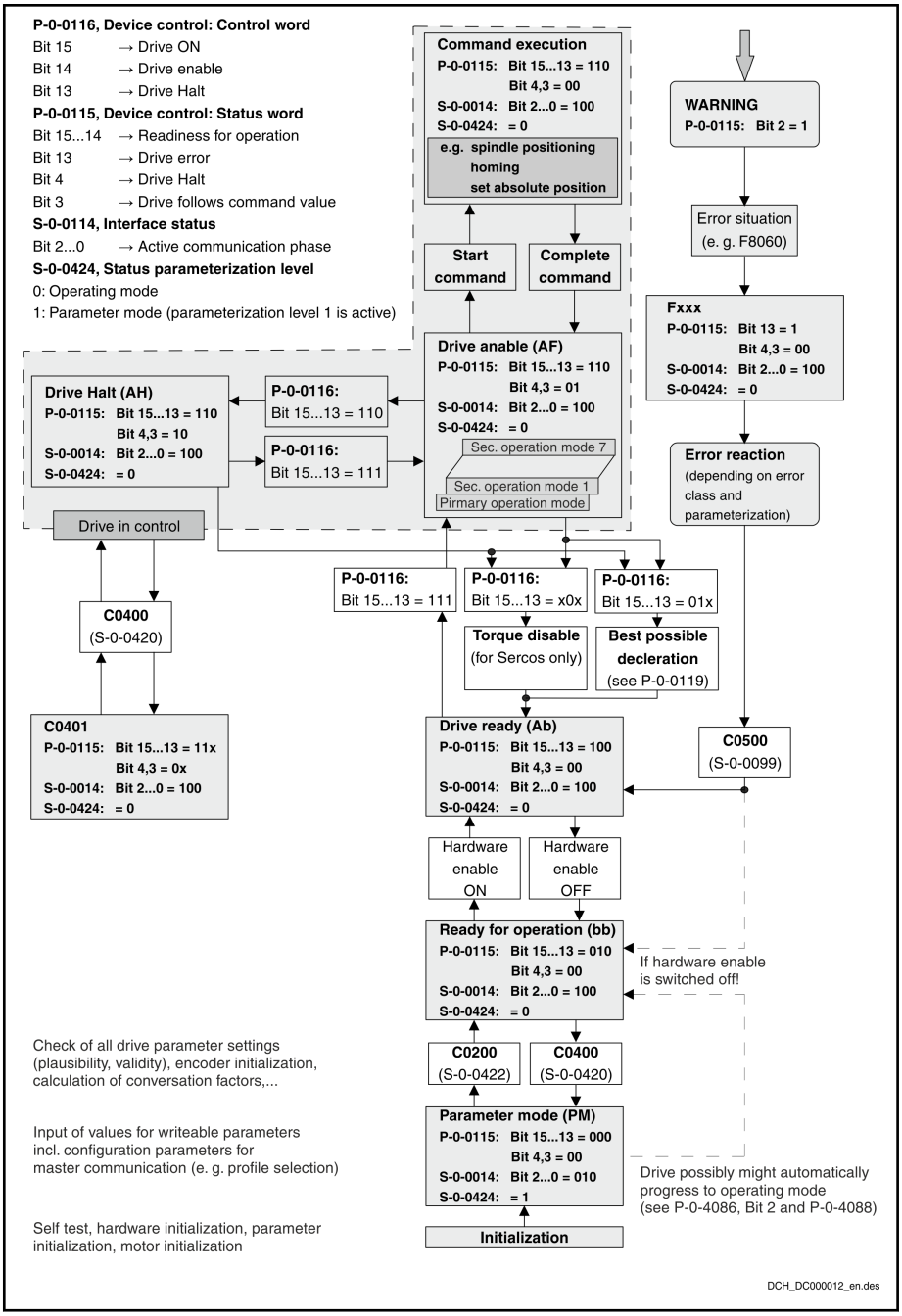


Fig. 4-16: Device control of variants of I/O mode (state machine)

The figure illustrates the status word (S-0-0144) in its default configuration. If required, it can be optionally configured.

NOTICE **Automatic restart after bus failure!**

In the case of bus failure (message "F4009" or "E4005"), an error reaction is to be carried out in the control unit, too, to prevent automatic restart after the bus has been restored. This means that in the case of bus failure, the bits "Drive Halt", "Drive enable" and "Drive ON" (e.g. bits 13, 14 and 15 in parameter"P-0-4077, Field bus: Control word") or bits 0 and 1 in parameter "P-0-4068, Field bus: Control word IO", is to be reset in the control unit.

Field bus control word in I/O mode

The bits in parameter "P-0-4068, Field bus: Control word IO", are fixed by the manufacturer and cannot be changed by the user. If additional control bits are required, parameter "S-0-0145, Signal control word" has to be configured accordingly and transmitted to the real-time channel of the field bus.

See parameter description "P-0-4068, Field bus: Control word IO"

See parameter description "S-0-0145, Signal control word"

Signal status word in I/O mode

- In the I/O modes (P-0-4084 = 0xFF82 or 0xFF92), parameter "S-0-0144, Signal status word" is transmitted instead of the field bus status word (P-0-4078). The configuration of S-0-0144 is given by default setting (see below).
- According to the selected I/O profile type, there is a different default configuration for S-0-0144 (see below).

The tables below show the two default configurations for S-0-0144 which depend on the profile type:

Bit	Pin assignment	Meaning
0	Active operation mode	**1:** Jogging (S-0-0437) **0:** Positioning
1	Position switch point (PSP)	**1:** To the right of PSP **0:** To the left of PSP (S-0-0060)
2	In reference	**1:** Drive has been homed (S-0-0403)
3	In motion	**0:** In motion (S-0-0331)
4	In position	**1:** Drive is in positioning window & no sequential block (P-0-4061)
5	Drive error (error flag)	**1:** Error (P-0-0115) **0:** No error
6	Readiness for operation	**1:** Ready for operation (P-0-0115)
7	Power switched on	**1:** Power switched on (P-0-0115)
13…8	Positioning block acknowledgment	P-0-4051, Positioning block acknowledgment
15…14	Not assigned	

Tab. 4-17: Default assignment of parameter "S-0-0144, Signal status word" for "I/O mode positioning" (P-0-4084 = 0xFF82)

Bit	Pin assignment	Meaning
0	Status of ramp generator	**1:** Run-up stop active (P-0-1210, bit 1)
1	Status of ramp generator	**1:** Accelerating active (P-0-1210, bit 2)
2	Status of ramp generator	**1:** Decelerating active (P-0-1210, bit 3)
3	In motion	**1:** Message n_feedback = 0 (S-0-0331, bit 0)

Bit	Pin assignment	Meaning
4	Status of ramp generator	1: Command value reached (P-0-1210, bit 0)
5	Drive error (error flag)	1: Error (P-0-0115) 0: No error
6	Readiness for operation	1: Ready for operation (P-0-0115)
7	Power switched on	1: Power switched on (P-0-0115)
8	Status of ramp generator	1: Command value within suppression window P-0-1210, bit 4)
9	Status of ramp generator	1: V-ramp within suppression window (P-0-1210, bit 5)
15...10	Not assigned	

Tab. 4-18: Default assignment of parameter "S-0-0144, Signal status word" for "I/O mode velocity" (P-0-4084 = 0xFF92)

☞ As the parameter "S-0-0144, Signal status word" is already used as field bus status word in the I/O mode, it cannot be configured again in the cyclic channel.

See also parameter description "S-0-0144, Signal status word"

Notes on parameterization/commissioning

Features with default configuration

The following definitions apply to the default setting in the I/O modes:

- Fixed real-time channel length of 2 bytes. Thus, the length of the real-time channel corresponds to the length of the cyclic data channel (P-0-4082 = P-0-4071 = 2)!
- "P-0-4068, Field bus: Control word IO" and "S-0-0144, Signal status word" have been set to the default configuration described above.
- In the real-time channel, only "P-0-4068, Field bus: Control word IO" and "S-0-0144, Signal status word" are transmitted.

Features/settings with free configuration or extension

There are the following possibilities for free configuration/extension:

- The user can freely expand the length of cyclic data channel P-0-4082 and P-0-4071 up to a maximum of 23 words. In addition to control word and status word, other real-time data can be configured via the parameters "P-0-4080, Field bus: Config. list of cyclic actual value data ch." and "P-0-4081, Field bus: Config. list of cyclic command value data ch.".
- The content of

  "S-0-0144, Signal status word" can be freely parameterized via "S-0-0026, Configuration list for signal status word" and "S-0-0328, Assign list signal status word".
- The content of "S-0-0145, Signal control word" can be freely parameterized via "S-0-0027, Configuration list for signal control word" and "S-0-0329, Assign list signal control word".

4.4.3 Fluid Power profile

Brief description

General information

General information

If the field bus interface is used for master communication, the device function is supported by the drive according to VDMA Fluid Power Profile, Version 1.6 and CiA408 Fluid Power Profile.

Device function, status and control word as well as cyclic communication are implemented according to the profile. In order to ensure that all communication objects (profile-defined and manufacturer-specific) can be displayed in a uniform format, no support of profile-conforming parameters (0x6000 ff) was provided. All communication objects can be accessed in uniform formats via manufacturer-specific objects (refer to "Manufacturer-Specific Objects (0x2000 to 0x3FFF)").

The table below contains an overview of the most important properties and features of the profile.

“Fluid Power” profile			
Content of “P-0-4084, Field bus: Profile type“	Master communication	Field bus or drive operation mode	Features
0x0113	CAN application layer over EtherCAT, CoE	Fluid Power profile	Apart from control and status word, other real-time data can be configured (in P-0-4080 Field bus: Config. list of cyclic actual value data ch. and P-0-4081 Field bus: Config. list of cyclic command value data ch.)

Tab. 4-19: "Fluid Power" profile type

General features

The Fluid Power profile is characterized by the following features:

- Real-time channel consisting of at least one 4-byte parameter, P-0-4094.0.1, Field bus: control word Fluid Power, and P-0-4094.0.2, Field bus: status word fluid power.
- Maximum number of payload data per real-time channel (including Fluid Power control or status word):

Bus clock cycle	Max. length of cyclic payload data
>= 2 ms	48 bytes
>= 1 ms	32 bytes
0.5 ms	16 bytes

- Freely expandable real-time channel by configuration of real-time data:

  Master → slave (drive) configuration of "P-0-4081, Field bus: Config. list of cyclic command value data ch."

  Slave (drive) → master configuration of "P-0-4080, Field bus: Config. list of cyclic actual value data ch."



The respective default settings are activated by selecting the profile type (in "P-0-4084, Application: Profile type") and subsequent action “load default communication parameters” (see also "P-0-4090, Configuration for loading default values" and "S-0-0262, C07_x Load defaults procedure command").

Structure of the real-time channel

Data direction	Parameter 1	Format
Master → slave	P-0-4094.0.1, Field bus: control word fluid power	u32
Slave → master	P-0-4094.0.2, Field bus: status word fluid power	u32

Tab. 4-20: Structure of the real-time channel of the Fluid Power profile

Abbreviations used

- **u32:** 32-bit variable without sign (2 words) in Intel format

Pertinent parameters

P-0-4071, Field bus: Length of cyclic command value data channel
P-0-4073, Field bus: Diagnostic message
P-0-4074, Field bus: Data format
P-0-4080, Field bus: Config. list of cyclic actual value data ch.
P-0-4081, Field bus: Config. list of cyclic command value data ch.
P-0-4082, Field bus: Length of cyclic actual value data channel
P-0-4084, Application: Profile type
P-0-4088, Master communication: Drive configuration
P-0-4089.0.1, Master communication: Protocol
P-0-4094.0.1, Field bus: control word fluid power
P-0-4094.0.2, Field bus: status word fluid power

State machine in Fluid Power profile

When the Fluid Power profile is activated, the drive behaves according to the following state machine:

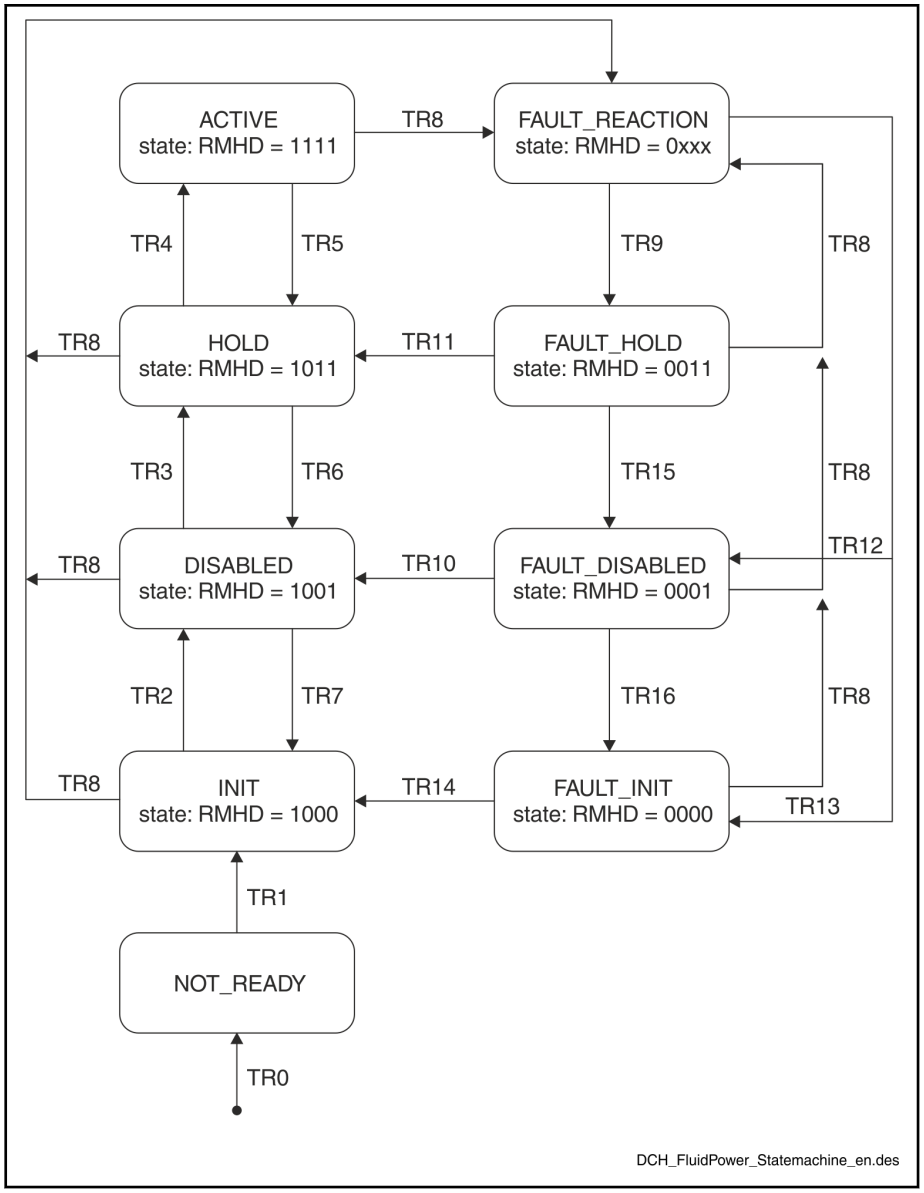


Fig. 4-17: Fluid Power state machine

States of the Fluid Power state machine

State/change in state	Description
NOT_READY	When the drive is activated, it runs through the state NOT_READY. Here, basic initializations are performed. After these are complete, the drive automatically changes to state INIT.
INIT	After the drive is switched on and basic initialization is completed, it automatically switches to state INIT. In this state, basic initializations are completed. The drive is waiting for data from the control system.
DISABLED	The drive is in status "Disabled".
HOLD	The drive is in status Drive Halt (AH) and already in control.

ACTIVE	The drive is in status Drive Enable (AF) and follows the input of command values from the control unit.
FAULT_INIT	Error condition
FAULT_DISABLED	Error condition
FAULT_HOLD	Error condition
FAULT_REACTION	Depending on the state in which the error was detected, a corresponding error reaction is performed. Afterwards the drive switches to one of the FAULT_xxx states.

Tab. 4-21: States of the Fluid Power state machine

The behavior of the drive is controlled by RMHD bits in the Fluid Power control word (P-0-4094.0.1, Field bus: control word fluid power, bit 0..3)

The drive reports the status of the Fluid Power state machine via the RMHD bits in the Fluid Power status word (P-0-4094.0.2, Field bus: status word fluid power, bit 0..3).

Bit	Control word		Status word	
3	R	Reset fault (R)	R	Ready (R)
2	M	Device mode active enable (M)	M	Device mode active enable (M)
1	H	Hold enable (H)	H	Hold enable (H)
0	D	Disabled (D)	D	Disabled (D)

Tab. 4-22: RMHD bits

Device control commands

The control unit can control the states of the drive. For this, several transitions are implemented in the drive. These are triggered by special bits (RMHD) in the Fluid Power control word “P-0-4094.0.1, Field bus: control word fluid power“.

Important transitions of the Fluid Power state machine

Transition	RMHD bits	Description
TR2 activate DISABLED	xxx1	Transition from status INIT to DISABLED
TR3 activate HOLD	xx11	Transition from status DISABLED to HOLD
TR4 activate ACTIVE	x111	Transition from status HOLD to ACTIVE
TR5 de-activate ACTIVE	x0xx	Transition from ACTIVE to HOLD
TR6 de-activate HOLD	x00x	Transition from HOLD to DISABLED
TR7 de-activate DISABLED	x000	Transition from DISABLED to INIT
TR10 reset FAULT_DISABLED	0001 → 1001 (edge of R)	Transition from FAULT_DISABLED to DISABLED
TR11 reset FAULT_HOLD	0011 → 1011 (edge of R)	Transition from FAULT_HOLD to HOLD
TR14 reset FAULT_INIT	0000 → 1000 (edge of R)	Transition from FAULT_INIT to INIT
TR15 FAULT_HOLD to FAULT_DISABLED	x001	Transition from FAULT_HOLD to FAULT_DISABLED
TR16 FAULT_DISABLED to FAULT_INIT	x000	Transition from FAULT_DISABLED to FAULT_INIT

Tab. 4-23: Table of transitions of the internal state machine

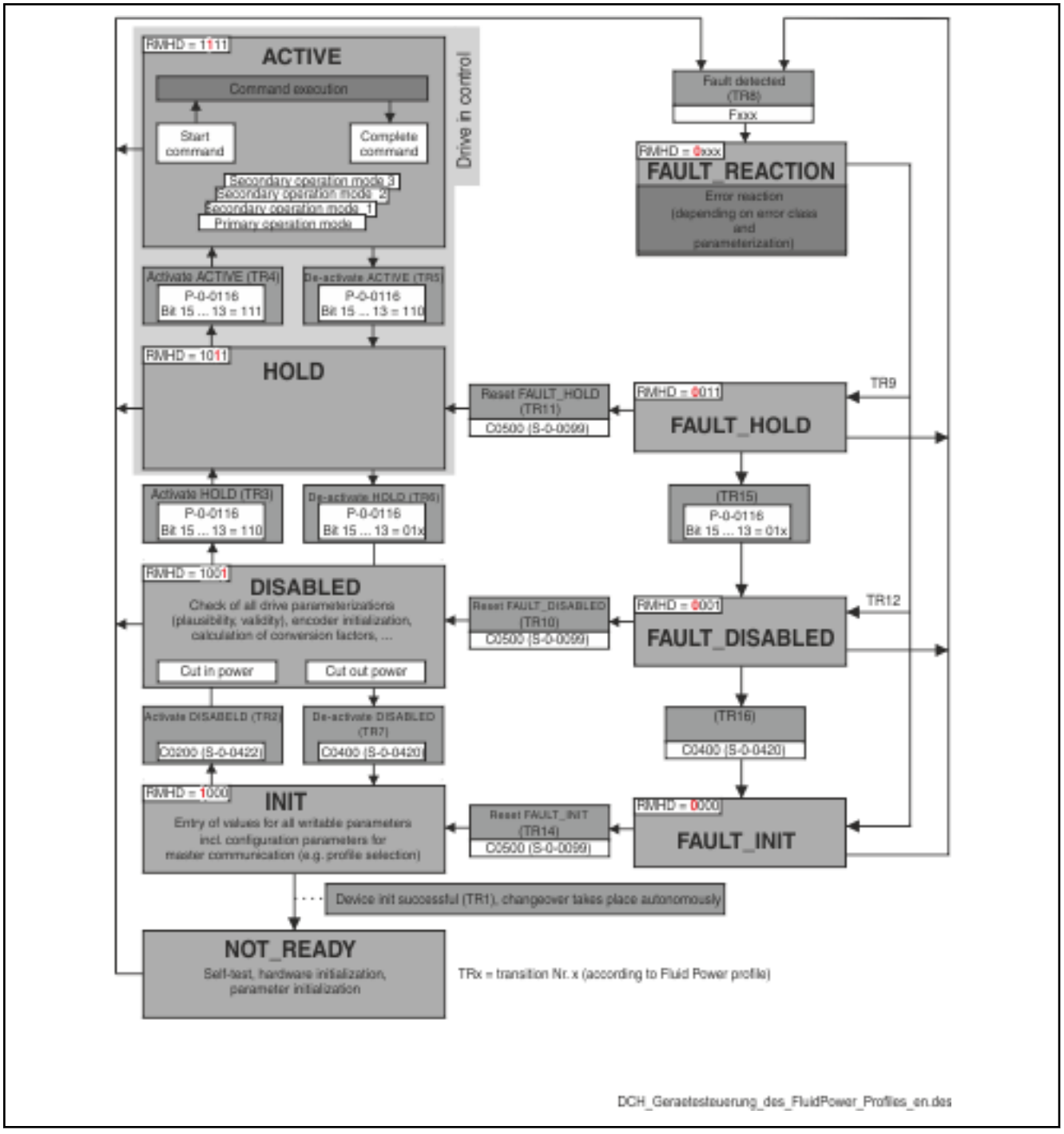


Fig. 4-18: Device control of the Fluid Power profile (state machine)

Automatic restart after bus failure!

In the case of a bus failure (message "F4009" or "E4005"), an error reaction is to be carried out in the control unit, too, to prevent automatic restart after the bus has been restored. This means, in the case of a bus failure, the bits "disabled (D)", "hold enable (H)" and "device mode active (M)" (bits 1..3 in parameter "P-0-4094.0.1, Field bus: control word fluid power") should be reset in the control unit.

Notes on parameterization/commissioning

In order to successfully communicate with the drive via Fluid Power profile, the following parameters are to be set to the listed values.

Parameter	Designation	Value
P-0-4080	Field bus: Config. list of cyclic actual value data ch.	0: P-0-4094.0.2 x: cyclic actual values
P-0-4081	Field bus: Config. list of cyclic command value data ch.	0: P-0-4094.0.1 x: cycl. command values
P-0-4084	Field bus: Profile type	0x0113 (= Fluid Power profile)
P-0-4088	Master communication: Drive configuration	Bit 0 = 1
P-0-4089.0.1	Master communication: Protocol	Bit 8 (= CAN application layer over EtherCAT, CoE)

Tab. 4-24: Parameter settings with Fluid Power

Additional informal parameters

Parameter	Designation	Value
P-0-4073	Field bus: Diagnostics	Shows the current state of the Fluid Power state machine in plain text (only from communication status Operational, otherwise current state of the communication state machine CiA301)
P-0-4094.0.1	Field bus: control word Fluid Power	Fluid Power control word
P-0-4094.0.2	Field bus: status word Fluid Power	Fluid Power status word

Tab. 4-25: Additional informal parameters of Fluid Power

When the drive is switched on, it is in the so-called parameter mode.

To bring the drive in control via the PDO channel, the following steps are to be performed:

Activating DISABLED state

- Set the **Disabled (D)** bit in the control word (1)
- The **Disabled (D)** bit in the status word is set by the drive (2)

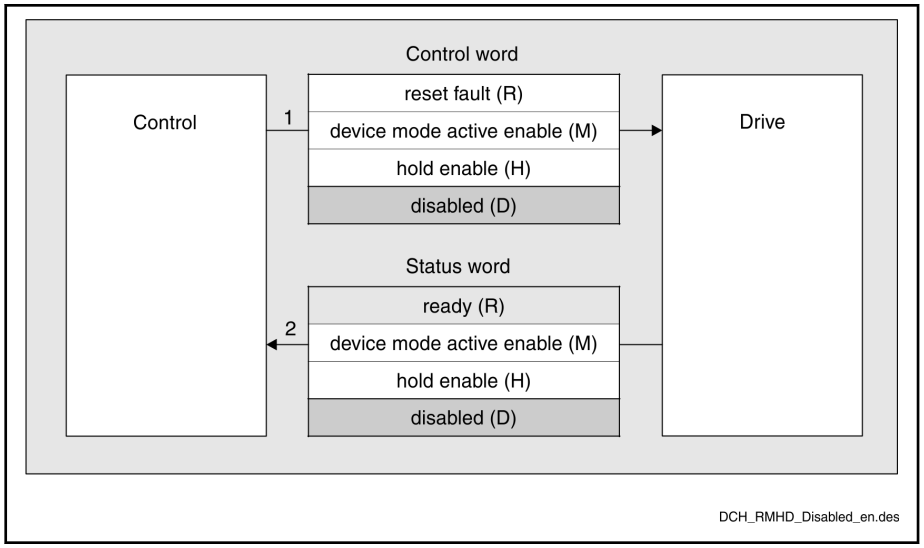


Fig. 4-19: Activating DISABLED state

Activating HOLD state

- Set the **Hold enable (H)** bit in the control word (3)
- The drive activates the "Drive Halt function", i.e., the axis is shut down with a defined acceleration and a defined jerk
- The drive is now in control
- The **Hold enable (H)** bit in the status word is set by the drive (4)

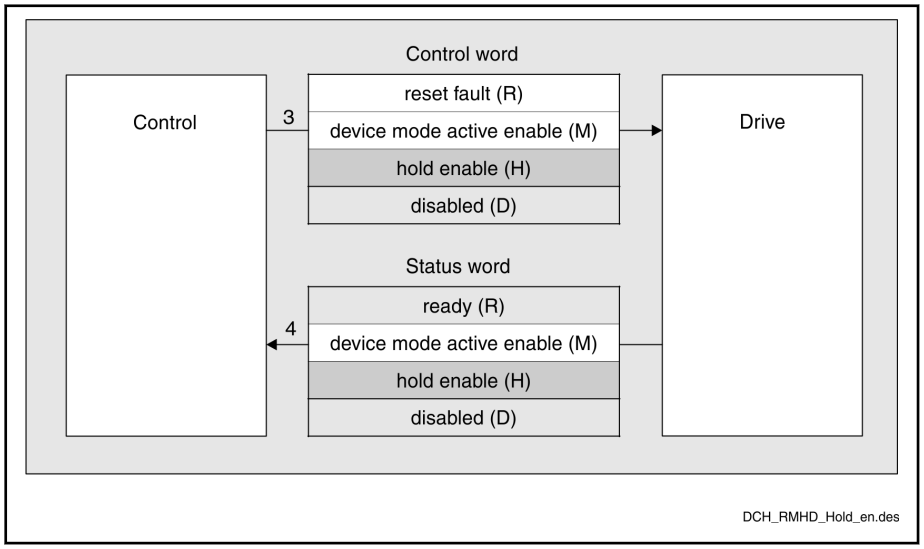


Fig. 4-20: Activating HOLD state

Activating device MODE ACTIVE ENABLE

- Set the **Device mode active enable** (M) bit in the control word (5)
- The drive is enabled
- The drive now follows the input via the PDO channel (command values)
- The drive feeds the actual values back to the control unit

  The **Device mode active enable** (M) bit in the status word is set by the drive (6)

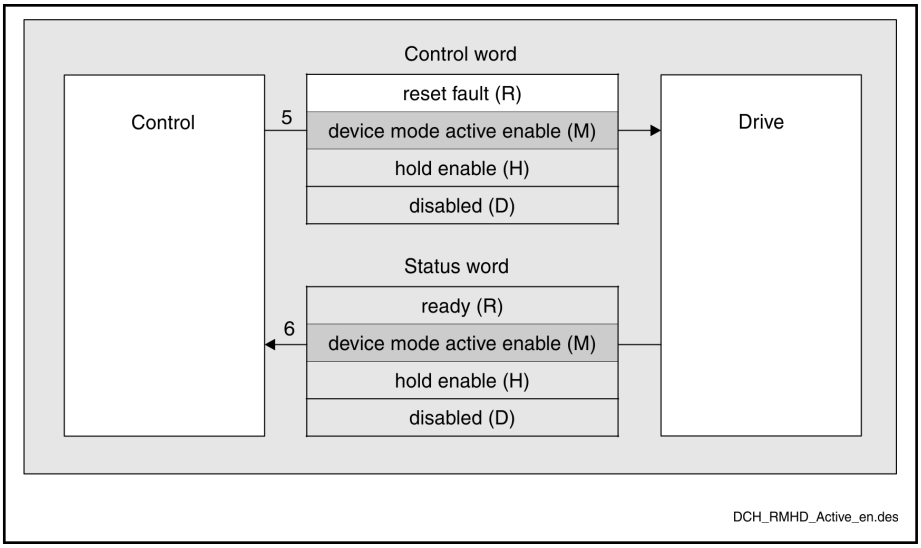


Fig. 4-21: Activating the MODE ACTIVE ENABLE state

By setting above-mentioned bits, the respective states are set drive-internally according to the Fluid Power state machine. When the disabled (D) bit is set, the drive internally switches from status INIT to DISABLED. By subsequently setting the “hold enable” (H) bit, the drive internally switches from DISABLED to HOLD. By subsequently setting the “device mode active enable” (M) bit, the drive internally switches from HOLD to ACTIVE. If the bits are removed in reverse order, the drive internally follows the respective states!



By simultaneously setting or resetting several control bits, states can be skipped. For example, it is possible to switch from DISABLED to ACTIVE by simultaneously setting “hold enable” (H) and “device mode active enable” (M).

In case of an error in the drive, the **Ready (R)** bit is set to 0. The error can then be acknowledged by sending the **Reset Fault (R)** bit in the control word. If the **Ready (R)** bit is not set to 1 after acknowledgement by the control unit, the error cause can be searched and remedied with the engineering software IndraWorks.

4.4.4 Parameter channel for PROFIBUS and PROFINET

Functional description

Via the parameter channel, the drive(s) can be parameterized over the field bus. The parameter channel is part of the cyclic data.

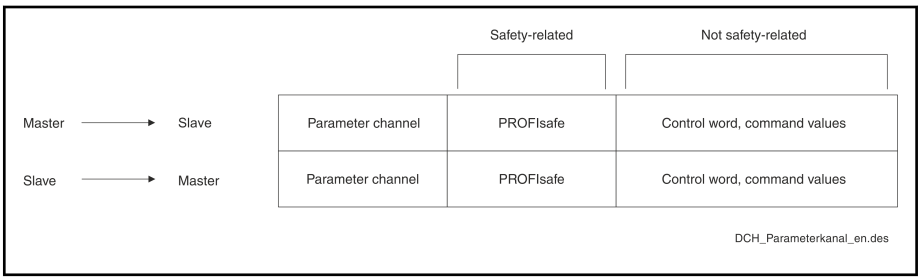


Fig. 4-22: Parameter channel as part of cyclic I/O data

The figure shows the parameter channel, which is transmitted at the beginning of cyclic I/O data. In principle, the parameter channel data block can be transmitted at any position of cyclic I/O data. At present, the parameter channel is used with PROFIBUS and PROFINET.

For Siemens S7 and PLCopen, function blocks are available which implement the parameter channel protocol. It is not necessary to deal with the parameter channel details.

However, should the parameter channel be used for other field bus masters, function blocks from Bosch Rexroth can be used as template in conjunction with this description.

Configuration

The parameter channel supports parameters of IDN and EIDN format. The format, which the drive is to expect, has to be set using parameter P-0-4083.0.001" Parameter channel: Configuration". (1: IDN access, 2: EIDN access).

With PROFIBUS, the length of the parameter channel is recognized during run-up. If no parameter format was configured, the IDN format is automatically expected from the drive and configured in parameter P-0-4083.0.001.

With PROFIBUS, the length of the parameter channel is not recognized during run-up. The length of the parameter channel is indirectly set via the configuration of parameter P-0-4083.0.001, " Parameter channel: Configuration".

Content of P-0-4083.0.1	Designation/function	Comment	Length of parameter channel
0	Deactivated	The parameter is deactivated.	0 bytes
1	IDN access	Access to the IDN parameters of the drive via the parameter channel	10 bytes
2	EIDN access	Access to the IDN and EIDN parameters of the drive via the EIDN parameter channel	12 bytes

Tab. 4-26: The table shows the interrelationship between the parameter channel configuration and the resulting parameter channel length in conjunction with PROFINET

The length of the parameter channel is displayed in parameter P-0-4083, " Parameter channel: Length".

Project planning

The parameter channel is set by selecting the respective I/O modules in the configuration software of the PROFIBUS. The following parameter channel modules can be selected. They are made available via the GSD/GSDML file.

- ParamCh not used: No parameter channel selected (length 0 words)
- ParamCh IDN: Used for accessing IDN parameters/EIDN substitute parameters (length: 5 words).
- ParamCh EIDN: Used for accessing EIDN parameters (length 6 words).

In case of PROFIBUS and PROFINET the selected parameter channel module must be plugged into slot 1.

Error codes

The table below contains an overview of the possible parameter channel error messages and their significance:

Error code	Meaning
0x0082	The data volume to be transmitted is too small, i.e. less than 4 bytes.
0x0083	The data volume yet to be transmitted exceeds the internal buffer.

Error code	Meaning
0x0088	The length of the valid data indicated in the control word is longer than the parameter channel.
0x008C	Status conflict; a new request was sent although there are still data to be transmitted.
0x008D	The length of data indicated in the control word as yet to be transmitted is incorrect
0x008E	The EIDN/IDN access mode set in control word bit 15 does not correspond to the access mode configured in P-0-4083.0.1.

Tab. 4-27: Error codes

The table below contains an overview of the possible parameter access errors and their significance. The error values are transmitted in word format:

Error code	Meaning
0x0009	Invalid access to element 0
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name available
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	No minimum value
0x5004	Minimum value cannot be edited
0x6001	No maximum value
0x6004	Maximum value cannot be edited
0x7002	Datum transmission too short
0x7003	Datum transmission too long
0x7004	Datum cannot be changed (read only)
0x7005	Datum cannot be written at present
0x7006	Datum is smaller than minimum input value
0x7007	Datum exceeds the maximum input value
0x7008	IDN is not supported, invalid bit number or bit combination
0x7009	Datum write-protected by customer password
0x700A	Datum is currently write-protected, as it is configured cyclically
0x700B	Invalid indirect addressing (e.g. data container, list handling)
0x700C	Datum is currently write-protected due to other settings (e.g. parameter, operation mode, drive enable, ...)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command at this time not executable (e.g., the procedure command cannot be activated in this phase)

Error code	Meaning
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	Invalid data record number
0x9004	Invalid data block number
0x9005	Data element number invalid
0x9006	Error in R/W flag
0x9007	Invalid character in the datum

Tab. 4-28: Overview parameter access errors

Structure of the parameter channel protocol (more detailed information in case PLC standard FBs made available by Bosch Rexroth are not used)

Length of the parameter channel protocol

In the GSD/GSDML file, certain modules, which correspond to a parameter channel length of 0 (ParamCh not used), 5 (ParamCh IDN) and 6 (ParamCh EIDN) words, are made available.

Moreover, the drive also supports parameter channel lengths of 2, 3, 4 and 7 words. With these lengths, the parameter channel functionality is not checked for the enable. In justified exceptional cases, developers can make available a GSD file, which supports these parameter channel lengths.

Basic structure of the parameter channel protocol

At the beginning of every parameter channel protocol the control word (master→drive) or status word (drive→master) is transmitted.

Control word / status word	...
1 word	1 to 7 words

Tab. 4-29: Basic structure of the parameter channel

Structure of the control word

The control word is sent in the direction from the master to the slave (drive). It is 16 bit wide and the individual bits have the following significance:

Bit	Meaning
15	**PF** parameter format (0: 2-byte IDN format, 1: 4-byte IDN format)
14	**G** no basic position
13	**L** load bit
12	**T** toggle bit
11-8	**FL** length of user data in the fragment (4 bits)
7-0	**GL** length of the data yet to be transmitted, including those in the current fragment (8 bits)

Tab. 4-30: Parameter channel control word

Structure of the status word

The status word is sent in the direction from the slave (drive) to the master. It is 16 bit wide and the individual bits have the following significance:

Bit	Meaning
15	**res** reserved (always 0)
14	**F** error
13	**L** load bit
12	**T** toggle bit
11-8	**FL** length of user data in the fragment (4 bits)
7-0	**GL** length of the data yet to be transmitted, including those in the current fragment (8 bits)

Tab. 4-31: Parameter channel status word

Addressing the drive parameters

With regard to addressing, we distinguish between:

- standard ("S") and product ("P") data
- Data block numbers from 0 to 4095
- 8 selectable parameter sets
- Addressing of various axes (for double-axis devices, CCD data)
- Access to different elements of a parameter (datum, minimum input value, etc.)
- The parameter format (2-byte IDN format / 4-byte IDN format). With the 4-byte IDN format, the parameter protocol is extended by structure instance and structure element.

To this end, for parameter addressing, an index, axis number and subindex were introduced for the parameter channel.

Index structure

Bit	Meaning
13-15	Fixed identifier
12:0	Standard data (S-x-xxxx)
12:1	Product data (P-x-xxxx)
11-0	Data block number from 0 to 4095

Tab. 4-32: Index structure

Axis number

Bit	Meaning
7-0	Axis number

Tab. 4-33: Axis number

Subindex structure

Bit	Meaning
7-5	Parameter sets 0-7
4-0	Element number 0-31

Tab. 4-34: Subindex structure

Structure instance The structure instance is used only in the 4-byte IDN parameter format.

Bit	Meaning
7-0	Instance number

Tab. 4-35: Structure instance

Structure element The structure element is used only in the 4-byte IDN parameter format.

Bit	Meaning
7-0	Element number

Tab. 4-36: Structure element

Format/type of operating datum with field buses

The operating datum can have four different formats:

W 2 bytes data length

L 4 bytes data length

X 8-byte data length (prepared)

T ASCII text with a minimum length of 64 bytes

There are three parameter types:

- Single parameters
- Command
- List

Addressing of parameter elements

The parameter elements are addressed as part of the subindex.

Irrespective of the parameter type, each parameter has the following read-only elements:

No.	Name	Function	Form
0	Number of elements	Number of supported elements	W
1	IDN	Sercos IDN	T(8)
2	Name	Parameter name	T(60)
3	Attribute	Form of representation of the parameter	L
4	Unit	Parameter unit	T(12)
5	Min. input value	Max. possible value of the datum	W/L/X/T
6	Max. input value	Max. possible value of the datum	W/L/X/T

Depending on its type, each parameter has further elements, which differ in their function:

No.	Name	Form
7	Operating datum	W/L/X/T
8	Max. number of list elements / length of text	L
9	Actual number of list elements / length of text	L
10	Pointer to the datum, which is processed on the next access to element 7	L
11	1 list element	W/L/X/T
12	2 list elements	W/L/X/T

No.	Name	Form
13	3 list elements	W/L/X/T
14	4 list elements	W/L/X/T
15	5 list elements	W/L/X/T
16	6 list elements	W/L/X/T
17	7 list elements	W/L/X/T
18	8 list elements	W/L/X/T
19	9 list elements	W/L/X/T
20	10 list elements	W/L/X/T

Structure of the parameter channel

Irrespective of fragmentation or an error, the parameter channel, when a parameter is written, is composed of the following:

	Control word	Index	Axis	Subindex	SI (depending on parameter format)	SE (depending on parameter format)	Data
M→S	2 bytes	2 bytes	1 byte	1 byte	1 byte	1 byte	Max. 80 bytes

Tab. 4-37: Parameter channel while writing a parameter

	Status word
S→M	2 bytes

Tab. 4-38: Parameter channel while writing a parameter

Irrespective of fragmentation or an error, the parameter channel, when a parameter is written, is composed of the following:

	Control word	Index	Axis	Subindex	SI (depending on parameter format)	SE (depending on parameter format)
M→S	2 bytes	2 bytes	1 byte	1 byte	1 byte	1 byte

Tab. 4-39: Parameter channel while reading a parameter

	Status word	Data
S→M	2 bytes	Max. 80 bytes

Tab. 4-40: Parameter channel while reading a parameter

Examples of parameter communication

Basic position

The control determines the basic position and the drive replies with the 2-byte identifier of the supported parameter channel format, in this case, 02V00.

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-
S→M	0	0	1	0/1	2	2	02h	00h	-	-	-	-	-	-

Tab. 4-41: Basic position

Non-fragmented reading

The control reads out the operating datum of parameter S-0-0057. It is a double word, which means that fragmenting is not necessary. The value is 100.

Parameter mapping:

Index = 2039 h

Subindex = 7 h

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	1	1	1/0	4	4	20h	39h	00h	07h	-	-	-	-
S→M	0	0	1	1/0	4	4	00h	00h	00h	64h	-	-	-	-

Tab. 4-42: Non-fragmented reading

Non-fragmented writing without error

The control writes a new operating datum to parameter S-0-0057. It is a double word, which means that fragmenting is not necessary. The value is 200. The drive returns an acknowledgement that reflects the length.

Parameter mapping:

Index = 2039 h

Subindex = 7 h

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	1	1	0/1	8	8	20h	39h	00h	07h	00h	00h	00h	00h
S→M	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-

Tab. 4-43: Non-fragmented writing without error

Non-fragmented writing with error feedback

The control writes a new operating datum to parameter S-0-0057. The value is 20000 and exceeds the permissible maximum. The drive returns an error message; in this example: 7006h.

Parameter mapping:

Index = 2039 h

Subindex = 7 h

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	1	1	0/1	8	8	20h	39h	00h	07h	00h	00h	4Eh	20h
S→M	0	0	1	0/1	2	2	70h	06h	-	-	-	-	-	-

Tab. 4-44: Non-fragmented writing with error feedback

Fragmented reading

The control reads out the operating datum of parameter S-0-0016. It is a list of words. In this example, it contains: 40 (28h), 51 (33h), 53 (36h), 84 (54h), 95 (5F), 130 (82h), and 131 (83h). First, the list pointer (subindex 10) is set to 0.

Parameter mapping:

Index = 2010h

Subindex = 11 h → 17 → 7 elements

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	1	1	1/0	8	8	20h	10h	00h	0Ah	00h	00h	00h	00h
S→M	0	0	1	1/0	0	0	-	-	-	-	-	-	-	-
M→S	0	1	1	0/1	4	4	20h	10h	00h	11h	-	-	-	-
S→M	0	0	0	0/1	8	14	00h	28h	00h	33h	00h	36h	00h	54h
M→S	0	1	1	1/0	0	6	-	-	-	-	-	-	-	-
S→M	0	0	1	1/0	6	6	00h	5Fh	00h	82h	00h	83h	-	-

Tab. 4-45: Fragmented reading

Fragmented writing

The control writes data to parameter P-0-4006. It is a list of double words. In this example it should contain 100 (64h), 200 (C8h), 300 (12Ch), 400 (190h), 500 (1F4) and 600 (258h). First, the list pointer (subindex 10) is set to 0.

Parameter mapping:

Index = 3FA6h

Subindex = 10 h → 16 → 6 elements

Length = 4 bytes header + (6*4 bytes data) = 28 bytes

	Control word/status word						User data							
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9
M→S	0	1	1	0/1	8	8	3Fh	A6h	00h	0Ah	00h	00h	00h	00h
S→M	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-
M→S	0	1	0	1/0	8	28	3Fh	A6h	00h	10h	00h	00h	00h	64h
S→M	0	0	1	1/0	0	20	-	-	-	-	-	-	-	-
M→S	0	1	0	0/1	8	20	00h	00h	00h	C8h	00h	00h	01h	2Ch
S→M	0	0	1	0/1	0	12	-	-	-	-	-	-	-	-
M→S	0	1	0	1/0	8	12	00h	00h	01h	90h	00h	00h	01h	F4h
S→M	0	0	1	1/0	0	4	-	-	-	-	-	-	-	-
M→S	0	1	1	0/1	4	4	00h	00h	02h	58h	-	-	-	-
S→M	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-

Tab. 4-46: Fragmented reading

Requesting the next fragment

For the request for the next fragment of a fragmented transmission, GL must be calculated on the basis of the received data from the control word/status word:

$$GL_{Sende} = GL_{Empfang} - FL_{Empfang}$$

Fig. 4-23: Requesting the next fragment

GL Length of the data yet to be transmitted, including those in the current fragment (8 bits)

FL length of user data in the fragment (4 bits)

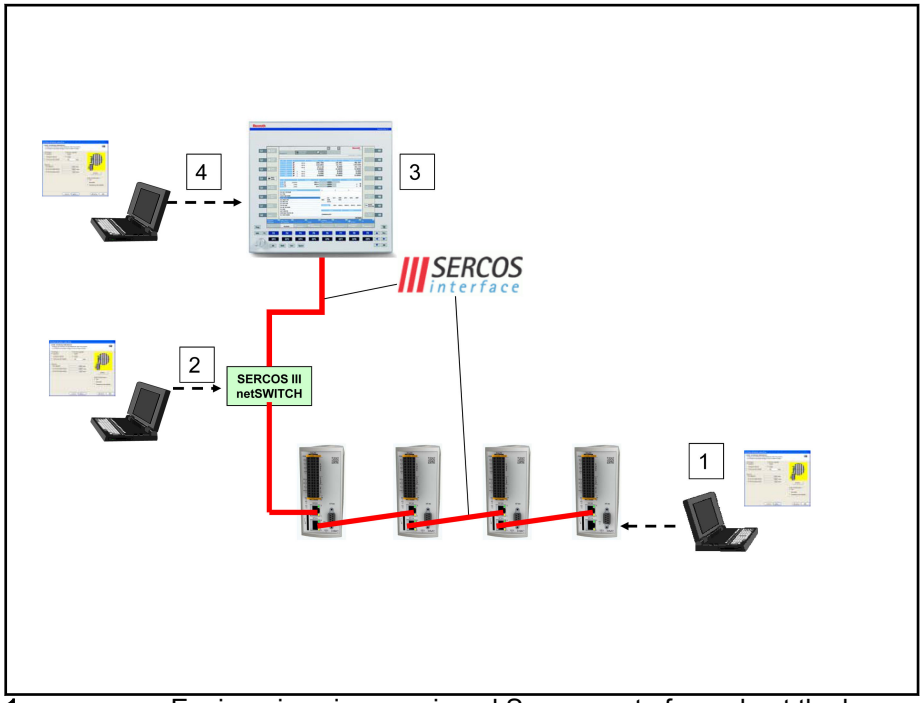
Pertinent parameters

Parameter
- P-0-4083, Parameter channel: Length
- P-0-4083.001, Parameter channel: Configuration

4.5 Sercos

4.5.1 Brief description

Topology



1 Engineering via unassigned Sercos port of a node at the bus
2 Engineering via optional Sercos netSwitch
3 Engineering via IndraWorks on Sercos control
4 Engineering via routing via control (if routing control available)

Fig. 4-24: Engineering options via Sercos

It is possible to operate HydraulicDrive with a Multi-Ethernet interface (ET) or a Sercos interface (S3) as Sercos master communication. Via these modules it is possible to exchange real-time data with a Sercos master.

We distinguish the following communication channels:

- **Cyclic data channel**

  → Channel for cyclic transmission of payload data (**process data**) in real time

- **Acyclic data channel** (service channel)

  → Channel for acyclic transmission of payload data (**service data**)

For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

- **Non-real time channel (NRT channel)**

→ Defined time slot within the cycle time for transmission of standard Ethernet telegrams

General features

- Transmission rate 100 Mbit/s
- Cyclical data exchange of command and actual values in equal time intervals
- Data transmission over Ethernet cable (CAT5e copper)
- Service channel for parameterization and diagnosis
- Free configuration of telegram contents
- Synchronization between time command value takes effect and measurement starting time of the actual values for all devices on a ring
- Overall synchronization of all connected devices

Firmware-specific features

Position controller clock cycle	$T_{position}$	ms	1	0
Master communication cycle time	min	ms	1	0
	max	ms	65	
MotionData in each case for MDT/AT [excl. 2-byte connection control word (C_Con)]	T_{Sercos}=>$T_{position}$	Byte	**50**	
		IDN	16	
CC connections [excl. 2-byte connection control word (C_Con)]		Byte	8	
		IDN	2	

Tab. 4-47: Sercos key data

- HydraulicDrive supports 2 connections between control unit and drive.
- Cycle time: min. 1 ms, max. 65 ms (multiples of the position controller cycle can be set)
- Max. amount of configurable consumer data: 50 bytes/16 IDNs
- Max. amount of configurable producer/consumer data: 50 bytes/16 IDNs

☞ The NRT channel is only possible, if a time slot of more than 125 µs is available.

Axis addressing

The address can be directly changed or displayed via parameter "S-0-1040, Drive address of master communication". With Sercos and remote address assignment, the address can be set remotely and automatically via the master. This function must be supported by the master.

Pertinent parameters

Specific parameters for Sercos communication

- S-0-1000, Sercos: SCP Type & Version
- S-0-1002, Sercos: Communication Cycle time (tScyc)
- S-0-1005, Sercos: Minimum feedback processing time (t5)
- S-0-1006, Sercos: AT0 transmission starting time (t1)
- S-0-1007, Sercos: Feedback acquisition capture point (t4)
- S-0-1008, Sercos: Command value valid time (t3)
- S-0-1009, Sercos: Device Control (C-Dev) offset in MDT
- S-0-1010, Sercos: Lengths of MDTs
- S-0-1011, Sercos: Device Status (S-Dev) offset in AT

- S-0-1012, Sercos: Length of ATs
- S-0-1013, Sercos: SVC offset in MDT
- S-0-1014, Sercos: SVC offset in AT
- S-0-1015, Sercos: Ring delay
- S-0-1016, Sercos: Slave delay (P/S)
- S-0-1017, Sercos: NRT transmission time
- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- S-0-1023, Sercos: SYNC jitter
- S-0-1024, C5300 Sercos: SYNC delay measuring procedure command
- S-0-1026, Sercos: Version of communication hardware
- S-0-1027.0.1, Sercos: Requested MTU
- S-0-1027.0.2, Sercos: Effective MTU
- S-0-1031, Sercos: Signal assignment TSx
- S-0-1034, Sercos: PHY error counter Port1 and Port2
- S-0-1035, Sercos: Error counter Port1 & Port2
- S-0-1035.0.1, Sercos: Error counter P&S
- S-0-1036, Sercos: Inter Frame Gap
- S-0-1037, Sercos: Slave Jitter
- S-0-1040, Drive address of master communication
- S-0-1041, Sercos: AT Command value valid time (t9)
- S-0-1042, Sercos: Topology index
- S-0-1044, Sercos: Device Control (C-Dev)
- S-0-1045, Sercos: Device Status (S-Dev)
- S-0-1046, Sercos: Slave addresses of the device
- S-0-1047, Sercos: Maximum Consumer Activation Time
- S-0-1050.x.1, Sercos Connection: Connection setup
- S-0-1050.x.2, Sercos Connection: Connection number
- S-0-1050.x.3, Sercos Connection: Telegram assignment
- S-0-1050.x.4, Sercos Connection: Max. length of connection
- S-0-1050.x.5, Sercos Connection: Current length of connection
- S-0-1050.x.6, Sercos Connection: Configuration list
- S-0-1050.x.8, Sercos Connection: Connection control (C-Con)
- S-0-1050.x.10, Sercos Connection: Producer cycle time
- S-0-1050.x.11, Sercos Connection: Allowed data losses
- S-0-1050.x.12, Sercos Connection: Error counter data losses
- S-0-1050.x.20, Sercos Connection: IDN allocation of real-time bit
- S-0-1050.x.21, Sercos Connection: Bit allocation of real-time bit
- S-0-1051, Sercos Connection: Image of connection setups
- S-0-1060.x.1, Sercos Connectiontype: Default configuration

- S-0-1060.x.2, Sercos Connectiontype: Configuration mask
- S-0-1060.x.3, Sercos Connectiontype: Max. quantity of conn. Capability
- S-0-1060.x.4, Sercos Connectiontype: Max. Length of Connection
- S-0-1060.x.6, Sercos Connectiontype: Configurable IDNs
- S-0-1060.x.7, Sercos Connectiontype: Min. processing time
- S-0-1060.x.10, Sercos Connectiontype: Minimum producer cycle time

Pertinent diagnostic messages

- A0000 Communication phase 0
- A0001 Communication phase 1
- A0002 Communication phase 2
- A0003 Communication phase 3
- A0008 Sercos: NRT-Mode
- E4020 Sercos: Ring interruption (FF to LF)
- F4001 Sync telegram failure
- F4002 RTD telegram failure
- F4003 Invalid communication phase shutdown
- F4004 Error during phase progression
- F4005 Error during phase regression
- F4006 Phase switching without ready signal
- F4017 Sercos: Incorrect sequence during phase switch
- F4020 Sercos: Cable break (L+F to NRT)

4.5.2 Functional description

Sercos diagnostic LED

In the HydraulicDrive a diagnostic LED is implemented according to the Sercos specification, see also chapter "Diagnostic and status messages".

Blinking code												Function	P
												No Sercos telegrams (NRT mode)	6
Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP0	6
Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP1	6
Orange	Green	Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP2	6
Orange	Green	Orange	Green	Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	CP3	6
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	CP4	6
Green		Green		Green		Green		Green		Green		CPx →Loop-back	5
Red	Orange	Red	Orange	Red	Orange	Red	Orange	Red	Orange	Red	Orange	Applicative C1D	4

Blinking code												Function	P
Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	S-Dev.Bit15 (MST warning)	3
Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	C1D of Communication	2
Or-ange		Or-ange		Or-ange		Or-ange		Or-ange		Or-ange		C-Dev.Bit15 (identification)	1
Red		Red		Red		Red		Red		Red		Internal watch-dog has responded	0

P Display priority, (1 = highest)
Black LED is off
CP Communication phase

Tab. 4-48: The supported blinking codes and the meaning of the diagnostic LEDs comply with the Sercos specification

4.5.3 Sercos timing

In the HydraulicDrive, process data are processed clock-synchronously. An indicator of clock-synchronous processing is that a master can exactly determine the time of actual value establishment (and command value acceptance) via timing parameters. For the calculation the HydraulicDrive makes its time-related framework conditions available by way of parameters. The master provides the time of processing as TS (S-0-1007, Sercos: Feedback acquisition capture point (t4)).

A slave indicates its maximum processing time (tmp-P) as producer in parameter "S-0-1005, Sercos: Minimum feedback processing time (t5)".

Rule: Process data (actual values) are returned in an AT block. Between the start and the synchronization time TS, the maximum processing time **complete** can be found.

A slave indicates its maximum activation time (tmp-C) as consumer in parameter "S-0-1047, Sercos: Maximum Consumer Activation Time".

Rule: Process data (command values) are specified in the telegram block (MDT and/or AT). Between the telegram block end and the synchronization time TS, the maximum activation time **complete** can be found.

4.5.4 Function groups

Identification of GDP classes and their versions

S-0-1301, List of GDP classes

Class Code bits 15-8	Reserved bits 7-4	Version bits 3-0	Class designation	Defined in Sercos version	Description
0x01	0x0	0x1	GDP_Basic	V1.1.1	Every sub-device has to support the generic profile.
0x04	0x0	0x1	GDP_Rev	V1.3	Revision
0x06	0x0	0x1	GDP_StM	V1.3	State machine

Class Code bits 15-8	Reserved bits 7-4	Version bits 3-0	Class designation	Defined in Sercos version	Description
0x07	0x0	0x1	GDP_CKs	V1.3	Checksum
0x08	0x0	0x1	GDP_CKsUser	V1.3	Checksum user
0x09	0x0	0x1	GDP_BKP	V13.	Backup
0x0D	0x0	0x1	GDP_PWD	V1.3	Password
0.10	0x0	0x1	GDP_RST	V1.3	Restart

Tab. 4-49: Structure of GDP classes and versions

Identification of FSP drive classes and their versions

S-0-1601, List of FSP Drive classes

This parameter contains the drive classes that the drive supports. The classes are adjusted according to the functional package (open loop, closed loop).

Class Code bits 15-8	Reserved bits 7-4	Version bits 3-0	Class designation	Defined in Sercos version	Description	Available with functional package			
						Open loop	Closed loop	IFB	p/Q
0x01	0x0	0x1	Torque axis	V1.3	Torque control	■	■		
0x02	0x0	0x1	Velocity axis	V1.3	Velocity control		■		
0x03	0x0	0x1	Velocity axis with position feedback	V1.3	Velocity control with position feedback		■		
0x04	0x0	0x1	Position axis	V1.3	Position control with cyclic position command value		■		
0x05	0x0	0x1	Positioning axis	V1.3	Positioning control with absolute or relative position command value		■		
0x06	0x0	0x1	Spool axis	V1.3	Spool control	■	■	■	■
0x07	0x0	0x1	Flow axis	V1.3	Flow control				■
0x08	0x0	0x1	Pressure axis	V1.3	Pressure control	■	■		■
0x09	0x0	0x1	Pressure/flow axis	V1.3	Pressure/flow control				■

Tab. 4-50: FSP Drive classes and their versions

Identification of the FSP and application type

S-0-1302.0.1, FSP Type

This parameter describes an instance for each resource (in a sub-device). It specifies, in which FSP (function-specific profile) the resource is specified.

In the case of drives, FSP drive (0x0002) is entered in instance 0.

IDN	FSP type bits 31-16	Version bits 15-0	Profile name
S-0-1302.0.1	0x0002	0x0001	FSP drive

Tab. 4-51:

The I/Os in the drives are currently not implemented according to FSP I/O.

S-0-1302.0.3, Application type

This parameter is used to describe the application on the drive or the axis (e.g. swivel axis)

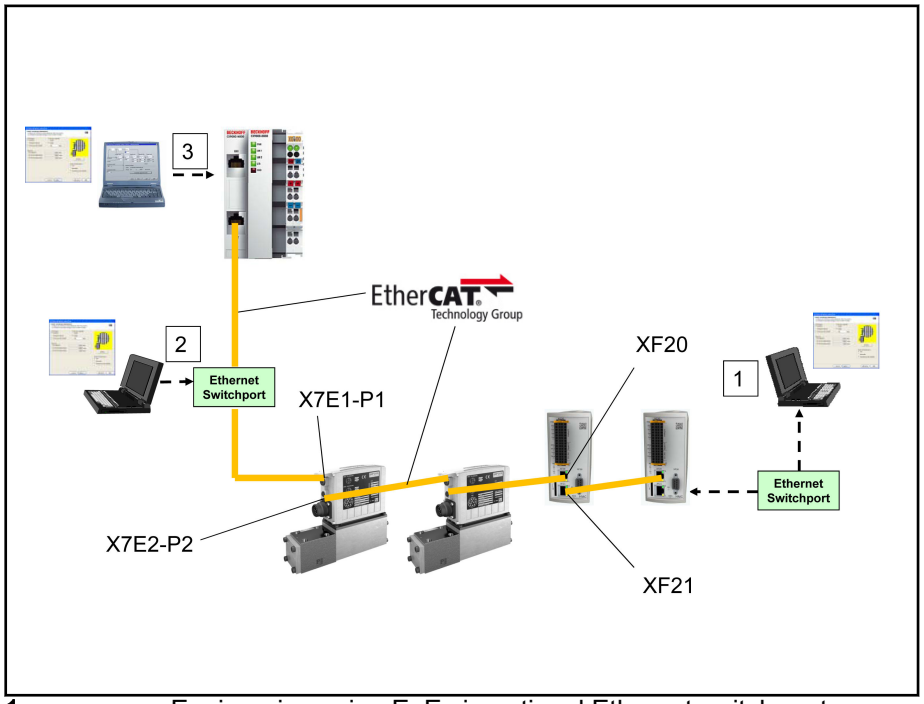
Pertinent parameters

- S-0-1301, List of GDP classes
- S-0-1601, List of FSP Drive classes
- S-0-1302.x.1, FSP Type
- S-0-1302.0.3, Application type

4.6 EtherCAT®

4.6.1 Brief description

Topology



1 Engineering using EoE via optional Ethernet switch port
2 Engineering by means of EoE via optional Ethernet switch port
3 Engineering by means of ADS interface via third-party control unit using EoE (control unit includes switch port)

Fig. 4-25: Engineering options with EtherCAT®

HydraulicDrives can be operated with EtherCAT® master communication. It is possible to exchange real-time data with an EtherCAT® master. Supports "Servo Drive Profile over EtherCAT®", which is in line with the Sercos II specification and the CANopen profile.

We distinguish the following communication channels:

- **Cyclic data channel** (process data)

→ Data container for cyclic transmission of payload data (**process data**) in real time

- **Acyclic data channel** (service channel)

  → EtherCAT® mailbox method for acyclic transmission of payload data (**service data**)

- **Non-realtime channel** [Ethernet over EtherCAT® (EoE)]

  → Transmission of Ethernet telegrams via an EtherCAT® mailbox method

General features

- Transmission rate 100 Mbit/s
- Data transmission over Ethernet cable (CAT5e copper)
- Access to 16-bit Sercos parameters of the drive via "SoE" protocol (“Servo Drive Profile over EtherCAT®“).
- EtherCAT® mailbox method for parameterization and diagnosis
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- Max. length of the configurable MDT/AT data: 15 IDNs with max. 48 bytes; with bus clock cycle = position controller clock cycle, the max. length is halved to 24 bytes
- Cycle time (multiples of the position controller cycle can be set)
- "Distributed clock synchronization" (exact adjustment of distributed clocks)
- Synchronization between the time when the command value takes effect and the time of measurement of the actual values for all drives connected to a ring
- Overall synchronization of all connected drives with the master
- Only released in connection with "Beckhoff TwinCAT"

Axis addressing

The drives identify themselves by means of the order in the bus (example: address = "1" in the master corresponds to "1st drive" in the line).

Physical wiring

When setting up an EtherCAT® network with HydraulicDrive, make sure that the slots are used as follows:

IAC2x	HMC
Slot X7E2 as output ("OUT")	Slot XF20 as input ("IN")
Slot X7E1 as input ("IN")	Slot XF21 as output ("OUT")

Tab. 4-52: Use of the slots

Addressing

With EtherCAT, a slave can be addressed in different ways. The most important ones are listed below:

- **Auto Increment Address:** The Auto Increment Address is used (during initialization) to address each EtherCAT device according to its physical position in the communication ring. The first EtherCAT slave in the ring is assigned the address 0000hex, and for each further slave, the address is decremented by 1 (FFFFhex, FFFEhex, etc.). With TwinCAT, the "Auto Inc Adr" of the slave is displayed as follows:

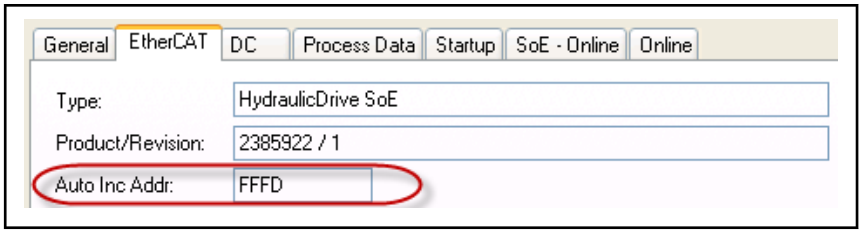


Fig. 4-26: Auto Increment Address

- **Configured station/node address:** This address is assigned by the EtherCAT master during initialization. The slave itself cannot influence it and it is lost when the drive is switched off. The address is displayed under "Drive" in parameter P-0-4089.0.4 and in TwinCAT:

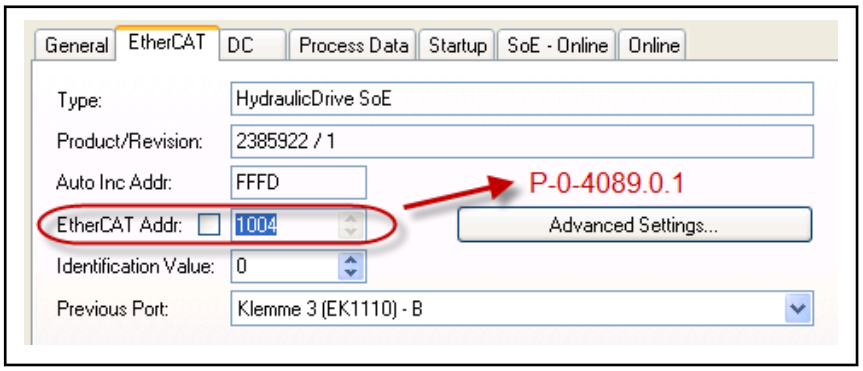


Fig. 4-27: EtherCAT address

During initialization of the master, the address is written to the "Configured Station Address" register of the slave. **As the master uses "Auto Increment Addressing" to write to this register, this address depends indirectly on the topology.**

- **Logical addressing:** "Logical addressing" is used for the process data. In this process, instead of an individual slave, an area with a virtual memory space of max. 4 GB is addressed. This range can be distributed over several slaves. The assignment of a physical memory address to a logical address is applied by the "Field Bus Memory Management Unit" (FMMU) of the slave. The slave FMMU is configured by the master (on transition PreOp→SafeOp).

  As the node address is used for initialization of the logical address, this address remains indirectly dependent on the topology.

  This means that all these addressing types are actually dependent on the topology. The order in the project always has to correspond to the actual order on the bus.

Topology-independent addressing / identification

Newer TwinCAT versions offer an extension on addressing.

Under "Advanced settings" of the slave, there are two new options:

General -> Identification:

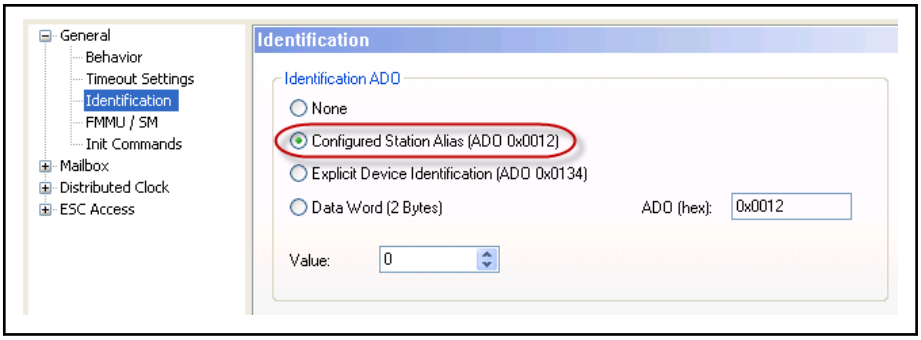


Fig. 4-28: Configured station alias

General→Behavior→"Check Identification":

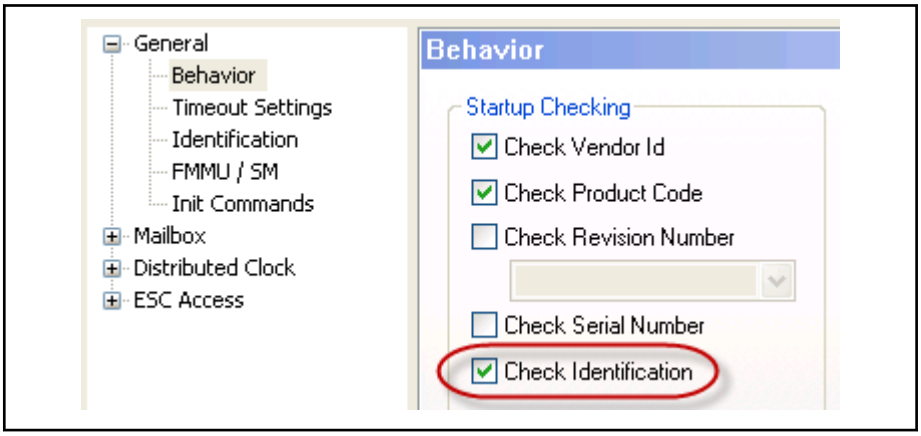


Fig. 4-29: Check identification

If these options are selected, a check is run during bus initialization to see whether the value defined under "Identification Value":

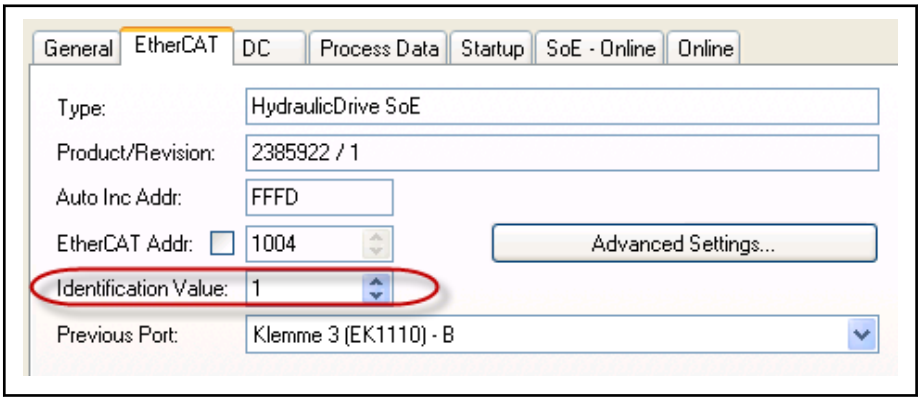


Fig. 4-30: Identification Value

corresponds to the value in the "Station Alias" register of the drive.

If the values do not correspond, the drive remains in phase "Init" and a "check identification failed" message is displayed in the TwinCAT logger window:

Currently, the value from parameter P-0-4089.0.3 is applied in the "Station Alias" register during booting.

If the address in P-0-4089.0.3 is changed, this value is applied as alias during next booting. If the parameter is changed without rebooting the drive, an inconsistency can occur between the alias and P-0-4089.0.3.

EtherCAT State Machine

Comparison of EtherCAT and Sercos state machine

The following figure illustrates the comparison of the EtherCAT and the Sercos state machine.

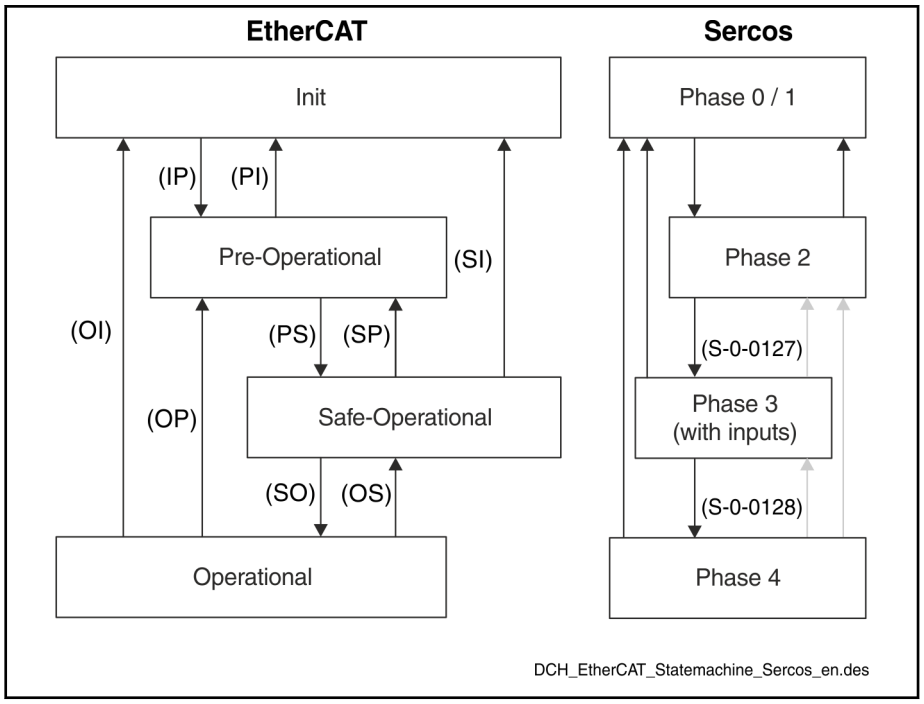


Fig. 4-31: EtherCAT and Sercos State Machine

EtherCAT phases

Init:

- No communication on the application layer
- Master can access the slave FPGA registers via the bus

Pre-Operational:

- Mailbox communication: SoE (read/write parameters)/CoE (read/write SOD) and EoE
- No process data transmission takes place

Safe-Operational:

- Mailbox communication: SoE (read/write parameters) and EoE
- Process data transmission: However, only actual values are transmitted/ evaluated. No command value evaluation takes place
- Synchronization via "distributed clocks"

Operational:

- Mailbox communication: SoE (read/write parameters) and EoE
- Process data transmission: Command/actual values are cyclically transmitted/evaluated
- Synchronization via "distributed clocks"

Synchronization and timing

Synchronization

Synchronization takes place via the "distributed clocks" of EtherCAT.

Via the "distributed clocks", a cyclic Sync signal (in the bus clock cycle) is generated for each drive. As the "distributed clocks" ensure that the same system time is available on all slaves, this Sync signal is simultaneously generated on all drives.

Timing

The correct timing of DC Sync signal and thus of command/actual value processing in the drive is set by the master. For this purpose, the values are directly written to the respective slave registers. These registers are assigned default values by the XML device description. These need to be adapted in exceptional cases only.

The actual values are generated in the drive simultaneously with the Sync1 signal. The command values are taken over in the drive already one position controller cycle before the actual values are generated. The telegram is to arrive shortly before the "logical Sync". It is offset by one position cycle in comparison to the Sync1 signal (by means of Sync0Shift). This way, the telegram arrives shortly before the command value is accepted by the drive.

If the bus clock cycle corresponds to the position controller clock cycle, the command value is accepted and the actual value generated in the same position controller cycle (with the max. data length (S-0-0016/S-0-0024) being halved with a bus clock cycle ≤ 1 ms).

Command value acceptance

During position control, fine interpolation of the position command values starts at the Sync1 time (T4). One bus cycle later, the actual command value is reached (in case of linear fine interpolation).

With closed-loop velocity, force, pressure, and flow control, the command value is usually (depending on the system load) transmitted to the V controller half a position controller cycle after the MDT run and directly applied.

DC settings in TwinCAT

The default settings (from the XML device description) are as follows:

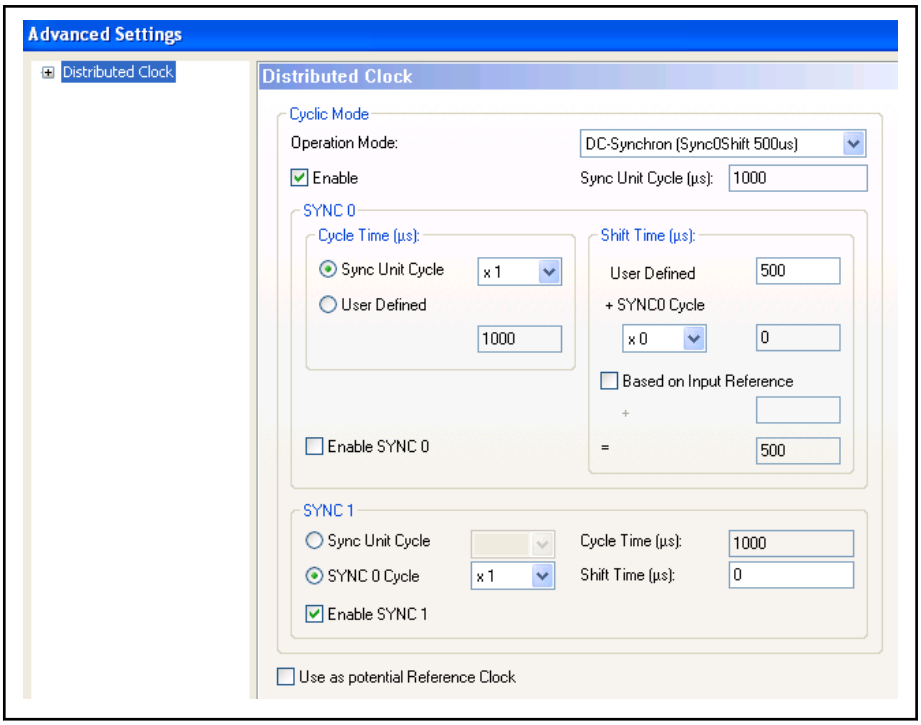


Fig. 4-32: Advanced settings - "Distributed Clocks"

Position controller cycles can have a length of 1000 µs or 2000 µs, depending on the device and the set performance level (refer to P-0-0556). For this reason, the respective shift times can be selected:

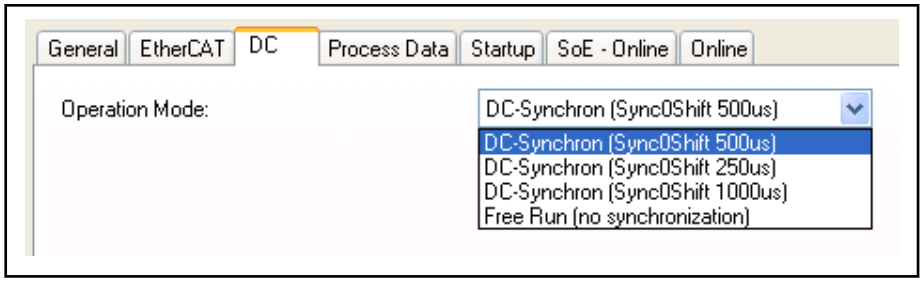


Fig. 4-33: Shift time selection

Timing monitoring

In phase "Operational", if two command value telegrams are expected in direct succession, but no telegram is received, error F4002, " RTD telegram failure", is generated in AF (otherwise the warning E4005).

The value of parameter S-0-0029, " MDT error counter", is set to 0 on transition to "Operational". If a command value telegram was expected (in phase Op), but none has been received, the value is incremented. The error counter stops at 65535 (0xFFFF).

Process data watchdog

The PD watchdog is reset when process data are received. The watchdog can either be triggered by AT or MDT data. If these data fail for a certain period, a flag is set. By querying these flags, cyclic data failures can be detected.

The response time can be set in the following menu under TwinCAT:

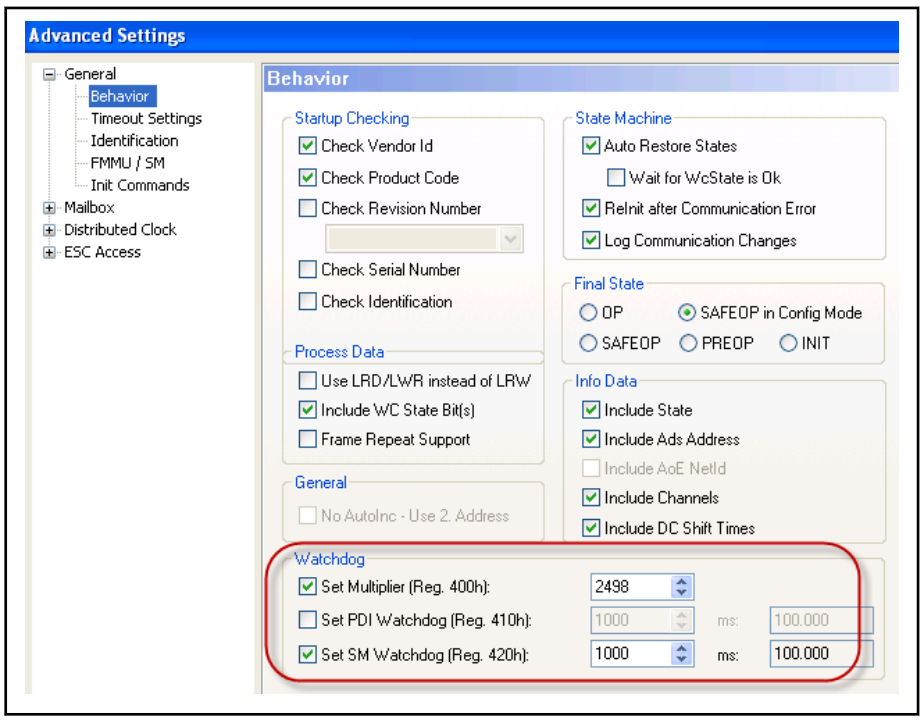


Fig. 4-34: Setting the watchdog response time under TwinCAT

Setting the time to 0 deactivates the watchdog.

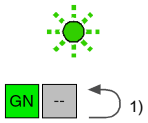
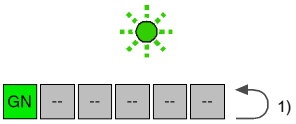
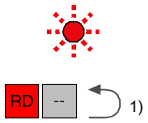
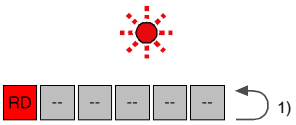
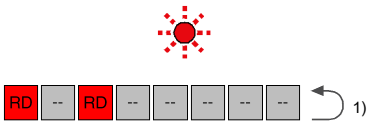
Minimum cycle time

The minimum cycle time of all HydraulicDrive derivatives is 1 ms. Only multiples of the position controller cycle can be set as cycle time.

Diagnostic and status messages, monitoring functions

Communication status LED

The bi-color LED 3 (IAC) or NS (HMC) at the drive controller is used for EtherCAT® communication diagnosis.

LED designation		Significance	Color/flashing pattern	Description
HMC	IAC			
NS	3	Status INIT	Off	• Cyclic process data and acyclic data channel are not transmitted • No error
		Status PRE-OPERATIONAL	 Flashing green	Acyclic data channel is transmitted
		Status SAFE-OPERATIONAL	 Green, single flash pattern	Acyclic data channel is transmitted
		Status OPERATIONAL	 Permanently lit green	Cyclic process data and acyclic data channel are transmitted
		Configuration error	 Flashing red	• The drive controller has not been synchronized with the EtherCAT master • Communication error of the drive controller
		Synchronization error	 Red, single flash pattern	• The drive controller has not been synchronized with the EtherCAT master • Communication error of the drive controller
		Timeout - watchdog	 Red, double flash pattern	• Timeout during monitoring of the cyclic process data • Watchdog of the EtherCAT master

1) Flashing pattern: One square corresponds to a duration of 200 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

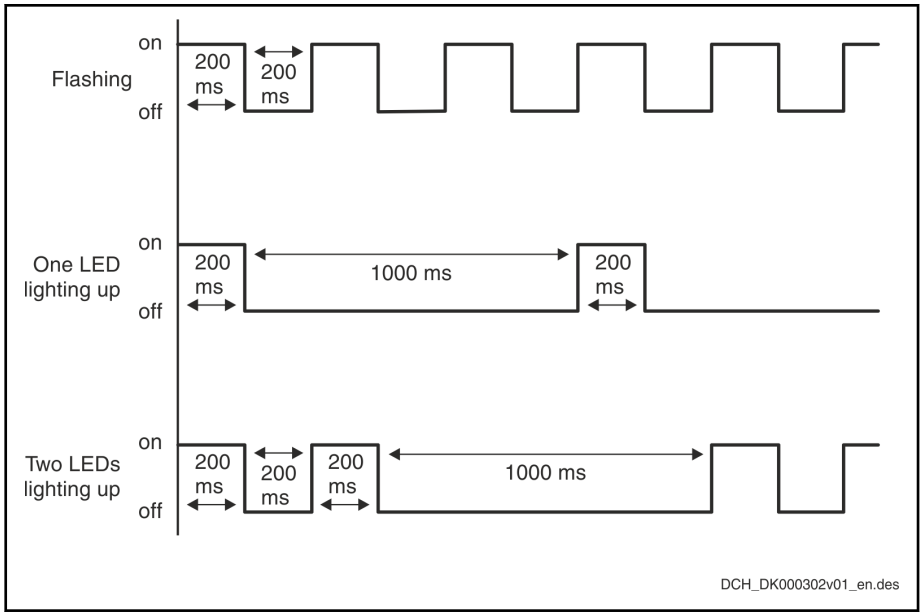


Fig. 4-35: Pulse interval ratio

LEDs on the housing

The LEDs serve for diagnosis of the physical EtherCAT® connection.

LED designation		Significance	Color/flashing pattern	Description
HMC	IAC			
L	1, 5	None	-	With EtherCAT, these LEDs have no function
S	2, 6	Link	off	No connection to the network
			Permanently lit green	Connection to network available, but no telegram exchange (EtherCAT bus inactive)
			Flickering green	Connection to network available with telegram exchange (EtherCAT bus active)

The yellow LED is not used for EtherCAT®

Pertinent parameters

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4089.0.1, Master communication: Protocol
- P-0-4089.0.3, Device address
- P-0-4089.0.4, Active device address
- S-0-0001, NC cycle time (TNcyc)
- S-0-0002, Sercos cycle time (TScyc)
- S-0-0005, Minimum feedback acquisition time (T4min)
- S-0-0007, Feedback acquisition starting time (T4)
- S-0-0014, Interface status
- S-0-0015, Telegram type parameter

- S-0-0016, Configuration list of AT
- S-0-0024, Configuration list of MDT
- S-0-0029, MDT error counter
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0127, C0100 Communication phase 3 transition check
- S-0-0128, C5200 Communication phase 4 transition check
- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-0185, Length of the configurable data record in the AT
- S-0-0186, Length of the configurable data record in the MDT
- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT
- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2
- S-0-0415, Bit number allocation of real-time status bit 1
- S-0-0416, Bit number allocation of real-time status bit 2

Pertinent diagnostic messages

- C0101, Invalid parameters (-> S-0-0021)
- C0104, Config. IDN for MDT not configurable
- C0105, Maximum length for MDT exceeded
- C0106, Config. IDNs for AT not configurable
- C0107, Maximum length for AT exceeded
- C0108, Time slot parameter > Sercos cycle time
- C0112, Set timing not permissible
- C0113, Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114, T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- C0201, Invalid parameters (->S-0-0423)
- C0299, Configuration changed. Restart
- E4005, No command value input via master communication
- F4002, RTD telegram failure
- F4009, Bus failure

4.6.2 CAN application layer over EtherCAT (CoE)

Brief description

General information

General information

It is possible to communicate with the drive via the "CAN application layer over EtherCAT" protocol (CoE, according to ETG.1000.6, V1.0.2). This can also be used to exchange real-time data with an EtherCAT master.

The following communication channels are distinguished:

- **Cyclic data channel** (process data objects → PDO)

  The field bus provides data containers in which payload data can be cyclically transmitted in real time (process data objects).

- **Acyclic data channel** (service data objects → SDO)

  The field bus provides data containers in which payload data (service data objects) can be acyclically transmitted.



For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

- **Ethernet data channel**

  The field bus channels standard Ethernet telegrams via the "Ethernet over EtherCAT" mechanism (EoE). This way, the drive can be configured using the commissioning tool "IndraWorks".



Process data are always transmitted via PDOs.

General features

- Configurable cyclic data up to 12 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes)
- LED indicator lamps at the drive for easy diagnostics of bus functions and the most important communication relations between drive and field bus (a bi-color LED: "Run" status (= green) and "Error" status (= red))
- All parameters of the drive can be directly read and, if permitted, written via SDO
- Support of the device behavior according to Fluid Power profile CiA408 (refer to Profile types).

"CAN application layer over EtherCAT" communication

EDS file

The EDS (Electronic Data Sheet) simplifies the configuration of "CAN application layer over EtherCAT" networks. The EDS file writes the parameters that are supported by the drive in a "CAN application layer over EtherCAT" network. In general, the EDS file can be read by a "CAN application layer over EtherCAT" master (PLC or PC).

Due to the different object directories, there is a separate "CAN application layer over EtherCAT" (CoE) EDS file.

This file complies with the specification according to CiA306 version 4.01. Its name is a combination of the firmware designation and the abbreviated name of the Multi-Ethernet communication:

- HDBxx_CoE.EDS

Configuring the cyclic data (PDO)

PDO configuration

The drive provides a data container in which payload data can be cyclically transmitted in real time (process data objects).

The parameters for configuring the cyclic data, "P-0-4080, Field bus: Config. list of cyclic actual value data ch." and "P-0-4081, Field bus: Config. list of cyclic command value data ch.", contain 16 elements each, of which four have been reserved for each PDO. The max. data length of a PDO is 16

bytes. PDOs have always to be filled with 4 elements. Before that, the next PDO cannot be configured.

Bus cycle	Max. length of cyclic payload data
>= 1 ms	48 bytes
Bus clock < 1 ms / bus clock = position controller clock cycle	16 bytes

Tab. 4-53: Maximum number of payload data per real-time channel

Element in P-0-4080	PDO (tx)		Element in P-0-4081	PDO (rx)
0	PDO1 (tx)		0	PDO1 (rx)
1			1	
2			2	
3			3	
4	PDO2 (tx)		4	PDO2 (rx)
5			5	
6			6	
7			7	
8	PDO3 (tx)		8	PDO3 (rx)
9			9	
10			10	
11			11	
12	PDO4 (tx)		12	PDO4 (rx)
13			13	
14			14	
15			15	

Tab. 4-54: Configuration of cyclic data

Acyclic parameter access (SDO)

All drive parameters can be read or written with the SDO services.

The following SDO services are supported

- "Initiate SDO download" to write max. 4-byte data to the drive (with "Initiate SDO Download" the data length is transmitted)
- "Download SDO segment" to transmit a fragment with data to the drive
- "Initiate SDO upload" to transmit max. 4-byte data from the drive to the master (the drive communicates the response data length to the master)
- "Upload SDO segment" to transmit a fragment with data from drive to master
- "Abort SDO transfer" to report errors and abort SDO accesses

Communication objects (0x1000 to 0x1FFF)

The "CAN application layer over EtherCAT" communication objects are described in CANopen standard CiA301.

These objects have one of the following functions within the "CAN application layer over EtherCAT" communication:

- Access to drive parameters
- Constants
- Read-only objects

The table below gives an overview of the objects prescribed for "CAN application layer over EtherCAT" communication:

Index	Name
0x1000:0	Device type
0x1001:0	Error register
0x1008:0	Manufacturer device name
0x1009:0	Manufacturer hardware version
0x100A:0	Manufacturer software version
0x1018:0	Identity
0x1018:1	Vendor ID
0x1018:2	Product code
0x1018:3	Revision
0x1018:4	Serial number
0x1600:0	1st receive PDO mapping parameter
0x1600:1	1st application object mapping
0x1600:2	2nd application object mapping
0x1600:3	3rd application object mapping
0x1600:4	4th application object mapping
0x1601:0	2nd receive PDO mapping parameter
0x1601:1	1st application object mapping
0x1601:2	2nd application object mapping
0x1601:3	3rd application object mapping
0x1601:4	4th application object mapping
0x1602:0	3rd receive PDO mapping parameter
0x1602:1	1st application object mapping
0x1602:2	2nd application object mapping
0x1602:3	3rd application object mapping
0x1602:4	4th application object mapping
0x1603:0	4th receive PDO mapping parameter
0x1603:1	1st application object mapping
0x1603:2	2nd application object mapping
0x1603:3	3rd application object mapping
0x1603:4	4th application object mapping
0x1A00:0	1st transmit PDO mapping parameter

0x1A00:1	1st application object mapping
0x1A00:2	2nd application object mapping
0x1A00:3	3rd application object mapping
0x1A00:4	4th application object mapping
0x1A01:0	2nd transmit PDO mapping parameter
0x1A01:1	1st application object mapping
0x1A01:2	2nd application object mapping
0x1A01:3	3rd application object mapping
0x1A01:4	4th application object mapping
0x1A02:0	3rd transmit PDO mapping parameter
0x1A02:1	1st application object mapping
0x1A02:2	2nd application object mapping
0x1A02:3	3rd application object mapping
0x1A02:4	4th application object mapping
0x1A03:0	4th transmit PDO mapping parameter
0x1A03:1	1st application object mapping
0x1A03:2	2nd application object mapping
0x1A03:3	3rd application object mapping
0x1A03:4	4th application object mapping
0x1100:0	EtherCAT address (for EtherCAT only)
0x1110:0	Virtual MAC address (for EtherCAT only)
0x1111:0	IP address info (for EtherCAT only)
0x1111:1	IP address (for EtherCAT only)
0x1111:2	Subnet mask (for EtherCAT only)
0x1111:3	Default gateway (for EtherCAT only)
0x1C00:0	Sync manager type (for EtherCAT only)
0x1C00:1	Number of Sync manager (for EtherCAT only)
0x1C00:2	Number of Sync manager (for EtherCAT only)
0x1C00:3	Number of Sync manager (for EtherCAT only)
0x1C00:4	Number of Sync manager (for EtherCAT only)
0x1C12:0	PDO Assign outputs (for EtherCAT only)
0x1C12:1	Index of the corresponding RXPDO (for EtherCAT only)
0x1C12:2	Index of the corresponding RXPDO (for EtherCAT only)
0x1C12:3	Index of the corresponding RXPDO (for EtherCAT only)
0x1C12:4	Index of the corresponding RXPDO (for EtherCAT only)
0x1C13:0	PDO Assign Inputs (for EtherCAT only)

0x1C13:1	Index of the corresponding TXPDO (for EtherCAT only)
0x1C13:2	Index of the corresponding TXPDO (for EtherCAT only)
0x1C13:3	Index of the corresponding TXPDO (for EtherCAT only)
0x1C13:4	Index of the corresponding TXPDO (for EtherCAT only)

Tab. 4-55: Overview of supported "CAN application layer over EtherCAT" objects

Other communication objects are listed in the annex of the separate documentation "Rexroth HydraulicDrive, Parameter Description" and the corresponding EDS file.

Manufacturer-specific objects (0x2000 to 0x3FFF)

All parameters of the drive can be reached via the manufacturer-specific objects.

The S-parameters are addressed via the objects 0x2000 to 0x2FFF, the P-parameters via the objects 0x3000 to 0x3FFF. The manufacturer-specific objects have the following structure:

Parameter access

Subindex	Description
0	Number of object entries
1	Operating datum block 0
2	Operating datum block 1 (if available)
3	Operating datum block 2 (if available)
4	Operating datum block 3 (if available)
5	Operating datum block 4 (if available)
6	Operating datum block 5 (if available)
7	Operating datum block 6 (if available)
8	Operating data block 7 (if available)
9	Number of parameter sets (1 or 8)
10	Index of list pointer
11	List element to which element 10 points (for list parameter only)
12 - 18	List element to which element 10 points (if 8 parameter sets available); for list parameters only
21	Name of the parameter
22 - 28	Name of parameter (if 8 parameter sets available)
31	Attribute of parameter
32 - 38	Attribute of parameter (if 8 parameter sets available)
41	Unit of parameter
42 - 48	Unit of parameter (if 8 parameter sets available)
51	Minimum value of parameter
52 - 58	Minimum value of parameter (if 8 parameter sets available)
61	Maximum value of parameter

62 - 68	Maximum value of parameter (if 8 parameter sets available)
71	Maximum length of list parameter
72 - 78	Maximum length of list parameter (if 8 parameter sets available)
81	Actual length of list parameter
82 - 88	Actual length of list parameter (if 8 parameter sets available)

Tab. 4-56: Overview of supported "CAN application layer over EtherCAT" objects

List access

The complete list of a list parameter can be read or written by accessing the operating datum of the parameter.

To access individual list elements, it is possible to set a list index (subindex 10) and access the respective list element of the list index via subindex 11 (to subindex 18). With each access via subindex 11 (to subindex 18), the list index is incremented by one element. This allows processing a successional part of a list in the case of repeated access to subindex 11 (to subindex 18).

With one of the following actions, the list index is reset to the first element:

- Change of parameter set
- Change of parameter
- Abortion of connection

For each list element access which does not start from the first element, it is therefore necessary to set the list index.

If the length of the list has to be changed, this can be corrected by changing the actual length of the list parameter (subindex 81 - 88). The maximum list length can be read via subindices 71 - 78.

With one of the following actions, the parameter value is stored:

- Writing to last element
- Change of parameter set

The changes are discarded when the control voltage fails.

4.6.3 ServoDrive over EtherCAT® (SoE)

Brief description

General information

Drive controllers with Multi-Ethernet interface (ET) can be operated as EtherCAT® master communication. Via these modules, it is possible to exchange real-time data with an EtherCAT® master.

We distinguish the following communication channels:

- Cyclic data channel (process data)
  - Data container for cyclic transmission of payload data (process data) in real time
- Acyclic data channel
  - EtherCAT® mailbox method for acyclic transmission of service data (parameter channel)
  - Transmission of Ethernet telegrams via the EtherCAT® mailbox method [Ethernet over EtherCAT® (EoE)]

For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

General features

- Transmission rate 100 Mbit/s
- Data transmission over Ethernet cable (CAT5e copper)
- Topology: "Line"
- Support of "Ethernet over EtherCAT" (EoE)
- Support of "Servo Drive Profile over EtherCAT®" (based on the Sercos II specification) (SoE)
- Support of "CAN application protocol over EtherCAT" (CoE)
- Access to 16-bit Sercos parameters of the drive via "SoE" protocol ("Servo Drive Profile over EtherCAT®" protocol)
- Access to 16-bit Sercos parameters of the drive via "CoE" protocol ("CAN over EtherCAT®" protocol)
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- Max. length of the configurable MDT/AT data 15 IDNs with max. 48 bytes; with bus cycle = position controller cycle, the max. length is halved to 24 bytes
- Minimum cycle time 1 ms. Only multiples of the position controller cycle can be set as cycle time
- "Distributed clock synchronization" (exact matching of distributed clocks)
- Synchronization between the time when the command value takes effect and the time of measurement of the actual values for all drives connected to a ring
- Overall synchronization of all connected drives with the master
- Only released in connection with "Beckhoff TwinCAT"

Cyclic and acyclic data channel

Cyclic data/process data

The cyclic data consist of parameter "S-0-0134, Master control word" or "S-0-0135, Drive status word" and the parameters entered in "S-0-0016, Configuration list of AT" or "S-0-0024, Configuration list of MDT".

In S-0-0016/S-0-0024 max. 15 IDNs can be entered each. The length of the parameters entered in S-0-0016/S-0-0024 may be max. 48 bytes. In case of bus cycle time = position controller cycle time, this length is reduced to 24 bytes.

The cyclic data have to be configured via the master. Then, the master configures the cyclic telegram and writes the parameters S-0-0016 and S-0-0024 on phase progression.

Acyclic data channel

Parameter channel

Access to 16-bit Sercos parameters of the drive via "SoE" protocol ("Servo Drive Profile over EtherCAT®" protocol) EIDN access is only possible if a corresponding 16-bit alias is available.

Device description file

The XML device description file communicates the device type (drive, IO, etc.) and the individual device properties to the master.

The device description of all HydraulicDrives with EtherCAT is provided by the manufacturer.

It has to be made available to the EtherCAT master (for TwinCAT, the archive is to be unpacked into the folder \TwinCAT\Io\EtherCAT\). When the device description is updated, older versions have to be deleted.

4.6.4 Ethernet over EtherCAT®

Functional description

General information

With "Ethernet over EtherCAT" (EoE), standard Ethernet telegrams are channeled to the drive via the EtherCAT mailbox. This way, the drive can be accessed via the standard Ethernet and the following engineering possibilities arise:

- Engineering using EoE via optional Ethernet switch port
- Engineering using EoE via optional Ethernet switch port
- Engineering by means of EoE (or ADS interface via third-party control unit)

Address settings

Slave address

The IP address of the slave is set in the master and then transmitted to the slave. For this reason, the parameters S-0-1020, S-0-1021 and S-0-1022 must not be changed (manually) directly in the drive. The (virtual) Mac address of the slave is not displayed in a parameter.

The command C6100 "Activate IP settings" (P-0-1534) is automatically started in the drive to apply the IP settings that were changed by the master.

In TwinCAT, the dialog for EoE IP settings is displayed as follows:

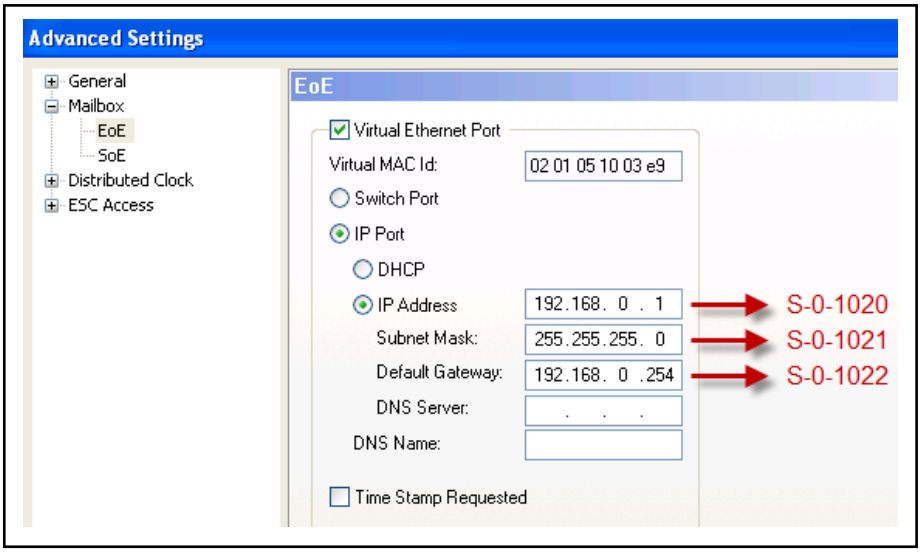


Fig. 4-36: IP settings in EoE

Master address

If an EoE slave is to be directly accessed from a master PC, the IP address (of the master) has to be in the same network segment as the address of the slave.

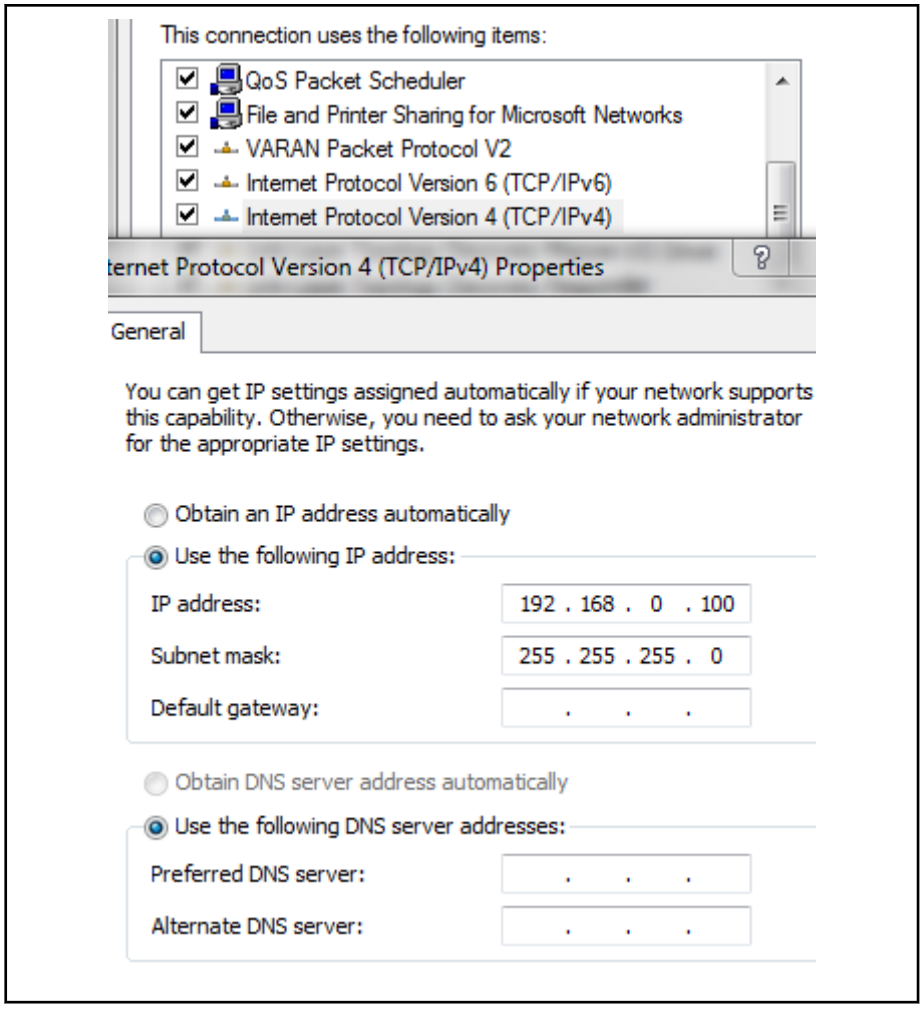


Fig. 4-37: Master IP address

If IndraWorks is directly installed on the EtherCAT master, the option "Connect to TCP/ IP stack" is to be activated for TwinCAT:

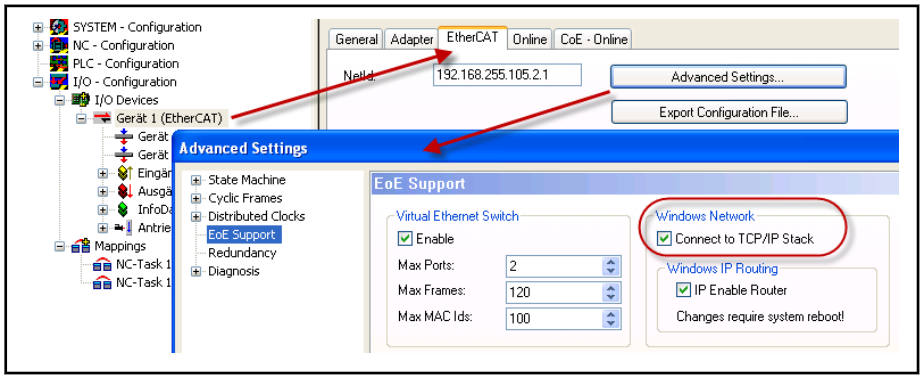


Fig. 4-38: TwinCAT settings

Connection via EoE

In IndraWorks, the connection to the drive is established via Ethernet as usual. The connection is selected in the "Connection selection" dialog.

Switch port

The switch port is implemented in the EtherCAT line and offers an additional Ethernet connection. The Ethernet telegrams are fed into the EtherCAT string via the switch port.

This type of switch port is, for instance, available from Beckhoff under the designation EL6601.

To use the EL6601 switch port, it has to be connected to EtherCAT terminals as it does not feature an RJ45 EtherCAT port.

Pertinent parameters

- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- P-0-1534, C6100 Command Activate IP settings
- P-0-1044, Master comm. engineering over IP: Status IP communication

Protocol switching

Initial commissioning requires particular care. If an "incorrect" protocol is set for this type of devices, operation is impossible, maybe not even the communication with IndraWorks for setting the correct protocol. To establish a connection to the drive, the following protocol switching options are provided:

Switching can be performed directly in the IndraWorks connection selection dialog if no EtherCAT master has been connected to the device after start-up.

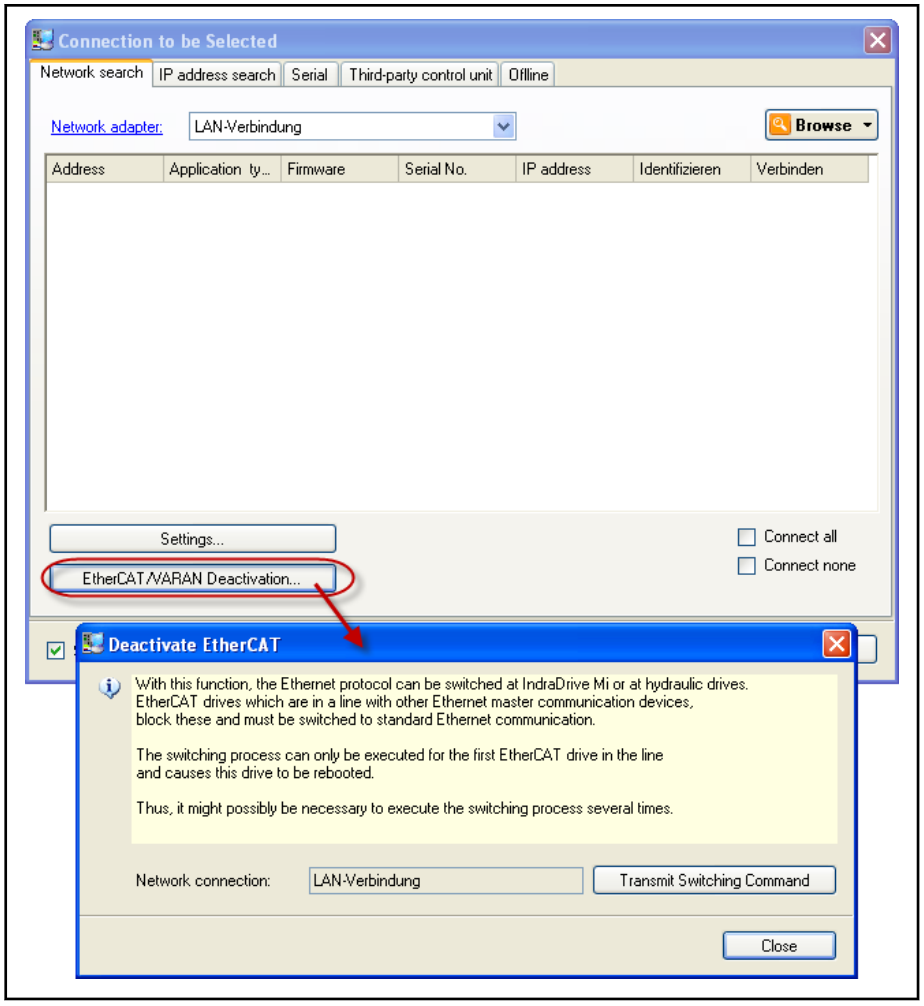
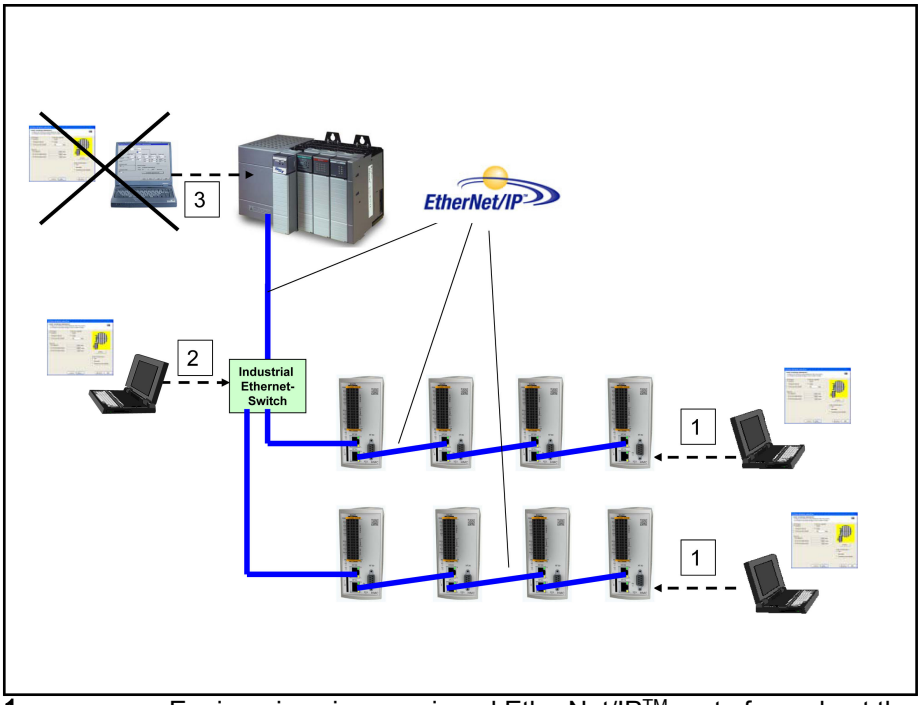


Fig. 4-39: Connection selection dialog in IndraWorks

4.7 EtherNet/IP™ interface

4.7.1 Brief description

Topology



1 Engineering via unassigned EtherNet/IP™ port of a node at the bus
2 Engineering via optional Industrial Ethernet switch
3 Engineering via third-party control unit not possible

Fig. 4-40: EtherNet/IP™ topology

HydraulicDrive controllers with Multi-Ethernet interface can be operated as EtherNet/IP™ master communication. Via this module, it is possible to exchange real-time data with an EtherNet/IP™ scanner.

Real-time data can be transmitted via this interface by means of an I/O connection (class 1 connection).

To achieve high system flexibility, all data are accessible via objects. With the EtherNet/IP™ interface, these objects can be addressed through class, instance and attribute. Some of these objects can be assigned to the I/O connection as real-time data and thus be cyclically transmitted. There is also the option of transmitting via "Explicit Message", but no objects defined in the real-time channel (P-0-4081) may be written by the master via "Explicit Message".

Features

- Transmission rate 100 Mbit/s (full duplex)
- Data transmission via Ethernet cable (CAT5e-copper)
- Topologies: "Star", "line" (with integrated cut through switch)
- Autonegotiation is supported, provided the above-mentioned transmission rate is available
- The profile type is "Generic Device", specified in ODVA 2.0 (**O**pen **D**eviceNet **V**endors **A**ssociation)
- EtherNet/IP™ Level 2 Server
- Cyclic exchange via "EtherNet/IP™ I/O Messaging" (Class 1)
- Acyclic data exchange via "EtherNet/IP™ Unconnected Explicit Messaging" and "Explicit Messaging" (Class 3)

For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

- The smallest supported cycle time (API → Actual Packet Interval) is 2 ms
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

- It is recommended that the Industrial Ethernet network should not be coupled to a corporate network (office communication). (Alternatively, a level 3 router can be used to connect the industrial Ethernet network to a corporate network).
- It is recommended using only cut-through switches for industrial Ethernet communication.
- Particularly for cables leading out of the control cabinet and cables that are longer than 10 m, it is recommended that a star topology with cable type AWG22 or shielded cables be used.

- Supported field bus profiles:
  - 0x0000: "No profile"
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "operation mode neutral"
  - 0xFFFE: Freely configurable mode

Axis addressing

With EtherNet/IP, the master communication address is an IP address. It can be set in "P-0-4089.0.13, Master communication: IP address"

The device address set in "P-0-4089.0.3, Device address" is applied in parameter "P-0-4089.0.4, Active device address" after the device is restarted. This address does not influence the EtherNet/IP communication!

Pertinent parameters

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4079, Field bus: Baud rate
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Profile type parameters

Apart from pure communication parameters, parameters related to the profile types are used.

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication possibilities.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "Multiplex channel"

Pertinent diagnostic messages

- C0229, Field bus: IDN for cycl. command val. not configurable
- C0230, Field bus: Max. length for cycl. command val. exceeded
- C0231, Field bus: IDN for cycl. actual val. not configurable
- C0232, Field bus: Length for cycl. actual values exceeded
- C0233, Field bus: Tcyc (P-0-4076) incorrect
- C0234, Field bus: P-0-4077 missing for cycl. command values
- C0299, Configuration changed. Restart
- E4005, No command value input via master communication
- E4006, Communication module overload
- E4011, Communication watchdog: Overload of cyclic communication
- F4009, Bus failure
- F4011, Communication watchdog: Overload of cyclic communication

4.7.2 Configuration of the EtherNet/IP™ slave

EDS file

For each EtherNet/IP™ device, it is necessary to have an EDS file (*.EDS) which contains the data required for operating the device on the field bus. This file is required for every node when configuring the bus masters that support the EDS file.

The EDS file for HydraulicDrive is an ASCII file with the name "HydraulicDrive_EIP_HDx19.EDS".

Setting the IP address of the slave

The settings are made using the commissioning tool "IndraWorks".

The IP address of the EtherNet/IP™ adapter is stored in parameter "P-0-4089.0.13, Master communication: IP address", the subnet mask in parameter "P-0-4089.0.14, Master communication: Network mask" and the gateway address in parameter "P-0-4089.0.15, Master communication: Gateway address".

☞ The device address set in "P-0-4089.0.3, Device address", is applied in the parameter "P-0-4089.0.4, Active device address", after the device is restarted. This address does not influence the EtherNet/IP communication!

☞ This IP address is only relevant for communication with the scanner! For engineering (e.g. IndraWorks), the engineering address (S-0-1020, Master comm. engineering over IP: IP address) has to be used.

Configuration of cyclic data

The parameters for configuring the cyclic data (P-0-4080 and P-0-4081) can contain a maximum of 15 elements each. The maximum length is limited to 24 words.

Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (multiples of the position controller clock cycle).

☞ Parameter "P-0-4076, Field bus: Process data - updating clock" is used to define the update cycle for applying the data from the Multi-Ethernet interface to the drive and vice versa.

These parameters are set using the commissioning tool "IndraWorks".

4.7.3 Specification of the EtherNet/IP™ interface

The drive works with the EtherNet/IP™ interface switched on as level 2 device. This means that the drive provides one server each for implicit messages (Class 1) and explicit messages (Class 3). Explicit messages are limited to standard objects.

The implemented EtherNet/IP™ object directory contains the objects specified for a "Generic Device":

- Identity object (0x01)
- Message router object (0x02)
- Ethernet link object (0xF6)
- TCP/IP object (0xF5)
- Port object (0xF4)
- Connection manager object (0x06)
- Assembly object (0x04)

4.7.4 Cyclic communication via the process data channel (class 1)

EtherNet/IP™ connection types

With a drive as EtherNet/IP™ slave, parameters can be cyclically transmitted via an I/O container. This can take place via an "Exclusive Owner Connection" (Transport Class 1) or a "Listen-Only Connection" (Transport Class 1).

With the "Exclusive Owner Connection", the EtherNet/IP™ input image is transmitted to the drive by means of a "point-to-point" connection. The output image can be transmitted by means of "point-to-point" or "multicast" connection.

With an already existing "Multicast Exclusive Owner Connection", a second master can read the EtherNet/IP™ output image of the drive with a "Listen-Only Connection". In this case, a "Heartbeat Connection Point" is used as Consuming Connection Point, and the connection point that is also used for the "Exclusive Owner Connection" is used as Producing Connection Point.

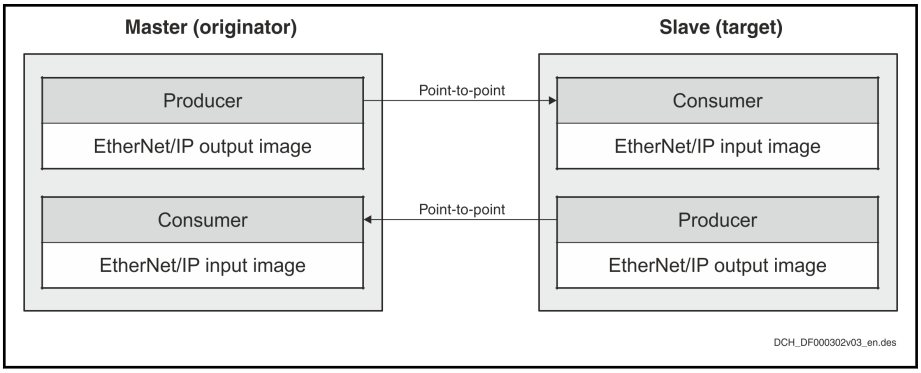


Fig. 4-41: EtherNet/IP™ connection type "point-to-point"

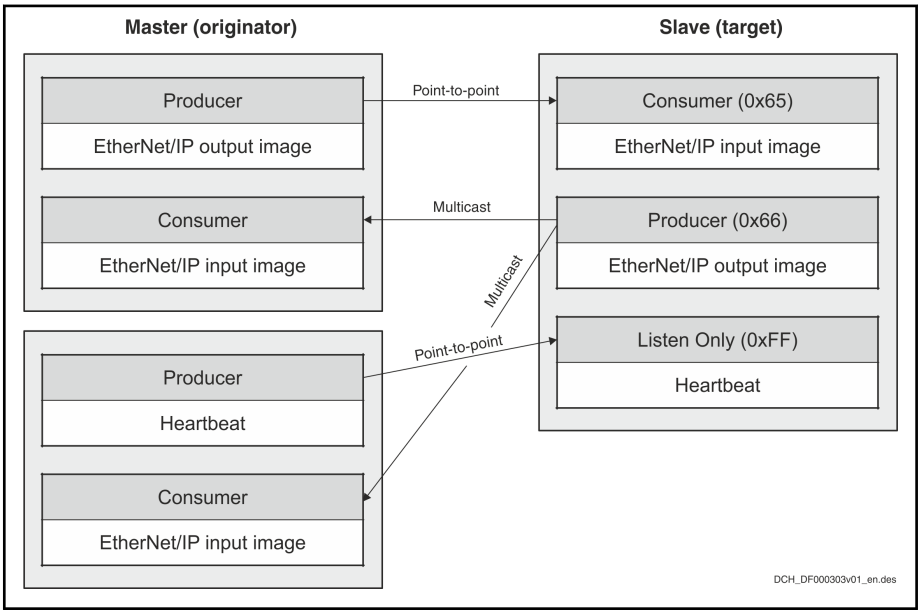


Fig. 4-42: EtherNet/IP™ connection type "multicast"

For the cyclic I/O data channel ("Implicit Message"), the drive provides a consumer and a producer, i.e. it consumes the command values from the master and generates the actual values for the master.

In this case, communication runs via a UDP protocol whereas the direction from master to slave is transmitted with unicast telegrams and the opposite direction is transmitted with multicast telegrams.

Characteristic of cyclic data transmission

Features

- The smallest cycle time that is supported by HydraulicDrive (API → Actual Packet Interval) is 2 ms.
- The "Idle/Run Header" of the EtherNet/IP™ interface is supported (32 bits). The header is not visible in the cyclic I/O image of the drive. The reaction of the drive to the Idle/Run Header is defined via the settings of the setting-up mode (easy startup mode).
- The consumer instance of the drive monitors the cyclic transmission of the master output image via a so-called "TimeOut" time that is determined by the master when the connection is established.

The monitoring time is calculated according to the formula below:

$$t = TM \times API$$

$$TM = 2^{(TMV + 2)}$$

t Monitoring time (in ms)
TM TimeOut multiplier
API Actual packet interval
TMV TimeOut multiplier value

Fig. 4-43: Calculating the monitoring time in two steps

Examples

TMV	TM	API (in ms)	t (in ms)
0	4	2	8
0	4	5	20
1	8	2	16
1	8	5	40
2	16	2	32
3	32	2	64
4	64	5	320
2	16	10	160

Tab. 4-57: Exemplary values of the monitoring time

In most of the configuration user interfaces, it is possible to enter the "Time-Out Multiplier" directly. The user then does not have to take the first formula into account.

Configuring the cyclic process data

The cyclic channel is configured by parameterization of "P-0-4080, Field bus: Config. list of cyclic actual value data ch." and "P-0-4081, Field bus: Config. list of cyclic command value data ch.".

At the EtherNet/IP™ communication level, a static Output Assembly Instance (Class 4, instance 101) and a static Input Assembly Instance (Class 4, instance 102) are created in the cyclic channel. In this case, the data direction is written from the master's point of view. If the parameter setting of P-0-4080 and P-0-4081 is changed, new assembly instances are created during the transition from parameterization mode (PM) to operating mode (OM). This results in a short interruption of the communication.

4.7.5 Acyclic parameter access via "Explicit Message" (Class 3 /UCM)

General information on parameter setting

To enable parameter setting via EtherNet/IP™ interface, all IDN parameters can be reached via a manufacturer-specific class object with the corresponding instances for each IDN parameter. The IDN parameters can be addressed either via an "Unconnected Explicit Message" (UCM) or via a "Connected Explicit Message" (Class 3).



Acyclic parameter access via "Explicit Message" (Class 3/UCM) only enables access to IDN parameters, e.g. "P-0-4006, Positioning block target position". EIDN, also refer to "Note on parameter access"

☞ The field bus control word cannot be operated via "Explicit Message". To enable axis control, the higher-level control of the cyclic data channel has to be used according to the "Class 1 Connection" specification or programmed according to the MLD logic with permanent control. If the control is not equipped with a "Class 1 Connection", no axis control can be carried out without MLD.

Addressing

For EtherNet/IP™ communication, the objects are addressed according to the following scheme:

Class → instance → attribute

Class All parameters of a subdevice (e.g. drive) are mapped to the manufacturer-specific classes 100 (0x64) + subdevice index, i.e. subdevice 0 --> class 100, subdevice 1 --> class 101,…, subdevice 98 --> class 198.

Instance The instance number is identical to the IDN of the drive parameter.

Bit	Significance
15	**0**: Default data (standardized) **1**: Product data (specified by the manufacturer)
14 … 12	Parameter sets from 0 to 7
11 … 0	Data block number from 0 to 4095

Tab. 4-58: Structure of the IDN

The instance number can be calculated with the following formula:

$$Inst = (32768 \times type) + (4096 \times set) + block$$

Inst instance number
type Parameter type (in case of S-parameter 0 and P-parameter 1)
set Set number
block Data block number

Fig. 4-44: Calculating the instance number

Attribute The format of the parameter depends on the attribute number.

The operating data can have four different formats:

- Data length 2 bytes → **W**
- Data length 4 bytes → **L**
- ASCII text with max. length of 64 bytes → **T**

There are three types of parameters:

- Single parameters
- Command parameters
- List parameters

Irrespective of its type, each parameter has these attributes (read-only):

No.	Name	Function	Format
0	Number of elements	Number of supported elements	W
1	IDN	Sercos identity number (IDN)	T [8]

No.	Name	Function	Format
2	Name	Parameter name	T [60]
3	Attribute	Form of representation of the parameter	L
4	Unit	Parameter unit	T [12]
5	Min. input value	Min. possible value of the datum	W/L/T
6	Max. input value	Max. possible value of the datum	W/L/T

Tab. 4-59: Basic attributes of a drive parameter

Depending on its type, each parameter has other attributes of different significance:

No.	Name/function	Format
7	Operating data	W/L/T
8	Max. number of list elements / length of text	L
9	Actual number of list elements / length of text	L
10	Pointer to the element which is processed on the next access to element 11 - 20	L
11	Action for 1 list element (list pointer is moved along)	W/L/T
12	Action for 2 list elements (list pointer is moved along)	W/L/T
13	Action for 3 list elements (list pointer is moved along)	W/L/T
14	Action for 4 list elements (list pointer is moved along)	W/L/T
15	Action for 5 list elements (list pointer is moved along)	W/L/T
16	Action for 6 list elements (list pointer is moved along)	W/L/T
17	Action for 7 list elements (list pointer is moved along)	W/L/T
18	Action for 8 list elements (list pointer is moved along)	W/L/T
19	Action for 9 list elements (list pointer is moved along)	W/L/T
20	Action for 10 list elements (list pointer is moved along)	W/L/T

Tab. 4-60: Type-dependent attributes of a drive parameter

Accessing single parameters

The value can be accessed by writing and reading the operating datum of the parameter. For single parameters, the value of number of attributes is "7".

Access to texts

The value can be accessed by writing and reading the operating datum of the parameter. The maximum length of the text and the actual length of the text can be read with attributes 8 and 9. Additionally, a text can be treated as a 1-byte list. On access to parameter texts, the value of number of attributes is "20".

Accessing command parameters

A command can be started by writing "3" to the operating datum. The command status is obtained by read-accessing the operating datum. On access to command parameters, the number of attributes results in a value of "7".

Accessing list parameters

The maximum list size can be determined by reading the maximum amount of data of the parameter (attribute 8). The real size is stored in the actual quantity of data of the parameter (attribute 9) and can be modified unless the list is write-protected. All data refer to the parameter format. The datum to be processed in the list is defined by the pointer to the datum (attribute 10). If the data value is zero, the pointer is automatically modified in the following situations:

- Zero is loaded when changing from another parameter to this parameter.
- After each operating data access, the pointer is raised by the number of elements which were read.

By accessing attribute 11, one element is processed, attribute 12, two elements are processed, etc. up to attribute 20 for processing 10 elements. The pointer is increased by the processed elements. On access to list parameters, the number of attributes results in a value of "20".



For successful access to the operating datum, the pointer has to be smaller than the actual length.

Example Parameter (P-0-0013) has 18 list elements and is to be read:

- Calculate instance with formula

  Input:

  – P-parameter → type = 1
  – Parameter set 0 → set = 0
  – Data block number 13 → block = 13

  → Instance = 32781
- Read: Class 100, instance 32781, attribute 9 = 18 (actual length)
- Write: Class 100, instance 32781, attribute 10 = 0 (list pointer)
- Read: Class 100, instance 32781, attribute 11 = element 0

  → List pointer now automatically pointing to 1
- Read: Class 100, instance 32781, attribute 20 = elements 1 to 10

  → List pointer now automatically pointing to 11
- Read: Class 100, instance 32781, attribute 12 = element 11, 12

  → List pointer now automatically pointing to 13
- Read: Class 100, instance 32781, attribute 15 = elements 13 to 17

  → List pointer now automatically pointing to 18
- Read: Class 100, instance 32781, attribute 10 = 18 (pointer)

Any further access to the operating datum without loading the list pointer again would not supply any data (list pointer = actual length). The number of attributes supplies the value "20".

Storing list elements

List elements are not directly stored permanently. Storing takes place by one of the following actions:

- Writing the last element of the list
- Read-accessing the list
- Access to another parameter
- Termination of connection

When the control voltage fails, all changes which were not stored are deleted!

Error codes while accessing parameters

When a vendor-specific error occurs during parameter access, the additional error code points out the cause of the error.

The following table lists the most important error codes.

Error no. (hex)	Significance
0x03	Invalid parameter value • Value is smaller than minimum value • Value is greater than maximum value • Incorrect value • Invalid indirect addressing • Procedure command not executable (invalid or false parameters)
0x0E	Parameter cannot be changed
0x0F	Parameter is password-protected
0x10	Parameter is write-protected • Parameter is currently write-protected • Parameter write-protected since it is cyclically configured in MDT • Parameter is currently write protected due to other settings (parameter, operation mode, drive enable...) • Procedure command currently not executable (e.g., procedure command cannot be activated in this phase)
0x13	Parameter transmitted too short
0x15	Parameter transmitted too long
0x1F	• Procedure command already active • Procedure command cannot be interrupted

Tab. 4-61: Error codes and their significances while accessing parameters

4.7.6 Diagnostic and status messages

Diagnostic messages via LEDs

The diagnostic displays via LED (module status, network status), which are required according to EtherNet/IP™ specification, have been realized by the corresponding status LEDs.

Module status The indication of the "module status LED" is described in chapter "Diagnostic LED".

Network status The EtherNet/IP™ network status is displayed via the respective "network status LED".

LED		Significance	Color	Description
IAC	HMC			
2, 6	S-XF20, S-XF21	Status	 Permanently lit yellow	Data transmission running
1, 5	L-XF20, L-XF21	Link	 Permanently lit green	Connection to network available
3	NS	Not active	 Off	Interface has been switched off (24 V supply) or has no IP address
		Not connected	 Flashing green	Interface has an IP address, but no connection
		Connected	 Permanently lit green	Connection to network available, data transmission running
		Timeout	 Flashing red	Existing connection was aborted
		Invalid IP address	 Permanently lit red	Assigned IP address is already used by another device
		Self-test	 Flashing red-green	After switching on, interface carries out a self test

Tab. 4-62: EtherNet/IP™ display elements

Diagnostic messages

Diagnostic messages and their significance in conjunction with the EtherNet/IP™ master communication:

- E4005, No command value input via master communication

  → The master is in the stop mode and the EtherNet/IP™ stack thereby is in the status "IDLE" or the master has specifically aborted the I/O connection and the EtherNet/IP™ stack thereby is in the status "CLOSED".

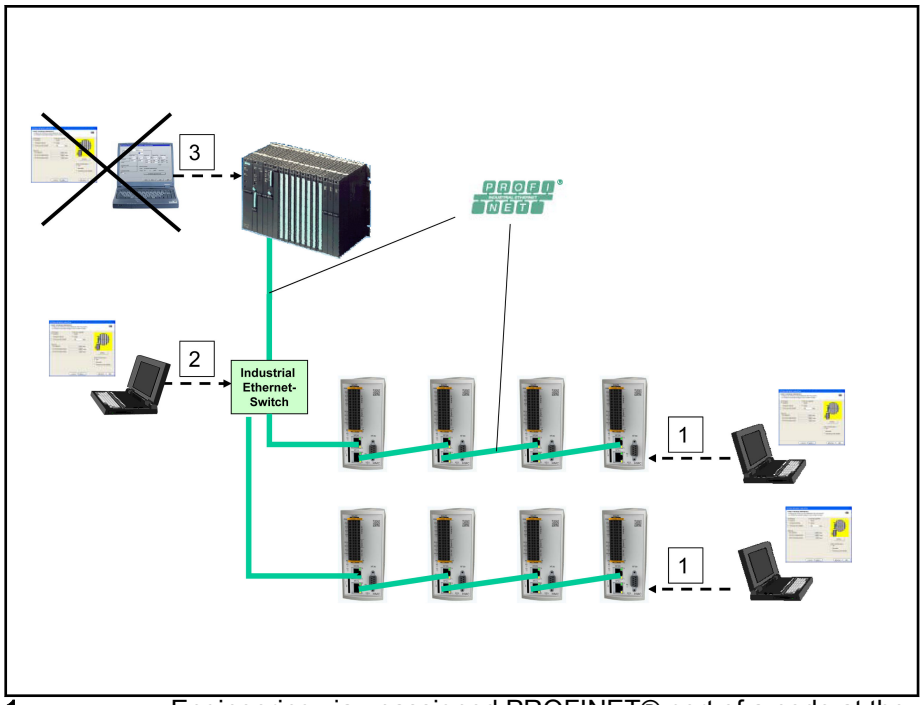
- F4009, Bus failure

  → The master has not received any telegram within the watchdog time. The watchdog time is calculated according to the described formula for the "TimeOut" time.

4.8 PROFINET®

4.8.1 Brief description

Topology



1 Engineering via unassigned PROFINET® port of a node at the bus
2 Engineering via optional Industrial Ethernet switch
3 Engineering via third-party control unit by means of TCI not possible

Fig. 4-45: Engineering options with PROFINET®

HydraulicDrives with Multi-Ethernet interface (ET) can be operated as PROFINET® master communication. Via this module, it is possible to exchange real-time data with a PROFINET® controller.

The field bus provides data containers in which payload data can be cyclically transmitted. This section is referred to as **cyclic data channel** (PROFINET®).

The cyclic data channel is subdivided as follows:

- One (optional) **device-specific parameter channel** for reading and writing of all parameters via PROFINET®.

☞ The **device-specific parameter channel** does not provide any "real-time properties"!

- One **axis-specific process data channel** (real-time channel) which contains firmly declared information that can be directly interpreted by the receiver.

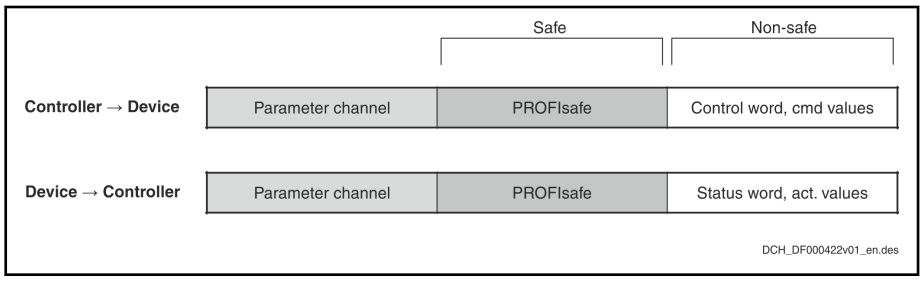


Fig. 4-46: Cyclic data channel overview

☞ To simplify field bus communication, PLC function blocks for different programmable logic controllers (PLCs) are provided. The function blocks support the basic functionalities of “axis-specific process data channel” and “device-specific parameter channel”. The principles applied can be easily used for other PROFINET® controllers.

Features The PROFINET® device connection with Multi-Ethernet interface offers the following features:

- Ethernet according to IEEE 802.3 and prioritization according to IEEE 802.1Q
- Transmission rate 100 Mbit/s
- Data transmission over Ethernet cable (CAT5e copper)
- Topologies: "Star", "line" (with integrated cut-through switch)
- Assignment of IP addresses via DCP protocol (**D**iscovery and **B**asic **C**onfiguration)
- The smallest supported cycle time (IO cycle update time) is 2 ms.

☞ The IO cycle update time is written by the control unit and is the time cycle in which the process data from the PROFINET network are applied to the Multi-Ethernet interface and written in the other direction.

- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)
- Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (multiples of the position controller clock cycle).

☞ Parameter "P-0-4076, Field bus: Process data - updating clock" defines the update cycle for applying the data from the Multi-Ethernet interface onto the drive and vice versa.

☞ During planning, installation and commissioning of a system, reference is made to the following guidelines (PROFINET trilogy):

- Planning guideline
- Installation guideline
- Commissioning guideline

The guidelines can be obtained from the PNO secretariat (PROFIBUS Nutzerorganisation e. V.).

☞ It is recommended

- not to couple the Industrial Ethernet network to a corporate network (office communication). (Alternatively, a level 3 router can be used to connect the industrial Ethernet network to a corporate network).
- to only use cut-through switches for Industrial Ethernet communication.
- to use a star topology with cable type AWG22 or shielded cables particularly for cables leading out of the control cabinet and cables that are longer than 10 m.

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- LED for PROFINET® status diagnosis (network status)
- LEDs to display the link/activity status
- CCA and RT_CLASS1 support
- For reasons of compatibility with drive controllers with PROFIBUS® master communication module, no diagnostic messages and alarms are used
- PROFINET® IRT is not supported
- Operation in PROFINET® IRT networks is not possible
- Supported field bus profiles:
  - 0x0000: "No profile" selected
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "operation mode neutral"
  - 0xFFFE: Freely configurable mode

Axis addressing

In PROFINET, nodes are addressed via the so-called device name. It is stored in P-0-4089.0.2, where it can also be changed.

☞ The device address set in "P-0-4089.0.3 Device address" is applied in parameter "P-0-4089.0.4, Active device address" after the device is restarted. This address does not influence the PROFINET communication!

Pertinent parameters

Communication parameters

Specific parameters for communication via PROFINET®:

- P-0-4089.0.11, Master communication: MAC address Port1
- P-0-4089.0.12, Master communication: MAC address Port2

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4079, Field bus: Baud rate
- P-0-4083, Parameter channel: Length
- P-0-4083.0.1, Parameter channel: Configuration

- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Profile type parameters

Apart from pure communication parameters, parameters related to the profile types are used.

See "Profile types (with field bus interfaces)"

See "Engineering/diagnostic interfaces"

Parameters for extended communication

Additional parameters are used for extended communication possibilities.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "Multiplex channel"

Pertinent diagnostic messages

- C0229, Field bus: IDN for cycl. command val. not configurable
- C0230, Field bus: Max. length for cycl. command val. exceeded
- C0231, Field bus: IDN for cycl. actual val. not configurable
- C0232, Field bus: Length for cycl. actual values exceeded
- C0233, Field bus: Tcyc (P-0-4076) incorrect
- C0234, Field bus: P-0-4077 missing for cycl. command values
- C0299, Configuration changed. Restart
- E4005, No command value input via master communication
- E4006, Communication module overload
- E4011, Communication watchdog: Overload of cyclic communication
- F4009, Bus failure
- F4011, Communication watchdog: Overload of cyclic communication
- F4012, Incorrect I/O length

4.8.2 Configuring the PROFINET® slave

General station description for HydraulicDrive

As any other PROFINET® device, HydraulicDrives also have to be configured in the field bus controller. For this purpose, the respective general station description file (GSDML) "**GSDML-V2.25-Bosch Rexroth AG-011F-HydraulicDrive_xxVxx-xxxxxxxx.xml**" is required and is to be integrated in the project ("YYYYMMDD" specifies the creation date of the GSDML file). When configuring the bus controller, this GSDML file is required for each node.



The general station description for HydraulicDrive supports all hardware variants and enabling of functional packages.

HydraulicDrives assign their data to four slots (in the case of single-axis devices) or seven slots (for double-axis devices), which may have to be configured. A slot is an interface for one module.

Each slot has a certain module assignment that has to be complied with for correct configuration.

- Slot 1: Parameter channel
- Slot 2: F-module axis 0 (reserved for PROFIsafe, currently not used)
- Slot 3: Inputs axis 0
- Slot 4: Outputs axis 0
- Slot 5: F-module axis 1 (reserved for PROFIsafe, currently not used)
- Slot 6: Inputs axis 1
- Slot 7: Outputs axis 1

The default configuration is stored in the general station description "Input 1 Word" and "Output 1 Word" (single-axis device) without safety technology and without parameter channel. This setting is active after loading of the default values.

☞ By default, "IndraWorks Ds/D/MLD" stores the general station description in the directory "C:\Programs\REXROTH\IndraWorks \DeviceDataSheets\IndraDrive\Profinet" in the course of the installation.

Module 1: Parameter channel

These modules are marked with "ParamCh" and are of the input/output module type. If no parameter channel is required, the module "ParamCh not used" has to be selected.

If IDN parameters or EIDN parameters are to be written via the parameter channel, observe the following aspects:

- IDN parameters

  To write a 2-byte IDN parameter (e.g. P-0-4006), the "ParamCh 5 Words" module has to be included and configured accordingly in parameter "P-0-4083.0.1, Parameter channel: Configuration".

- EIDN parameters

  To write a 4-byte EIDN parameter (e.g. P-0-4006.0.0), the "ParamCh 6 Words" module has to be included and configured accordingly in parameter "P-0-4083.0.1, Parameter channel: Configuration".

☞ The parameter channel length is displayed in bytes in parameter "P-0-4083, Parameter channel: Length".

If the command/actual values are incorrectly configured, error "F4012, Incorrect I/O length" is displayed.

☞ For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

F-module

The blank module "F-Module not used" is assigned to slot 2.

Module inputs

For these modules, the length of the input data is set in words. The module identifier is "Input". For successful data exchange of the axis-specific process data channel, the set length must be equal to the value in parameter "P-0-4082, Field bus: Length of cyclic actual value data channel" that specifies the length in bytes.

☞ Also if an incorrect input data length is specified, communication via the device-specific parameter channel is possible.

☞ If the configuration of the controller does not correspond to the configuration of the HydraulicDrive, the HydraulicDrive will generate the error message "F4012, Incorrect I/O length".

Module outputs For these modules, the length of the output data is set in words. The module identifier is "Output". The set length of the output data has to correspond to the value of parameter "P-0-4071, Field bus: Length of cyclic command value data channel".

☞ If the configuration of the controller does not correspond to the configuration of the HydraulicDrive, the HydraulicDrive will generate the error message "F4012, Incorrect I/O length".

Modules 5 to 7 Used exclusively for double-axis devices.

Display of the device name/IP address of the HydraulicDrive device

The assigned device name is displayed in parameter "P-0-4089.0.2, Master communication: Device name". If a device is replaced, the device name can be manually set via IndraWorks by means of this parameter. The IP settings that are assigned to the device during project planning are displayed in the following parameters:

- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

If "temporary assignment" is configured, (assignment by the controller during run-up) the IP address "0.0.0.0" is displayed in the parameters.

☞ The device address set in "P-0-4089.0.3, Device address" is applied in parameter "P-0-4089.0.4, Active device address" after the device is restarted. This address is shown in the display and does not influence the PROFINET communication!

☞ The IP address is only relevant for communication with the controller! For engineering (e.g. IndraWorks), the engineering address (S-0-1020, Master comm. engineering over IP: IP address) has to be used.

Configuring the process data channel

Standard process data channel (not safety-related) The user can freely configure the cyclic data in the standard process data channel according to the process requirements.

☞ For the profile types "freely configurable mode" (P-0-4084 = 0xFFFE), "I/O mode positioning" (P-0-4084 = 0xFF82) or "I/O mode" (P-0-4084 = 0xFF92 preset velocity) a default configuration is set, which can be changed by the user at any time.

Also refer to "Profile types (with field bus interfaces)"

Configuration list of cyclic actual value data channel In parameter "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", the structure and therefore the number of words and their assigned objects (indices) for the process input data (device → controller) are mapped. The controller can use this configuration in order to localize the individual real-time data in the field bus.

Configuration list of cyclic command value data channel

In parameter "P-0-4081, Field bus: Config. list of cyclic command value data ch.", the structure of the process output data (controller → device) is mapped. This enables reading the current structure and hence the assignments in the field bus over the parameter channel.

☞ Up to 15 real-time parameters (incl. control and status word) can be configured on the bus per data direction (max. 48 bytes or 24 words).

PROFIsafe process data channel (safety-related)

☞ The **safety-related, axis-specific process data channel** is not available in HydraulicDrive. For configuration, however, the module "F-Module not used" is to be integrated!

Length of the process data channel (real-time data channel)

Standard process data channel (not safety-related)

The parameter channel (optional) and the process data channel, in which the real-time data of the drive controller are transmitted, are arranged within the cyclic channel.

The PROFINET® device interface allows a flexible configuration of the process data channel, with the length of the process data channel changing accordingly.

☞ The currently effective length is specified in the parameters "P-0-4082, Field bus: Length of cyclic actual value data channel", and "P-0-4071, Field bus: Length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. The length, however, is specified in bytes to ensure compatibility with other bus systems.

The length of the process data channel is defined by the content of the configuration lists "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", or "P-0-4081, Field bus: Config. list of cyclic command value data ch.", and is specified in the following parameters:

- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4082, Field bus: Length of cyclic actual value data channel

The setting is calculated from the contents of parameters P-0-4080 and P-0-4081 and takes effect as the drive controller runs up to operating mode.

☞ Note that a change in the length of the process data channel also requires a change in the controller configuration. The set length of the process data channel has therefore to be in accordance with the projected length in the controller. If not, the error message "F4012 Incorrect I/O length" is generated.

4.8.3 Cyclic communication via process data channel

Communication cycle time

The smallest supported cycle time (IO cycle update time) is 2 ms and is determined by the control unit. It describes the time in which cycle the data from the PROFINET network are applied or read out to the Multi-Ethernet interface.

Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (multiples of the position controller clock cycle).

Parameter "P-0-4076, Field bus: Process data - updating clock" is used to define the update cycle for applying the data from the Multi-Ethernet interface onto the drive and vice versa.

Axis-specific process data channel

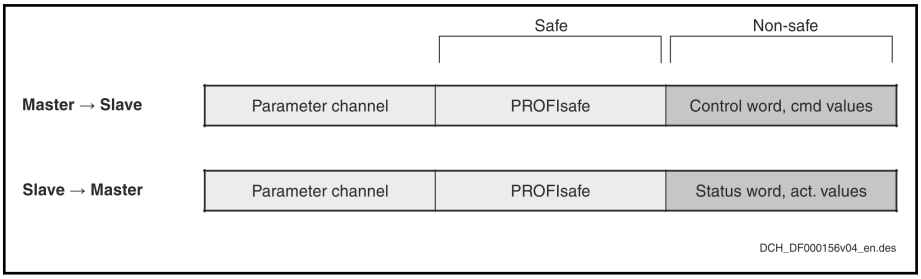


Fig. 4-47: Position of the not safety-related process data channel in the cyclic data channel

Processing the cyclic data

Internal processing of the command values and actual values is carried out synchronously with the control clock cycle. As the communication via PROFINET® RT is not handled clock-synchronously, this type of master communication is not suited for clock-synchronized operation modes such as "position control with cyclic command value input", but only for positioning modes and the "velocity control" mode.

There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

Configuration of cyclic data

Cyclic data have to be configured in the parameterization mode.

Parameter channel in the cyclic channel (device-specific)

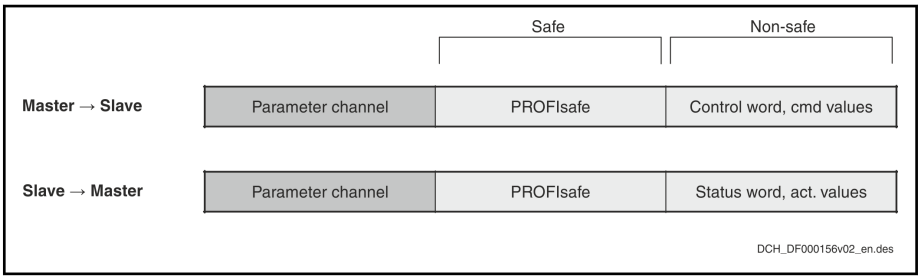


Fig. 4-48: Position of the parameter channel in the cyclic data channel

Using the parameter channel, the drive can be parameterized via the field bus. The parameter channel is part of the cyclic data.

For IndraLogic and Siemens S7, there are function blocks available which implement the parameter channel protocol. The user does not need to deal with the parameter channel details.

The parameter channel is described in the Technical Note "TN_40_Bosch_Rexroth PROFIBUS_PROFINET_Parameterkanal_V1.x".

The parameter channel is always at the beginning of the cyclic data channel. The length of the parameter channel is configured in the controller and the drive. To this end, parameter "P-0-4083.0.1, Parameter channel: Configuration" has to be used.

The field bus control word cannot be operated via the optional parameter channel. To enable axis control, the cyclic data channel is to be used in the higher-level control or a corresponding logic must be programmed in the MLD with permanent control. If the control is not equipped with a cyclic data channel, the axis cannot be controlled without MLD.

4.8.4 Diagnostic and status messages

Diagnostic possibilities

For easy diagnostics of the network status, a network status LED is provided.

The following table illustrates the possible states:

LED		Meaning	Color	Description
IAC	HMC			
3	NS	Status	Off	The device has no valid IP address or is switched off
		Link	Flashing green	The device has booted with a valid IP address but does not have a cyclic connection.
		Connected	Permanently lit green	The I/O connection has been established without error.
		Timeout	Flashing red	The existing I/O connection was unexpectedly terminated (e.g. watchdog).
		Invalid IP address	Permanently lit red	The “Duplicate IP Address Check” detected that the set IP address already exists in the network.
		Self-test	Flashing red-green	The device is booting and performs a self-check.

Tab. 4-63: Overview of parameter channel errors

Error codes of PROFINET® communication

Parameter channel errors

The table below contains an overview of the possible parameter channel error messages and their meaning:

Error code	Meaning
0x0082	Total volume of transmitted data is too low, i.e. less than 4 bytes
0x0083	The data volume yet to be transmitted exceeds the internal buffer.
0x0088	The length of the valid data indicated in the control word is longer than the parameter channel
0x008C	Status conflict; a new request was sent although there are still data to be transmitted

Error code	Meaning
0x008D	The length of data indicated as yet to be transmitted in the control word is incorrect
0x008E	The EIDN/IDN access mode set in control word bit 15 does not correspond to the access mode configured in P-0-4083.0.1.

Tab. 4-64: Overview of parameter channel errors

Parameter access errors

The table below contains an overview of the possible parameter access errors and their meaning; the error values are transmitted in word format:

Error no. (hex)	Meaning
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name available
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	No minimum value
0x5004	Minimum value cannot be edited
0x6001	No maximum value
0x6004	Maximum value cannot be edited
0x7002	Datum transmission too short
0x7003	Datum transmission too long
0x7004	Datum cannot be changed (read only)
0x7005	Datum is currently write-protected
0x7006	Datum is smaller than minimum value
0x7007	Datum exceeds the maximum value
0x7008	IDN is not supported, invalid bit number or bit combination
0x7009	Datum write-protected by customer password
0x700A	Datum is currently write-protected, as it is configured cyclically
0x700B	Invalid indirect addressing (e.g. data container, list handling)
0x700C	Datum is currently write-protected due to other settings (e.g. parameter, operation mode, drive enable, ...)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command currently not executable (e.g., procedure command cannot be activated in this phase)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application

Error no. (hex)	Meaning
0x9002	Parameter type error
0x9003	Invalid data record number
0x9004	Invalid data block number
0x9005	Data element number invalid
0x9006	Error in R/W flag
0x9007	Invalid character in the datum

Tab. 4-65: Overview of parameter access errors

4.9 PROFIBUS-DP

4.9.1 Brief description

Controllers with PROFIBUS interface (PB) can be operated as PROFIBUS slaves in a PROFIBUS system. Via this PROFIBUS component, it is possible to exchange real-time data with a PROFIBUS-DP master.

Cyclic data channel (PROFIBUS-DP)

The field bus provides data containers in which payload data can be cyclically transmitted. This section is referred to as cyclic data channel.

The cyclic data channel is subdivided as follows:

- One (optional) **device-specific parameter channel** for reading and writing of all parameters via PROFIBUS-DP.

☞ The **device-specific parameter channel** does not provide any "real-time properties"!

- One **axis-specific process data channel** (real-time channel) which contains firmly declared information that can be directly interpreted by the receiver.

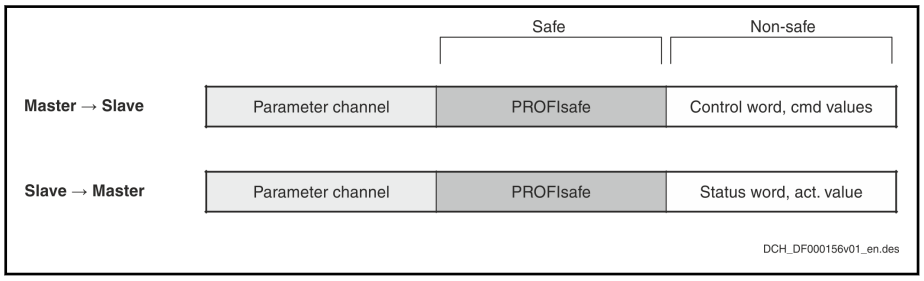


Fig. 4-49: Cyclic data channel overview

☞ To simplify field bus communication, Rexroth makes available PLC function blocks for different programmable logic controllers (PLCs). The function blocks support the basic functionalities of “axis-specific process data channel” and “device-specific parameter channel”. The principles applied can be easily used for other field bus masters.

Features The slave/PROFIBUS-DP connection offers the following features:

- Support of **RS485 interface according to IEC 61158-2**

- Support of all **data rates according to IEC 61158-2** with exclusive use of PROFIBUS-DP (9.6 kBaud, 19.2 kBaud, 45.45 kBaud, 93.75 kBaud, 187.5 kBaud, 500 kBaud, 1.5 MBaud, 3 MBaud, 6 MBaud, 12 MBaud)
- Automatic baud rate recognition
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)
- Setting possibilities for P-0-4076: min. 2 ms, max. 65 ms (adjustable in increments of 1 ms).

☞ Parameter "P-0-4076, Field bus: Process data - updating clock" is used to define the update cycle for applying the process data from the PROFIBUS interface onto the drive and vice versa.

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- Monitoring of the cyclic data exchange (watchdog function)
- LED for PROFIBUS interface diagnosis
- Supported DPV0 services:
  - Slave_Diag (read diagnostic data)
  - Get_Cfg (read out configuration data)
  - Set_Prm (send parameterization data)
  - Chk_Cfg (check configuration data)
  - Data exchange (transferring I/O data)
  - Global Control (synchronization)
  - RD_Outp (read output data)
  - RD_Inp (read input data)
- Supported DPV1-class-1 services:
  - DDLM_Initiate (establishment of connection)
  - DDLM_Read (acyclic read access)
  - DDLM_Write (acyclic write access)
  - DDLM_Abort (termination of connection)
  - DDLM_Idle (connection monitoring)
- Support of up to two DPV1-class-2 connections
- Supported field bus profiles:
  - 0x0000: "No profile selected"
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "operation mode neutral"
  - 0xFFFE: Freely configurable mode

Hardware requirements

The master communication "PROFIBUS-DP" requires the following device variant:

- HMC (Hydraulic Motion Controller) with the PROFIBUS-DP option

Axis addressing

The address can be directly changed or displayed via parameter "S-0-1040, Drive address of master communication".

Restrictions

The following boundary conditions have to be taken into account when configuring the device:

- The position controller cycle has to be set to >= 1 ms. With a smaller position controller cycle, diagnostic message F4011 may be issued and PROFIBUS communication interrupted.

Pertinent parameters

Communication parameters

Specific parameters for communication via PROFIBUS-DP:

- P-0-4069, Field bus: Module diagnosis

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4079, Field bus: Baud rate
- P-0-4083, Parameter channel: Length
- P-0-4083.0.1, Parameter channel: Configuration

Profile type parameters

Apart from pure communication parameters, parameters related to the profile types are used.

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication possibilities.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "Multiplex channel"

Pertinent diagnostic messages

- C0229, Field bus: IDN for cycl. command val. not configurable
- C0230, Field bus: Max. length for cycl. command val. exceeded
- C0231, Field bus: IDN for cycl. actual val. not configurable
- C0232, Field bus: Length for cycl. actual values exceeded
- C0233, Field bus: Tcyc (P-0-4076) incorrect
- C0234, Field bus: P-0-4077 missing for cycl. command values
- E4005, No command value input via master communication
- F4009, Bus failure
- ((F4011))
- F4012, Incorrect I/O length

4.9.2 Configuration of the PROFIBUS-DP slave

General station description

Like any other PROFIBUS slave, HydraulicDrive controllers have to be configured in the field bus master. To this end, the respective general station description (GSD) "**RX**0170.GSD**" is necessary, which has to be integrated in the project ("**" stands for the version number of the GSD file). When configuring the bus master, this GSD file is required for each node.

☞ The general station description (GSD) for HydraulicDrive controllers supports all hardware types and enabling of functional packages.

HydraulicDrive controllers assign their data to four slots (for single-axis devices), which may have to be configured. Each drive is provided with an F-module, an input module and an output module. A slot is an interface for one module. Example: A parameter channel module is plugged into slot 1. The parameter channel module can have various lengths as described.

IndraDrive controllers assign their data to four slots (for single-axis devices), into which certain modules have to be plugged.

- Slot 1: Parameter channel module (device-specific)
- Slot 2: F-module (axis 0)
- Slot 3: Inputs module (axis 0)
- Slot 4: Outputs module (axis 0)
- Slot 1: Parameter channel
- Slot 2: F-module axis 0 (optional for PROFIsafe)
- Slot 3: Inputs axis 0
- Slot 4: Outputs axis 0

The default configuration is stored in the general station description file "Input 1 Word" and "Output 1 Word" (single-axis device) without parameter channel. This default configuration is set automatically in the case of configurators, which support GSD version 03 or higher. With IndraDrive, this setting is active after loading of the default values.

The general station description file also contains the IDN assigned to the HydraulicDrive controller by the PROFIBUS user organization (PNO):

- **IDN 170 hex**

☞ By default, "IndraWorks MLD" stores the general station description in the directory "C:\Programs\REXROTH\IndraWorks\DeviceDataSheets\IndraDrive\Profibus" in the course of the installation.

Module 1: Parameter channel

These modules are marked with "ParamCh" and are of the input/output module type. If no parameter channel is required, the module "ParamCh not used" has to be selected.

If IDN parameters or EIDN parameters are to be written via the parameter channel, observe the following aspects:

- IDN parameters

  To write a 2-byte IDN parameter (e.g. P-0-4006), the "ParamCh 5 Words" module has to be included and configured accordingly in parameter "P-0-4083.0.1, Parameter channel: Configuration".

- EIDN parameters

  To write a 4-byte EIDN parameter (e.g. P-0-4006.0.0), the "ParamCh 6 Words" module has to be included and configured accordingly in parameter "P-0-4083.0.1, Parameter channel: Configuration".

☞ The parameter channel length is displayed in bytes in parameter "P-0-4083, Parameter channel: Length".

If the command/actual values are incorrectly configured, error "F4012, Incorrect I/O length" is displayed.

For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

The drive automatically recognizes the configuration of the master and adjusts itself accordingly. Consequently, parameterizing by the master is always possible, also with an incorrect configuration of the command/actual values. This allows downloading of parameters from the master after a device was replaced.

F-module

The blank module "F-Module not used" is assigned to slot 2.

Inputs module

For these modules, the length of the input data is set in words. The module identifier is "Input". For successful data exchange of the axis-specific process data channel, the set length must be equal to the value in parameter "P-0-4082, Field bus: Length of cyclic actual value data channel" that specifies the length in bytes.

Also if an incorrect input data length is specified, communication via the device-specific parameter channel is possible.

If the configuration of the master does not correspond to the configuration of the IndraDrive controller, the IndraDrive will generate the error message "F4012, Incorrect I/O length".

Module outputs

For these modules, the length of the output data is set in words. The module identifier is "Output". The set length of the output data has to correspond to the value of parameter "P-0-4071, Field bus: Length of cyclic command value data channel".

If the configuration of the master does not correspond to the configuration of the IndraDrive controller, the IndraDrive will generate the error message "F4012, Incorrect I/O length".

Configuring the process data channel

Standard process data channel

The user can freely configure the cyclic data in the standard process data channel according to the process requirements.

For the profile types "freely configurable mode" (P-0-4084 = 0xFFFE), "operating mode neutral" (P-0-4084 = 0xFFFD), "I/O mode" (P-0-4084 = 0xFF82), "I/O mode" (P-0-4084 = 0xFF92 preset velocity) or "no profile" (P-0-4084 = 0x0000) a default configuration is set, which can be changed by the user at any time.

Also refer to "Profile types (with field bus interfaces)"

Configuration list of cyclic actual value data channel

In parameter "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", the structure and therefore the number of words and their assigned objects (indices) for the process input data (slave → master) are mapped. The master can use this configuration in order to locate the individual real-time data in the field bus.

Configuration list of cyclic command value data channel

The structure of the process output data (master → slave) is mapped in parameter "P-0-4081, Field bus: Config. list of cyclic command value data ch.". This enables reading the current structure and hence the assignments in the field bus over the parameter channel.

☞ Up to 15 real-time parameters (incl. control and status word) can be configured on the bus per data direction (max. 48 bytes or 24 words).

Length of the process data channel (real-time data channel)

Standard process data channel

Within the cyclic channel, the parameter channel (optional) and the process data channel, in which the real-time data of the drive controller are transmitted, are arranged.

The PROFIBUS slave connection allows a flexible configuration of the process data channel, with the length of the process data channel changing accordingly.

☞ The currently effective length is specified in the parameters "P-0-4082, Field bus: Length of cyclic actual value data channel" and "P-0-4071, Field bus: Length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. The length, however, is specified in bytes to ensure compatibility with other bus systems.

The length of the process data channel can be 1…24 words or 2…48 bytes in both directions.

The length of the process data channel is defined by the content of the configuration lists "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", or "P-0-4081, Field bus: Config. list of cyclic command value data ch.", and is specified in the following parameters:

- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4082, Field bus: Length of cyclic actual value data channel

The setting is calculated from the contents of the parameters P-0-4080 and P-0-4081 and takes effect as the drive controller runs up to operating mode.

☞ Note that a change in the length of the process data channel also requires a change in the master configuration. The set length of the process data channel has therefore to be in accordance with the projected length in the master. If not, the error message "F4012 Incorrect I/O length" is generated.

4.9.3 Cyclic communication via process data channel

Communication cycle time

The communication cycle time is determined by the baud rate set in the master. It is transferred to the slave and shown in parameter "P-0-4079, Field bus: Baud rate".

Via the parameter "P-0-4076, Field bus: Process data - updating clock", the update cycle for applying the data from the PROFIBUS® interface onto the drive and vice versa is defined. For reasons of performance, the default settings should be maintained.

Enter valid values for "P-0-4076, Field bus: Process data - updating clock": min. 2 ms, max. 65 ms (adjustable in 1-ms steps)

Axis-specific process data channel

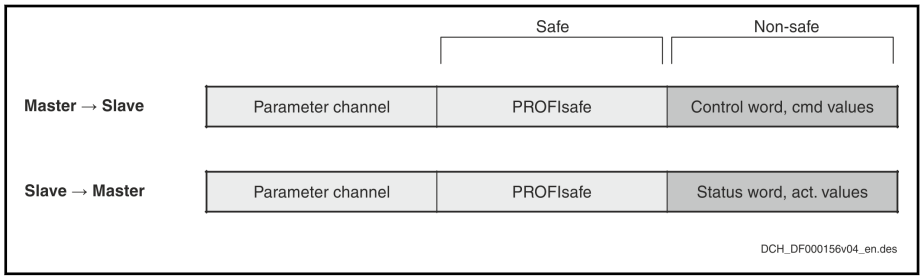


Fig. 4-50: Position of the not safety-related process data channel in the cyclic data channel

Processing the cyclic data

Internal processing of the command values and actual values is carried out synchronously with the control clock cycle. As the communication via PROFIBUS-DP is not carried out clock-synchronously, this type of master communication is not suited for clock-synchronized operation modes such as "position control with cyclic command value input", but only for positioning modes and the "velocity control" mode.

☞ There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

Configuration of cyclic data

Cyclic data have to be configured in the parameterization mode. This is described in section "Configuring the PROFIBUS-DP slave".

Parameter channel in the cyclic channel (device-specific)

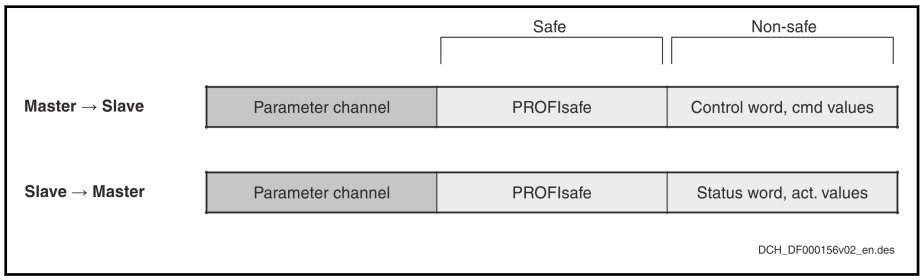


Fig. 4-51: Position of the parameter channel in the cyclic data channel

Via the parameter channel, the drive(s) can be parameterized over the field bus. The parameter channel is part of the cyclic data.

For IndraLogic and Siemens S7, function blocks are available which implement the parameter channel protocol. The user does not need to deal with the parameter channel details.

The parameter channel is described in chapter 4.4.4.

☞ The parameter channel is always at the beginning of the cyclic data channel. The length of the parameter channel is configured in the master and accepted by the drive in parameter "P-0-4083, Parameter channel: Length".

☞ The field bus control word cannot be operated via the optional parameter channel. To enable axis control, the cyclic data channel is to be used in the higher-level control or the respective logic must be programmed in the MLD with permanent control. If the control is not equipped with a cyclic data channel, the axis cannot be controlled without MLD.

4.9.4 Acyclic data exchange (DPV1)

Overview of acyclic communication

DP-master class 1

An acyclic communication relationship of type "MSAC_C1" with a DP-master class 1 (MSAC_C1) is supported. The following DP services are available for this communication relationship:

- DDLM_Read (MSAC1_Read)
- DDLM_Write (MSAC1_Write)

DP-master class 2

A maximum of two acyclic communication relationships of type "MSAC_C2" with a DP-master class 2 (MSAC_C2) is supported. The following DP services are available for this communication relationship:

- DDLM_Initiate (MSAC2_Initiate)
- DDLM_Abort (MSAC2_Abort)
- DDLM_Read (MSAC2_Read)
- DDLM_Write (MSAC2_Write)

4.9.5 Diagnostic and status messages

Monitoring functions

Watchdog for cyclic communication

In standard cases, the time required by watchdog monitoring is automatically calculated and configured by the configuration program of the master. It is displayed (in ms) in parameter "P-0-4075, Field bus: Watchdog".

☞ The entry "0" in parameter "P-0-4075, Field bus: Watchdog" means that watchdog monitoring is deactivated.

F4012 Incorrect I/O length

When the error message "F4012 Incorrect I/O length" is generated, the drive is in the PROFIBUS state "Data_Exchange"; the diagnostic LED is on. The parameter channel functions, but internally the data of the input and the output module are not processed.

Diagnostic possibilities

Diagnostics of the state of field bus master communication of a HydraulicDrive is carried out via

- the diagnostic LED on the front panel of the controller

  - and -

- the diagnostic parameter "P-0-4073, Field bus: Diagnostic message".

Diagnostic LED

The diagnostic LED is on, when the drive is in the PROFIBUS state "Data_Exchange". This means that real-time data are exchanged between the drive and the master.

Parameters for field bus diagnostics

The state of the field bus master communication is stored in parameter "P-0-4073, Field bus: Diagnostic message" in plain text. The contents in parameter P-0-4073 have the following meaning:

Text	Meaning
"OFFLINE"	Initialization value of diagnostics
"Power-On"	PROFIBUS-DP was recognized as master communication and hardware is checked.
"Baud search"	The hardware is ok; the PROFIBUS interface is monitored in order to recognize the baud rate used.

Text	Meaning
"Wait-Prm"	The baud rate was found; the drive is waiting for a parameterization telegram of the master, which contains its IDN (is stored in the general station description).
"Wait-Cfg"	The drive has received a valid parameterization telegram and now waits for the configuration telegram in which the master signals the drive which modules it is expecting for input/output configuration.
"Data-Exch WD+"	The drive has received a valid configuration and exchanges real-time data with the master. The communication is monitored by a watchdog.
"Data-Exch WD-"	The drive has received a valid configuration. It exchanges real-time data with the master without the communication being monitored by a watchdog.

Tab. 4-66: Significance of entries in parameter P-0-4073

Error codes of PROFIBUS communication

Parameter channel error

The table below contains an overview of the possible parameter channel error messages and their significance:

Error code	Meaning
0x0082	Total volume of transmitted data is too low, i.e. less than 4 bytes
0x0083	The data volume yet to be transmitted exceeds the internal buffer.
0x0088	The length of the valid data indicated in the control word is longer than the parameter channel
0x008C	Status conflict; a new request was sent although there are still data to be transmitted
0x008D	The length of data indicated as yet to be transmitted in the control word is incorrect
0x008E	The EIDN/IDN access mode set in control word bit 15 does not correspond to the access mode configured in P-0-4083.0.1.

Tab. 4-67: Overview of parameter channel errors

DPV1 errors

The table below contains an overview of the possible DPV1 error messages and their meaning:

Error code	Meaning	Designation to DPV1 standard
0x80 0xA0 0x00	The read request has a length of more than 10 bytes	DPV1, access, read error
0x80 0xA1 0x00	The write request has a length of less than 11 bytes	DPV1, access, write error
0x80 0xA9 0x00	DPV1 service not supported	DPV1, application, feature not supported
0x80 0xB0 0x00	No access to index 47.	DPV1, access, invalid index
0x80 0xB1 0x00	No DPV1 header available.	DPV1, access, write length error

Error code	Meaning	Designation to DPV1 standard
0x80 0xB2 0x00	No access to slot 0.	DPV1, access, invalid slot
0x80 0xB3 0x00	Access is only allowed to the value of the object.	DPV1, access, type conflict
0x80 0xB5 0x00	Parameter request not yet received; therefore, response not yet available.	DPV1, access, state conflict
0x80 0xB6 0x00	The parameter cannot be written.	DPV1, access, access denied
0x80 0xB8 0x00	In one access, only one parameter may be processed.	DPV1, access, invalid parameter
0x80 0xC0 0x00	The request is still being processed, the read request has to be repeated.	DPV1, resource, read constrain conflict

Tab. 4-68: Overview of DPV1 errors

Parameter access errors

The table below contains an overview of the possible parameter access errors and their significance; the error values are transmitted in word format:

Error no. (hex)	Meaning
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name available
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	No minimum value
0x5004	Minimum value cannot be edited
0x6001	No maximum value
0x6004	Maximum value cannot be edited
0x7002	Datum transmission too short
0x7003	Datum transmission too long
0x7004	Datum cannot be changed (read only)
0x7005	Datum is currently write-protected
0x7006	Datum is smaller than minimum value
0x7007	Datum exceeds the maximum value
0x7008	IDN is not supported, invalid bit number or bit combination
0x7009	Datum write-protected by customer password
0x700A	Datum is currently write-protected, as it is configured cyclically

Error no. (hex)	Meaning
0x700B	Invalid indirect addressing (e.g. data container, list handling)
0x700C	Datum is currently write-protected due to other settings (e.g. parameter, operation mode, drive enable, ...)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command currently not executable (e.g., procedure command cannot be activated in this phase)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	invalid data record number
0x9004	invalid data block number
0x9005	Data element number invalid
0x9006	Error in R/W flag
0x9007	Invalid character in the datum

Tab. 4-69: Overview of parameter access errors

4.10 VARAN

4.10.1 Brief description

General information

HydraulicDrives can be operated as VARAN master communication. Via these modules, it is possible to exchange real-time data with a VARAN master.

The "Servo Drive Profile over VARAN" (SoV) is supported, which is based on the Sercos II specification.

We distinguish the following communication channels:

- Cyclic data channel (process data)
  - Data container for cyclic transmission of payload data (process data) in real time
- Acyclic data channel
  - Process for acyclic transmission of service data (parameter channel)
  - Process for acyclic transmission of Ethernet telegrams (EoV)



For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

General features

- Transmission rate 100 Mbit/s
- Data transmission over Ethernet cable (CAT5 copper)
- 100 m maximum cable length

- Topology: "Star" and/or "line" (depending on whether port 2 is occupied)
- Access to 16-bit Sercos parameters of the drive via "SoV" protocol ("Servo Drive Profile over VARAN" protocol)
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- Support of "fast asynchronous direct access" mechanism
- Max. length of the configurable MDT/AT data is 15 IDNs with max. 48 bytes; with bus clock cycle = position controller clock cycle or utilization of "fast asynchronous direct access", the max. length is halved to 24 bytes, if the position controller clock cycle was configured to less than 1 ms.
- Minimum cycle time: Position controller clock cycle
- Overall synchronization of all connected drives with the master
- Support of "Ethernet over VARAN" (EoV)

Physical wiring

When setting up a VARAN network it is to be observed that the VARAN bus supports star as well as line topologies. For star topology, an additional VARAN splitter may be necessary. A line topology can only be used for HydraulicDrive controllers if these are equipped with 2 VARAN ports.

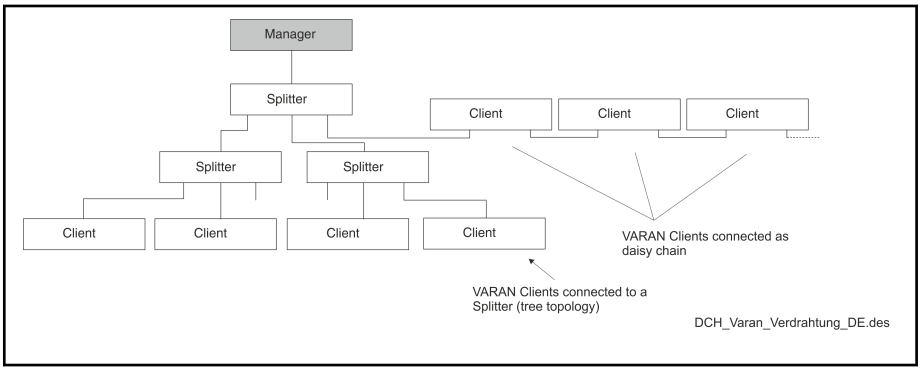


Fig. 4-52: Physical wiring of VARAN

Addressing

Under VARAN, addressing is always achieved by projecting the bus stations in the master. Each bus node is assigned a separate 64 kB address range that is part of the total address range of 4 GB used for addressing. In multi-axis devices, all axes of a drive share this 64 kB address range. If the master sends data to one of the slaves, it has to write to the respective address range of the slave. The drive itself cannot provide its own bus address. Addressing is exclusively carried out by the master.

VARAN state machine

The following figure illustrates the comparison of the VARAN and the Sercos state machine.

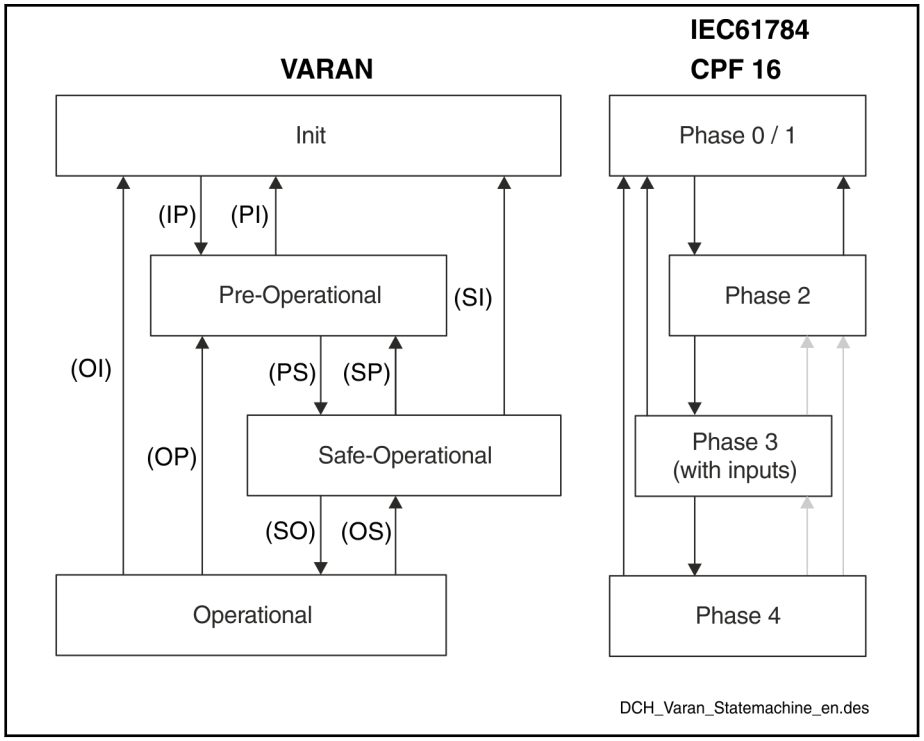


Fig. 4-53: Comparison of VARAN and Sercos state machine

In contrast to Sercos, also “switching back" between the phases (states) is possible, i.e. from "Operation" to "Safe-Operational" (OS transition). In the "Pre-Operational" state, acyclic communication with the slave is possible. In the "Safe-Operational" state, the slave transmits its inputs to the master, but does not apply any command values. In the "Operational" state, the complete cyclic channel is valid. If a slave detects an error, it is switched to state "Safe-Operational" instead of "Init". This way, communication in the system is maintained partly. From the "Safe-Operational" state on, the drive has to deliver valid actual values. From the "Operational" state on, also the command values are processed. To be able to provide valid actual values in the "Safe-Operational" state, the drive has to switch to “OM” when changing the state from "Pre-Operational" to "Safe-Operational".

Transition	Condition
IP (Init → Pre-Operational)	
PI (Pre-Operational → Init)	
PS (Pre-Operational → Safe-Operational)	Valid configuration of cyclic data in ID 16/24
SP (Safe-Operational → Pre-Operational)	
SI (Safe-Operational → Init)	
SO (Safe-Operational → Operational)	Internal clearing of errors successful
OS (Operational → Safe-Operational)	
OP (Operational → Safe-Operational)	
OI (Operational → Init)	

Tab. 4-70: Transitions between the individual states

If a slave fails due to an error reaction resulting from the transition from "Operational" to "Safe-Operational" or if the master initiates this change in state in the slave, it is automatically switched off.

Cyclic data/process data

The cyclic data consist of parameter "S-0-0134, Master control word" or "S-0-0135, Drive status word" and the parameters entered in "S-0-0016, Configuration list of AT" or "S-0-0024, Configuration list of MDT".

In S-0-0016/S-0-0024 max. 15 IDNs can be entered each. The length of the parameters entered in S-0-0016/S-0-0024 may be max. 48 bytes. In case of bus cycle time = position controller cycle time or with activated "fast asynchronous direct access (P-0-4089.0.5 bit 4)", this length is reduced to 24 bytes. However, this reduction only applies if the position cycle is set below 1 ms. With a position clock cycle of 1 ms or higher, 48 bytes can be entered in S-0-0016/S-0-0024 also if bus clock cycle = position controller clock cycle or with activated "Direct Access".

The cyclic data have to be configured via the master. Then, the master configures the cyclic telegram and writes the parameters S-0-0016 and S-0-0024 on phase progression.

Acyclic data channel

Parameter channel

Access to 16-bit Sercos parameters of the drive via "SoV" protocol ("Servo Drive Profile over VARAN" protocol). Access to 32-bit EIDNs is only possible if the corresponding 16-bit alias is available.

Ethernet over VARAN (EoV)

With "Ethernet over VARAN" (EoV), standard Ethernet telegrams are tunneled to the drive via the VARAN bus. This enables access to the drive via standard Ethernet. The VARAN logic ware contains an Ethernet MAC, which handles the transmission of standard Ethernet telegrams. "IP" Ethernet telegrams can be "tunneled" to the VARAN bus via a splitter and the existing port.

Pertinent parameters

- S-0-0001, NC cycle time (TNcyc)
- S-0-0002, Sercos cycle time (TScyc)
- S-0-0007, Feedback acquisition starting time (T4)
- S-0-0014, Interface status
- S-0-0015, Telegram type parameter
- S-0-0016, Configuration list of AT
- S-0-0024, Configuration list of MDT
- S-0-0029, MDT error counter
- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, Class 3 diagnostics
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-0185, Length of the configurable data record in the AT
- S-0-0186, Length of the configurable data record in the MDT

- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT
- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2
- S- 0-0415, Bit number allocation of real-time status bit 1
- S- 0-0416, Bit number allocation of real-time status bit 2
- P-0-4089.0.1, Master communication: Protocol
- P-0-4089.0.5, Master communication: Configuration
- S-0-0032, Primary operation mode
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

Pertinent diagnostic messages

- A0004, Initialization
- A0005, Pre-Operational
- A0006, Safe-Operational
- C0101, Invalid parameters (-> S-0-0021)
- C0104, Config. IDN for MDT not configurable
- C0105, Maximum length for MDT exceeded
- C0106, Config. IDNs for AT not configurable
- C0107, Maximum length for AT exceeded
- C0108, Time slot parameter > Sercos cycle time
- C0112, Set timing not permissible
- C0113, Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114, T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- C0201, Invalid parameters (->S-0-0423)
- C0299, Configuration changed. Restart
- E4005, No command value input via master communication
- F4002, RTD telegram failure
- F4009, Bus failure

4.10.2 Synchronization and timing

Ensuring data integrity

If the client does not respond to a telegram of the manager, the manager automatically repeats the last telegram within the current bus cycle. The mes-

sage counter is not increased to ensure that the repetition can be detected by the client.

The consecutive sequence of the message counters in the cyclic telegrams is checked in the drive. If the message counter is incorrectly incremented twice in succession in the new bus clock cycle, the drive is shut down and an error message ("F4002, RTD telegram failure") is issued. In the case of telegram failures, the error counter "S-0-0029, MDT error counter" is incremented. The number of non-processed "fast asynchronous direct accesses" is also monitored in the drive when this mechanism has been activated with parameter "P-0-4089.0.5, bit 4, Master communication: Configuration". Also here, the direct access message counter is checked for correct incrementation, and, if two failures/errors occur in succession, this may also lead to the shutdown of the drive with an error message. The error counter "S-0-0029, MDT error counter" is also incremented in the case of telegram failures/errors. In addition, an entry is made in the internal diagnostic logbook.

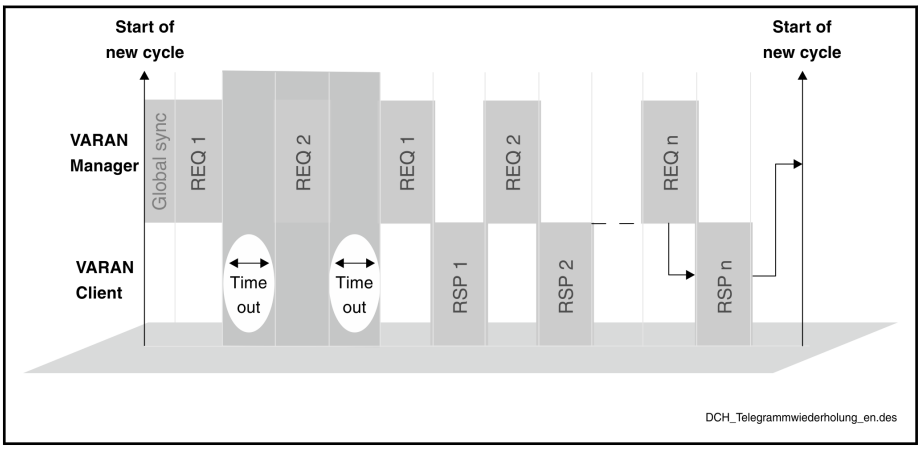


Fig. 4-54: Repetition of a telegram in the same bus clock cycle

Synchronization

In VARAN, synchronization of drives is also possible without Distributed Clocks according to IEEE 1588. The VARAN logicware cyclically creates a Sync signal in the bus cycle that can be used for synchronization of the drive PLL. The Sync signal is always generated in the logicware when the "isochronous VARAN task" is started. During booting of the internal state machine from Pre-Operational to Safe-Operational, the drive can synchronize with the Sync signal. When switching to "Operational", drive synchronization needs to be successful as switch-over is otherwise denied.

Support of “fast asynchronous direct access” mechanism

With VARAN, a fast asynchronous direct access is possible during the bus clock cycle. In this context, the manager interrupts its current real-time processing for a maximum of 25 µs and sends new cyclic data to the client. If the drive is configured so that several position controller clock cycles are processed within one bus cycle, the drive can, upon a direct access, transmit the command values again in the subsequent position controller clock cycle. The actual values are newly generated during a direct access and made available on the bus at the next Sync time. To be able to utilize the "fast asynchronous direct access" mechanism, it has to be activated explicitly in the drive "P-0-4089.0.5, Bit 4, Master communication: Configuration". If only one position controller clock cycle is processed per bus clock cycle (position controller clock cycle = bus clock cycle), the direct access mechanism can be activated, but the additional command values cannot be re-copied faster. The data of the "fast asynchronous direct access" are then processed at the regular

Sync time. The drive ignores the next standard command value telegram after a direct access, since this may contain old command values. At the time of the direct access, the actual values for the next bus clock cycle are generated so that in the next bus clock cycle the actual values valid at the time of the direct access are made available to the manager. Generally, only one "fast asynchronous direct access" can be processed per free position controller clock cycle (position controller clock cycles before or after the Sync time).

For position-controlled operation modes, the "fast asynchronous direct access" mechanism should not be used, since the new command values cannot be adopted for the active generators in every position controller clock cycle.

Timing

Depending on the ratio of the bus clock cycle to the position controller clock cycle, the cyclic command and actual values are either processed within a position controller clock cycle (= bus clock cycle with 1:1 timing) or distributed to several position controller cycles. If so distributed, the actual values of the drive are thus accepted in the VARAN manager only in the next bus clock cycle. If the "fast asynchronous direct access" mechanism is activated in the drive "P-0-4089.0.5, bit 4, Master communication: Configuration", the cyclic command and actual value data are always processed at the point in time of Sync within a position controller clock cycle, or additional command value processing takes place in the next position controller clock cycle following signaling of a "fast asynchronous direct access".

The actual values can then be accepted by the VARAN manager in the current clock cycle. The actual value acquisition in the drive takes place so that the values are available at the Sync time.

Processing starts with the position controller cycle in which the Sync signal is received from the FPGA. In this process, the time of T4 is always directly after the Sync signal. A double buffer connection in the VARAN logicware ensures that no conflicts arise during access to cyclic data in FPGA.

Data consistency is always guaranteed. Direct access data are exchanged via a memory range without double buffer. Data consistency within a bus clock cycle can be ensured by writing the direct access message counter after writing of the direct access data.

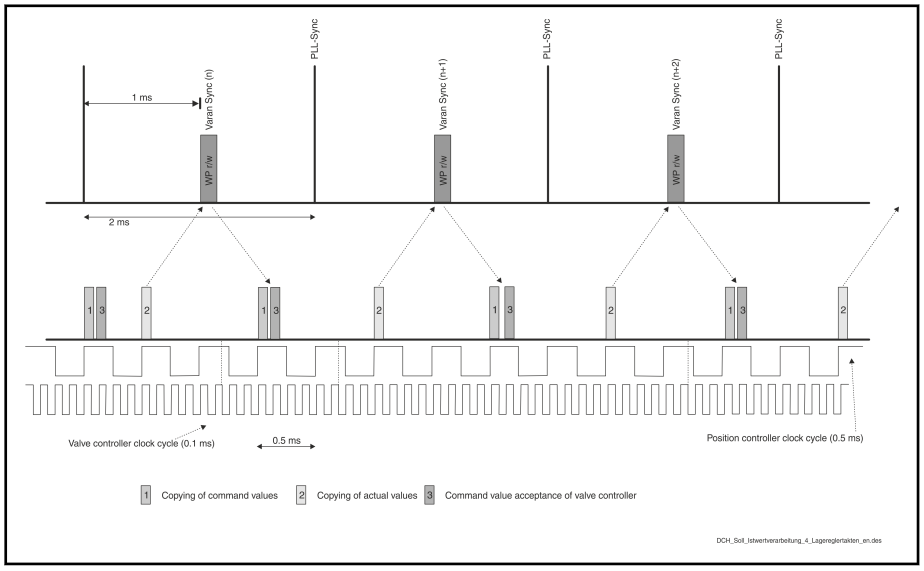


Fig. 4-55: Command/actual value processing in four position controller clock cycles per bus clock cycle

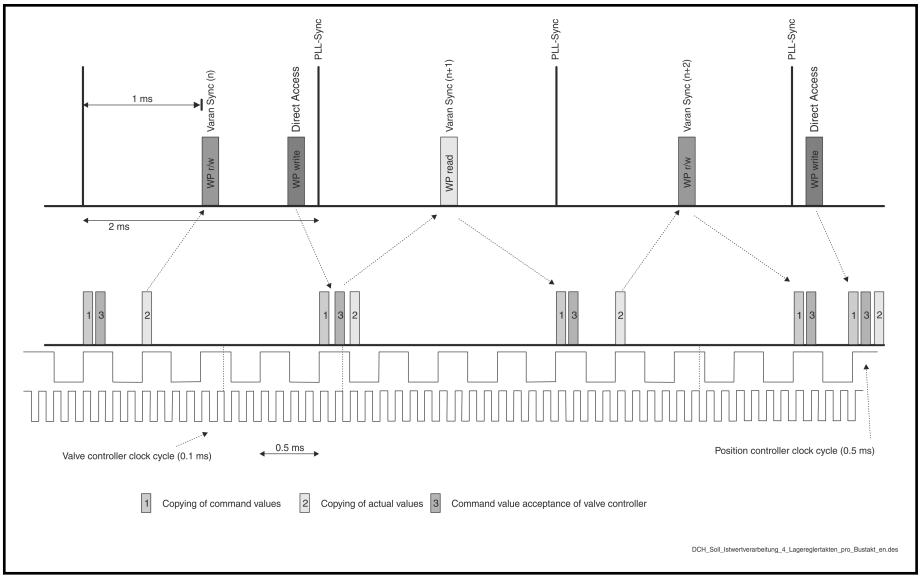


Fig. 4-56: Command/actual value processing in four position controller clock cycles per bus clock cycle while "fast asynchronous direct access" is activated

4.10.3 Ethernet over VARAN

Functional description

General information

With “Ethernet over VARAN" (EoV), standard Ethernet telegrams are tunneled to the drive via the "Foreign Package" mechanism. This enables access to the drive via standard Ethernet.

Protocol switching

Initial commissioning with Multi-Ethernet devices without control panel or (**HydraulicDrive with Multi-Ethernet**) is quite problematic. If an "incorrect" protocol is set for this type of device, operation is impossible, maybe not even the communication with IndraWorks for setting the correct protocol.

Critical applications are:

- Application 1: Drive with active VARAN in a non-VARAN network
- Application 2: Drive with non-active VARAN in a VARAN network

For application 1, the following solution is realized:

After having been switched on, a drive with Multi-Ethernet option and active VARAN protocol waits to see whether either:

1. Phase progression master is set → then run-up in VARAN mode

   or

2. Ethernet telegram = UDP target port 0x88cd (cf. Sercos Ethertype &&Messagetype 0x8ec00064 (manufacturer-specific S/IP service I vendor code) → then automatic changeover to standard Ethernet protocol

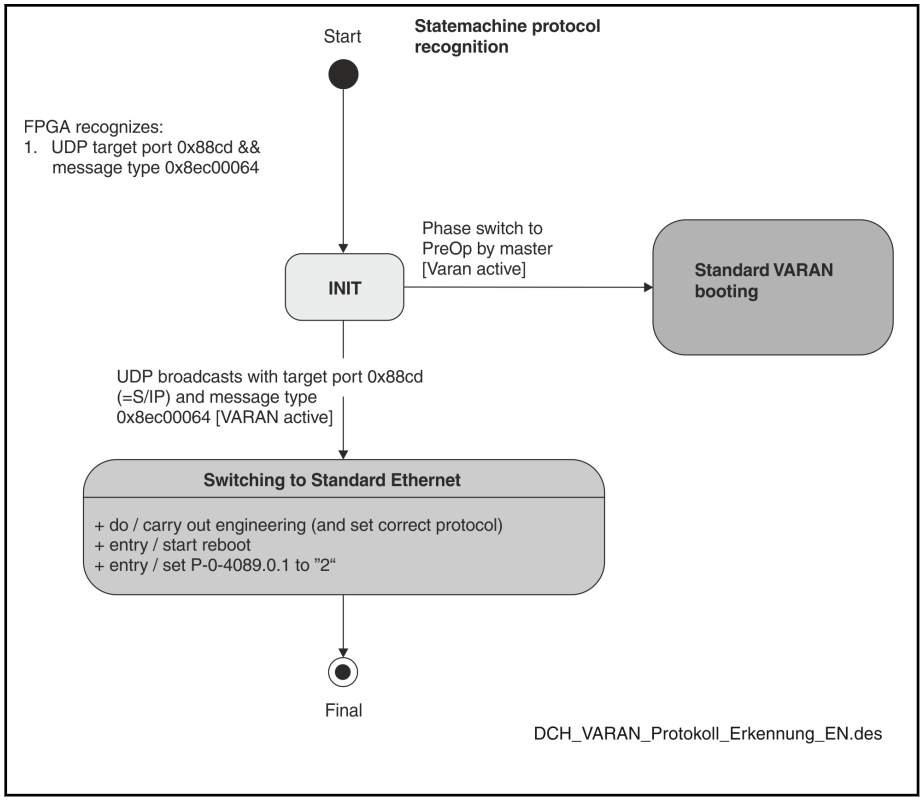


Fig. 4-57: Protocol recognition

For the solution regarding 2, the engineering tool IndraWorks Ds has to be connected and "EtherCAT/VARAN" has to be deactivated.

Refer to the following dialog:

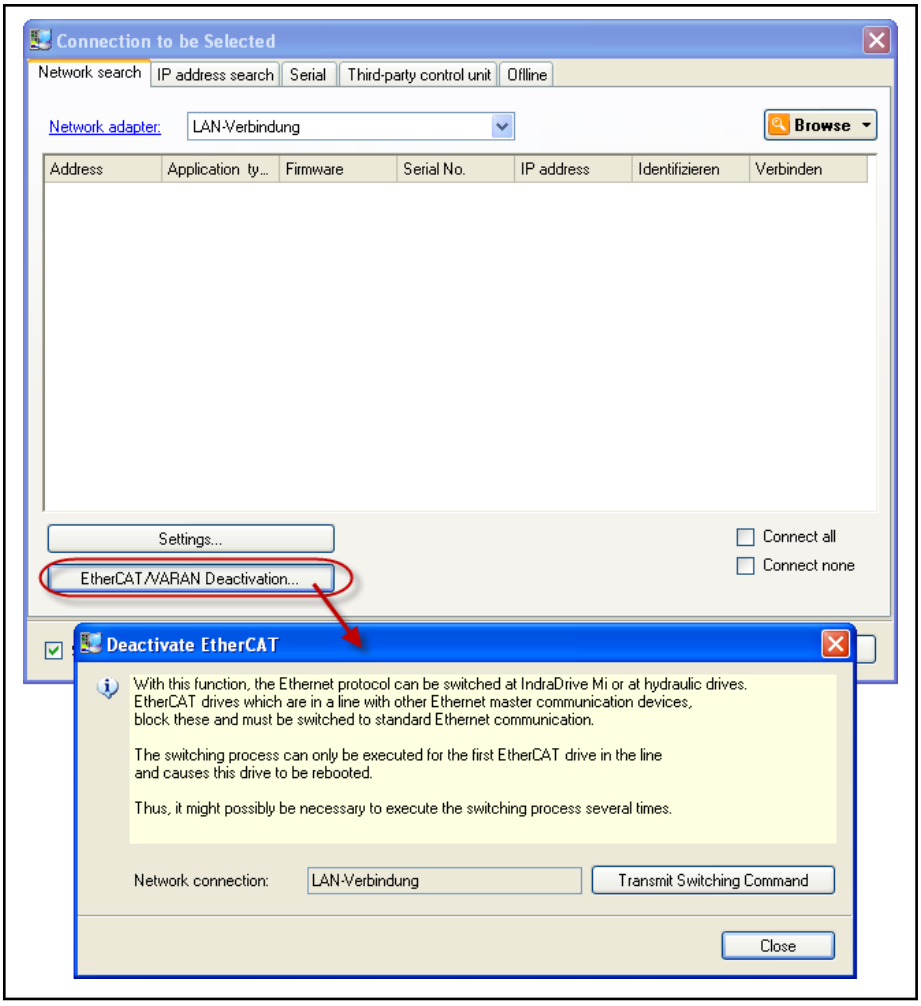


Fig. 4-58: Connection selection dialog

The commissioning sequence will then be as follows:

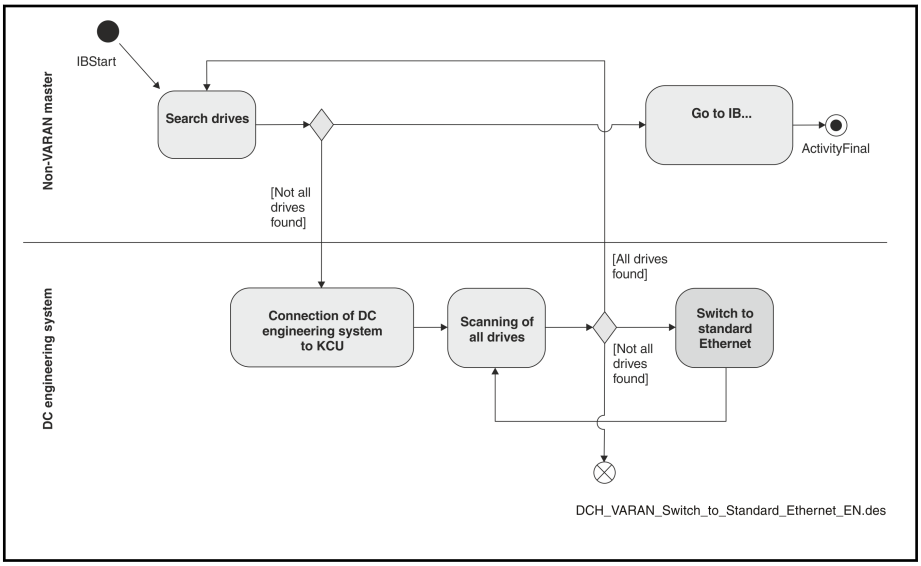


Fig. 4-59: VARAN switch to standard Ethernet

For application 2, the following solution is realized:

Application 2 can be realized using the proposed mechanism. With this solution, the engineering tool is to be connected and the drives are to be switch-

ed to default engineering. Then, the correct protocol (in this case VARAN) has to be set for all drives. During this, the control voltage must not be switched off and no rebooting may be executed.

4.10.4 Diagnostic and status messages

For use of "Servodrive Profile over VARAN" several LEDs are available on the housing of the HydraulicDrive controller for diagnosis of the current drive state. They help to evaluate the current status of the drive.

PHY LEDs on the housing

The PHY LEDs on the HydraulicDrive housing serve for diagnosis of the physical VARAN connection. The green Link LED (1st LED from the top) signals whether the VARAN cable has been connected to the HydraulicDrive. The yellow activity LED (2nd LED from the top) signals the data transmission to and from the HydraulicDrive controller.

STATUS LED on the housing

The bi-color STATUS LED on the HydraulicDrive controller (3rd LED from the top) is used for VARAN communication diagnosis. The flash codes are triggered according to "CANopen Draft 303 Part 3 - Indicator Specification". The applied flashing codes are specified in the table below.

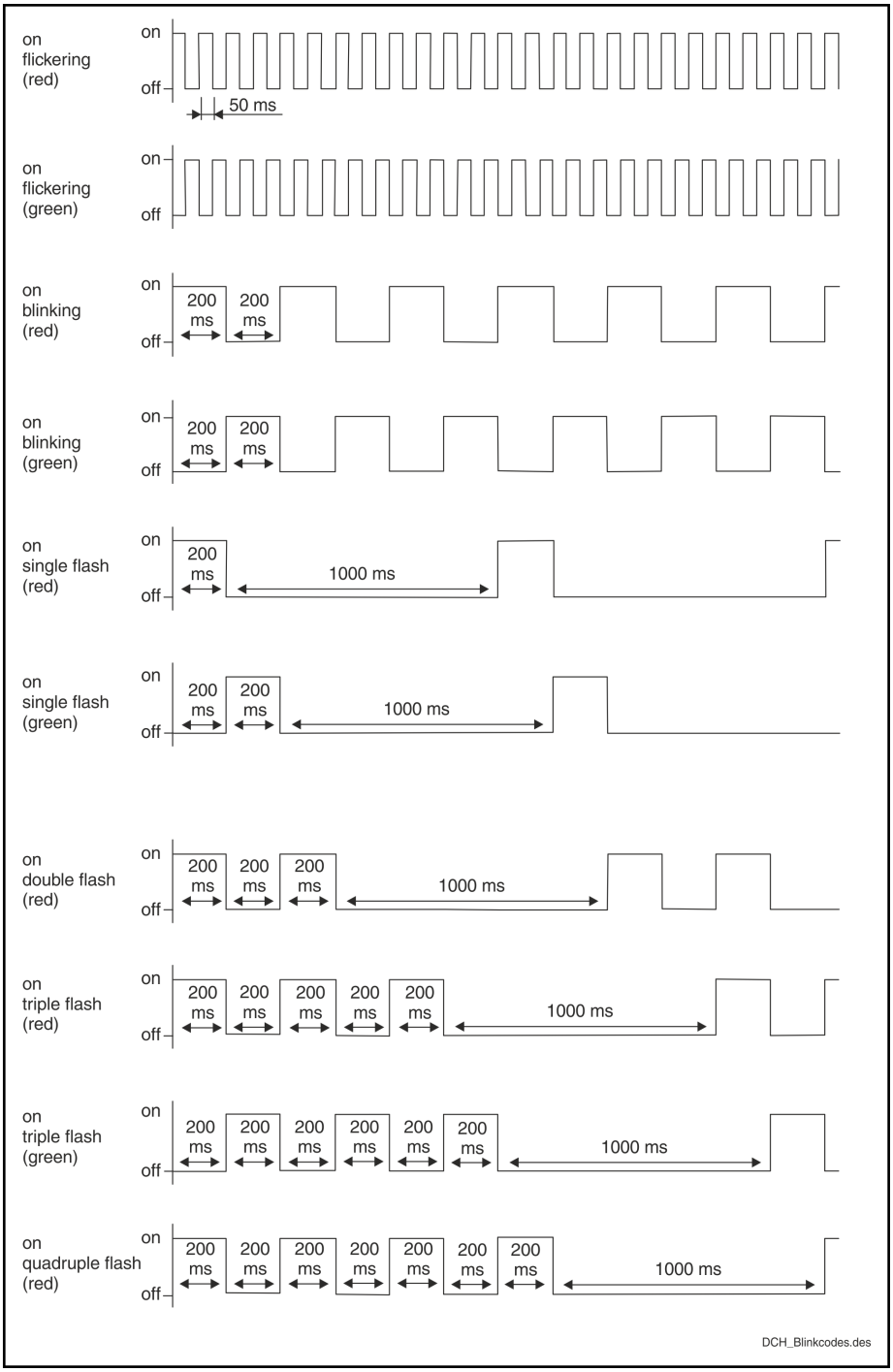


Fig. 4-60: LED activation according to CANopen Draft 303 Part 3

Bus state	LED activation	Description
INIT	GREEN: off	The VARAN bus is in state "INIT". No transmission of cyclic or service channel data. EoV data are transmitted.
PRE-OPERATIONAL	GREEN: on, blinking	The VARAN bus is in state "Pre-Operational". Service channel data can be transmitted.

Bus state	LED activation	Description
SAFE-OPERATIONAL	GREEN: on, single flash	The VARAN bus is in state "Safe-Operational". The drive already delivers valid actual values. Command values are not yet applied.
OPERATIONAL	GREEN: on	The VARAN bus is in state "Operational". The drive delivers actual values and processes command values.
Configuration error	RED: on, blinking	The drive is incorrectly configured and denies switch-over of states.
Synchronization error	RED: on, single flash	Error on synchronization of the drive with the VARAN master.
Timeout	RED: on, double flash	Error during cyclic process data transmission

Tab. 4-71: Flashing codes of the HydraulicDrive with SoV

MODULE STATUS LED on the housing

For internal diagnosis of the HydraulicDrive controller, the housing features a bi-color MODULE STATUS LED to display the drive-internal status (S3).

The additional two LEDS on the HydraulicDrive housing (L2, S2) do not have any function if the VARAN bus is used.

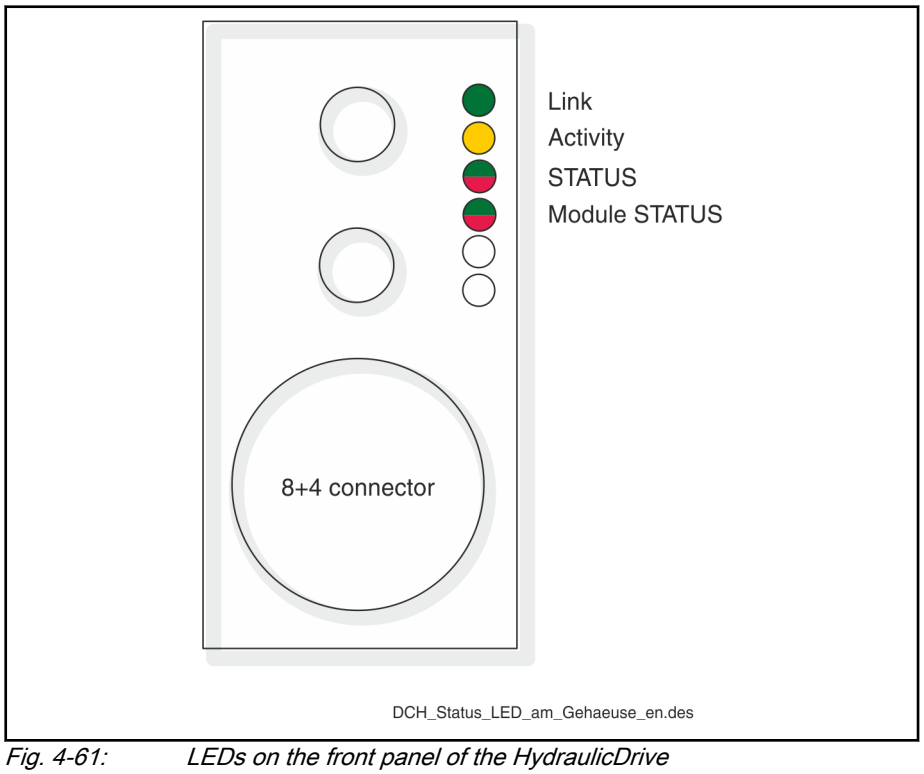


Fig. 4-61: LEDs on the front panel of the HydraulicDrive

4.10.5 VARAN info page

The VARAN info page can be read with the help of the VARAN tools.

The VARAN info page is composed of up to 12 elements:

ID	Description	Comment
01	Identification list	Vendor ID (12 for Bosch Rexroth) Device ID (depending on device, see below) License number Product version
02	SPI flash configuration	FPGA settings for VARAN
03	Vendor name	"Bosch Rexroth AG"
04	Device name	Corresponds to S-0-0140
05	Serial number	Corresponds to S-0-1300.0.12
06	Ordering number	Corresponds to S-0-1300.0.11
07	Documentation in pdf format	Not supported
08	Multi-file	Not supported
09	Device compatibility list	If necessary, second device ID to indicate compatibility
10	Calibration data	Not supported
11	MAC / IP address	The 1st MAC/IP information is filled with the following contents: Corresponds to S-0-1019 Corresponds to S-0-1020 Corresponds to S-0-1021 Corresponds to S-0-1022
12	Comment text	Is used for firmware string Corresponds to S-0-1300.0.9

Tab. 4-72:

The device ID results from the following:

Identifier	ID
IACD2	1195
IACQ2	1094
IACF2	1196
IACP2	1197
IFBF1	1265
IFBQ1	1266
Default	1195 (same as IACD)

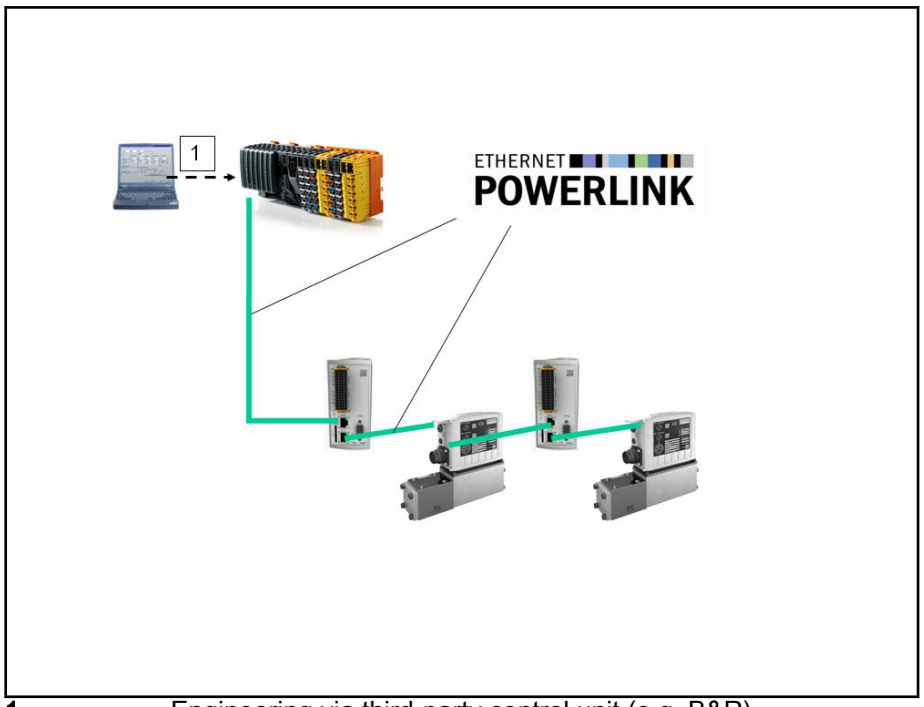
Tab. 4-73:

4.11 Ethernet POWERLINK

4.11.1 Brief description

General information

Topology



1 Engineering via third-party control unit (e.g. B&R)

Fig. 4-62: Ethernet POWERLINK topology

Drive controllers can be operated with Ethernet POWERLINK master communication. Ethernet POWERLINK is a field bus based on real-time Ethernet. The associated bus organization is EPSG (Ethernet POWERLINK Standardization Group). Bus masters are referred to as "Managing Nodes" (MN), slaves as "Controlled Nodes" (CN). The Ethernet POWERLINK communication according to EPSG specification is implemented in the drive.

The Ethernet frames are distributed to the individual "Controlled Nodes" (CN) via hubs. If the "Controlled Nodes" have a hub and a 2nd POWERLINK port integrated, the devices can be connected in series.

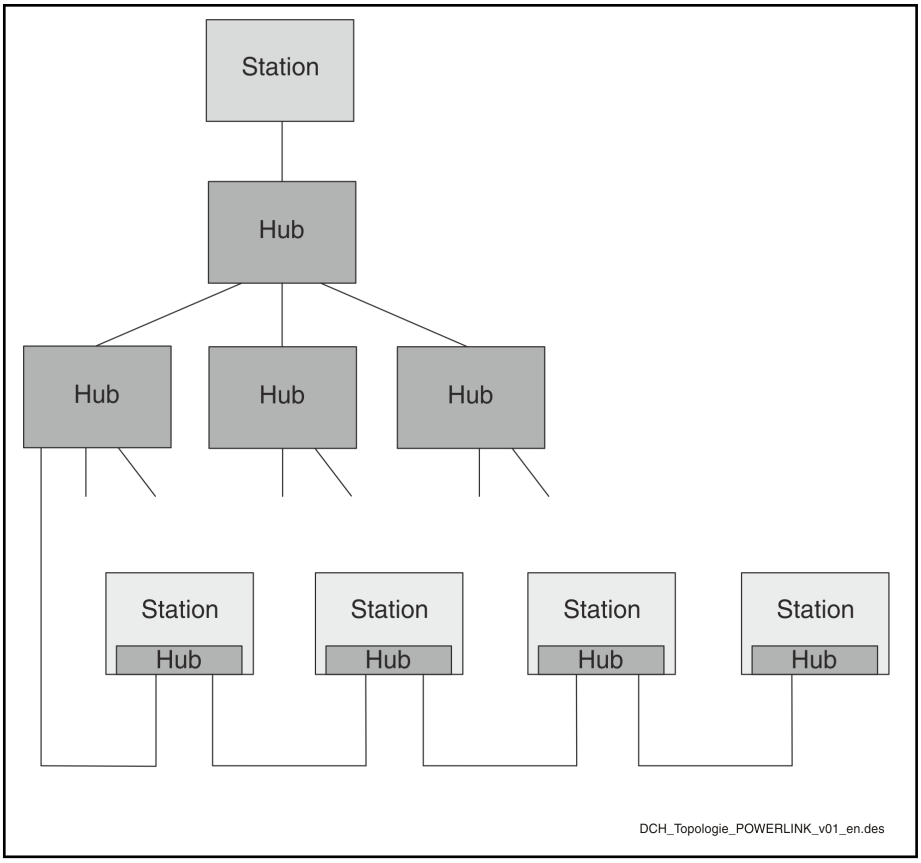


Fig. 4-63: Topology of Ethernet POWERLINK

General features

- Transmission rate 100 Mbit/s
- Data transmission over Ethernet cable (CAT5 copper)
- Maximum cable length between the nodes: 100 m
- Support of up to two 240 devices in a network
- Synchronization of all connected drives with the master
- Support of the transmission of standard Ethernet telegrams (e.g. for Engineering using IndraWorks) by means of “Basic Ethernet Mode“ or in the acyclic channel

Activation

Ethernet POWERLINK can be activated by setting parameter "P-0-4089.0.1, Master communication: Protocol" to the value “9“ and subsequent rebooting.

State machine of the Ethernet-POWERLINK controlled node (CN)

The following section describes the part of the state machine that is used for booting the "Controlled Node". When the "Controlled Node" has booted to the NMT_GS_COMMUNICATION mode, the states of the CN NMT State Machine are run through.

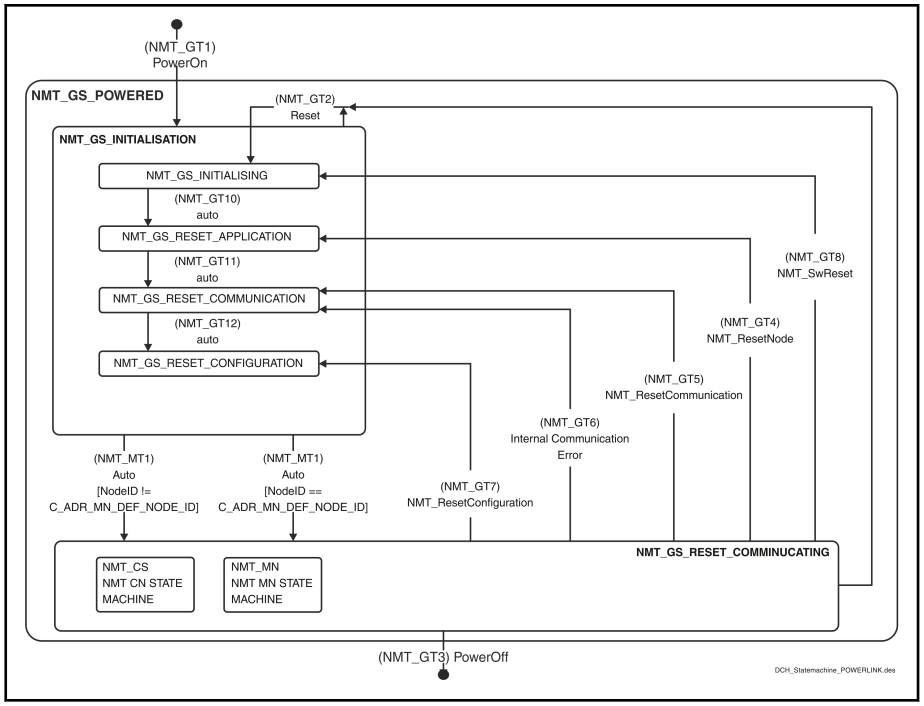


Fig. 4-64: State machine Ethernet POWERLINK initialization

Transitions

NMT_GT1 When the device is switched on (PowerOn), it autonomously changes over to the sub-state NMT_GS_INITIALISING.

NMT_GT2 After a hardware or local software reset, the device autonomously changes over to the sub-state NMT_GS_INITIALISING.

NMT_GT3 The Ethernet POWERLINK node was switched off.

NMT_GT4 When an NMT ResetNode command is received in NMT_GS_COMMUNICATING, changing over to NMT_GS_RESET_APPLICATION takes place.

NMT_GT5 When an NMT ResetCommunication command is received in NMT_GS_COMMUNICATING, changing over to NMT_GS_RESET_COMMUNICATION takes place.

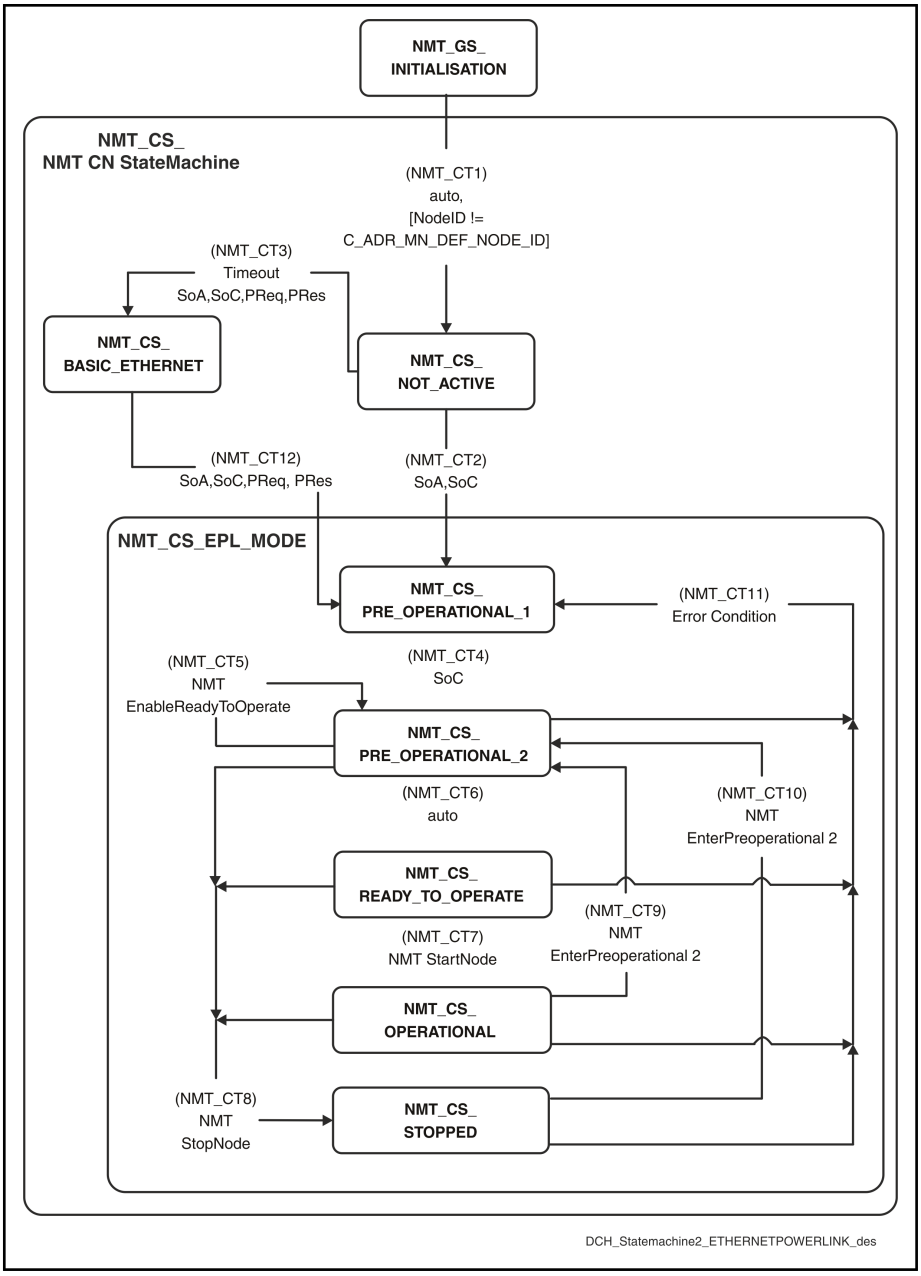


Fig. 4-65: Ethernet POWERLINK CN NMT state machine

Cyclic communication

Cyclic data are transmitted via PDOs. The PDOs are configured by means of defined objects of the object directory. In these PDOs, a maximum of 48 bytes of cyclic data can be transmitted.

Possible bus cycle times

The minimum bus cycle time is determined by the position controller clock cycle of the drive controller.

Acyclic communication

The communication between MN and CN is based on SDO communication according to CANopen (DS301). However, the data width of an SDO telegram was extended compared to CANopen so that at least 256 bytes of payload data can be transmitted per telegram.

For the use of the acyclic data channel observe chapter 9.1.2 "Loading, storing and saving parameters" on page 533.

The individual objects of the CN are accessed via an object directory according to CANopen.

Object directory entries with Ethernet POWERLINK, which must/can be available irrespective of the device profile.

In addition, standard Ethernet telegrams can be acyclically transmitted. This enables the use of, for example, IndraWorks.

For drive controllers, a time of 100 ms is determined as timeout time for acyclic communication. This means, when the drive does not reply to an acyclic request within this time, a reply can no longer be expected.

A parameter system according to Sercos is implemented drive-internally. The objects in conformity with CANopen are mapped as Sercos parameters in the drive. This means that for each object according to CANopen a corresponding parameter according to Sercos is available in the drive.

Mapping according to Sercos is effective only within the manufacturer-specific area (0x2000..0x5FFF) as well as for engineering by means of IndraWorks.

Currently, the Ethernet POWERLINK-specific objects cannot yet be read completely via the engineering tool “IndraWorks“. This has no influence on the functionality of the drive as Ethernet POWERLINK CN (Controlled Node).

The objet directory of the drive

An object dictionary according to EPSG DS 301 is implemented in the drive. It is subdivided into three general areas (see table).

Index	Object
16#1000..16#1FFF	Communication Profile Area
16#2000..16#5FFF	Manufacturer Specific Profile Area
16#6000..16#9FFF	Standardized Device Profile Area

Tab. 4-74:

The default objects according to EPSG DS 301 are implemented in the Communication Profile Area.

The Standardized Device Profile Area is currently not used for communication with the HydraulicDrive.

Manufacturer-Specific Profile Area (16#2000..16#3FFF)

In the manufacturer-specific area, all Sercos parameters provided with a 16-bit identification number can be accessed. Sercos parameters with 32-bit ident number (EIDN) cannot be reached directly. Some of these EIDN parameters are accessible via so-called alias parameters (16-bit IDNs).

Calculating the index number:

The corresponding index of the Sercos parameter can be calculated with the following formula:

- S-parameters: Index = 16#2000 + "S-parameter no."
- P-parameters: Index = 16#3000 + "P-parameter no."

Examples:

- S-0-0001 = 16#2000 + 1 = 16#2001
- P-0-0001 = 16#3000 + 1 = 16#3001

Sercos attributes via subindex number

The attributes of the Sercos parameters can be reached via the following subindices:

No.	Name	Function	Format
0	Number of elements	Number of supported elements	W
1	IDN	Sercos identity number (IDN)	T[8]
2	Name	Parameter name	T[60]
3	Attribute	Form of representation of the parameter	L
4	Unit	Parameter unit	T[12]
5	Min. input value	Possible minimum value of datum	W/L/T
6	Max. input value	Possible maximum value of datum	W/L/T
7	Operating datum	Operating datum of the parameter	W/L/T
8	Max. number of list elements	Max. number of list elements	L
9	Actual number of list elements	Actual number of list elements	L
10	Pointer to current element	Pointer to the element which is processed on the next access to element 11 - 20	L
11	Action for 1 list element	Action for 1 list element (list pointer is applied)	W/L/T
12	Action for 2 list elements	Action for 2 list elements (list pointer is applied)	W/L/T
13	Action for 3 list elements	Action for 3 list elements (list pointer is applied)	W/L/T
14	Action for 4 list elements	Action for 4 list elements (list pointer is applied)	W/L/T
15	Action for 5 list elements	Action for 5 list elements (list pointer is applied)	W/L/T
16	Action for 6 list elements	Action for 6 list elements (list pointer is applied)	W/L/T
17	Action for 7 list elements	Action for 7 list elements (list pointer is applied)	W/L/T
18	Action for 8 list elements	Action for 8 list elements (list pointer is applied)	W/L/T
19	Action for 9 list elements	Action for 9 list elements (list pointer is applied)	W/L/T
20	Action for 10 list elements	Action for 10 list elements (list pointer is applied)	W/L/T

Tab. 4-75: Subindex mapping with manufacturer-specific profile area

Data length 2 bytes → W

Data length 4 bytes → W

ASCII text with max. length of 64 bytes → T

Parameter sets

The parameter sets are coded in the upper 3 bits of the subindex number (0bxxx0.0000). The HydraulicDrive supports 4 different parameter sets (parameter set 0 to parameter set 3).

Calculating the subindex number:

To calculate the subindex number, the desired attribute (lower 5 bits, 0b000x.xxxx) and the parameter set (higher 3 bits, 0bxxx0.0000) must be entered.

Examples:

- Subindex no. of the operating datum (7) of the 1st parameter set (0)
  0b0000.0111 = 16#07
- Subindex no. of the operating datum (7) of the 4th parameter set (3)
  0b0110.0111 = 16#67

Standard Ethernet communication

Standard Ethernet telegrams are transmitted in the acyclic part. This enables the use of, for example, IndraWorks. If no Ethernet POWERLINK master is connected to the drive, the latter automatically changes to the "Basic Ethernet mode". In this mode, communication is only possible over standard Ethernet.

As soon as the "Controlled Node" starts Ethernet POWERLINK communication, direct Ethernet communication is no longer possible via the connector at the device. Ethernet communication then has to be handled via the "Managing Node".

To allow the connection to the drive via the "Managing Node", a corresponding IP routing has to be set at the computer used. In order to reach the target network of the "Client Node", a route must be configured on the engineering computer.

Route ADD <Target network> MASK <Subnet mask> <Gateway>

<Target network>	IP network address, in which the drive can be reached.
<Subnet mask>	Mask for the subnet to be reached (in most cases: 255.255.255.0)
<Gateway>	IP address of the gateway (here: "Managing Node")

Tab. 4-76:

Ethernet POWERLINK addressing

Each Ethernet POWERLINK node (Managing Node, Controlled Node and router) has a clear node ID within the Ethernet POWERLINK segment. The node ID can be configured by means of parameter "P-0-4089.0.3, Device address". The set value is accepted as active node ID when the drive is booting. The currently active node ID is displayed via parameter "P-0-4089.0.4, Active device address".

Node ID	Significance
0	Invalid ID/network
1-239	Controlled node
240	Managed node
241-250	Reserved
251	Local node ID
252	Dummy node
253	Diagnosis node
254	EPL Ethernet router
255	Broadcast

Tab. 4-77: Meaning of the node IDs with Ethernet POWERLINK

Node IDs 1 to 239 are used for a "Controlled Node". The "Managed Node" (corresponds to adapter, controller or master in conjunction with other bus systems) always takes node ID 240. In most of the cases, the "Managed Node" also assumes the functionality of the outward gateway. If a special gateway is used, it takes node ID 254.

IP addressing

Each Ethernet POWERLINK node is provided with an IPv4 address, a subnet mask as well as a default gateway. This IP address is used for bus addressing as well as for pure IP communication in the basic Ethernet mode.

IPv4 address

The Ethernet POWERLINK network is a class C network with address 192.168.100.x. The host ID of the IPv4 address is identical to the node ID of the station. This means that the last byte of the ID address has the identical value like that of the Ethernet POWERLINK node ID.

Value range of the drive's host ID: 1-239

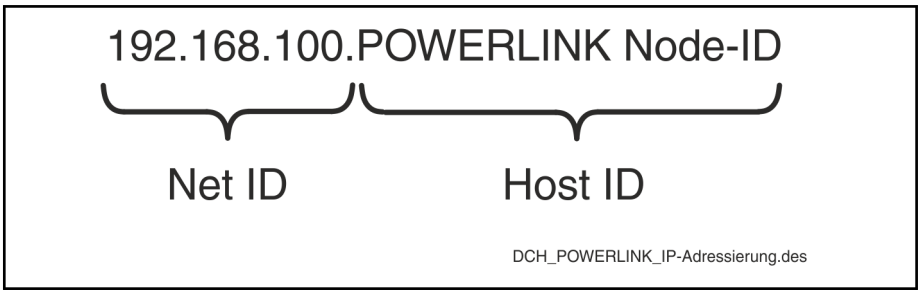


Fig. 4-66: IP addressing with Ethernet POWERLINK

Access via gateway

If the device is to be accessed within an Ethernet POWERLINK network, the gateway address must be correctly set. The address is contained in the IP suite, but can also be changed via an SDO access to object "P-0-3637.0.6, EPL: Default Gateway IPAD". The "Managing Node" sets this object mostly during booting and must therefore be configured accordingly.

Device description file (electronic data sheet) in "XDD" format

The properties of the Ethernet POWERLINK device are determined in the device description file. This file is termed "XML Device Description" (XDD). The XDD file is made available to the drive in the required specific revision and is utilized by the "Managing Node" for configuring the drive (CN).

4.11.2 Synchronization and timing

General timing

Ethernet POWERLINK divides the bus cycle time into a synchronous and an asynchronous part (isochronous phase and asynchronous phase). The bus cycle time starts with the so-called "start of cyclic" (SoC). Each node is directly addressed by the "Managing Node" via a "Poll Request" (PReq) and has then to reply immediately with its "Poll Response" (PRes). Due to direct addressing of the individual nodes, collisions on the bus are prevented and real-time capability is ensured.

The end of the isochronous phase is followed by the "start of acyclic" (SoA). Then, the "Controlled Nodes" can send acyclic data. The completion of the acyclic phase is followed by the "Idle Phase" which is active until the next SoC starts. Depending on the data in the acyclic phase, this "Idle Phase" can take different amounts of time. The duration from SoC to SoA depends on the number of "Controlled Nodes" within the bus.

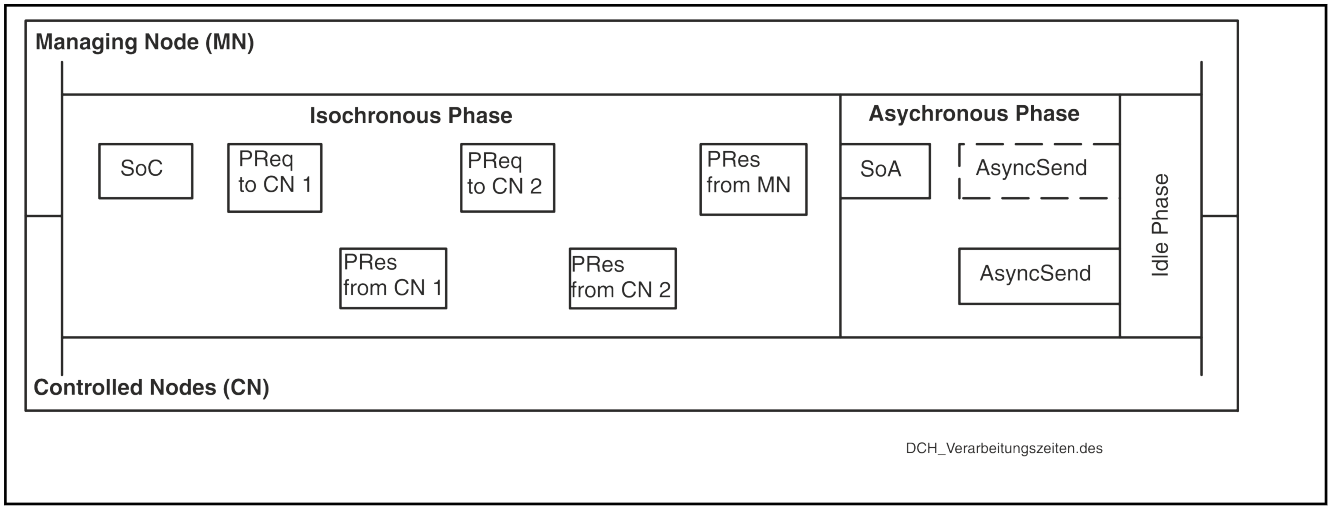


Fig. 4-67: Processing times cyclic/acyclic

During the acyclic phase (SoA until the next SoC) only one "Controlled Node" is allowed to send asynchronous data. At this point in time, also "Standard Ethernet Frames" can be sent. The order, in which the individual "Controlled Nodes" may send data, is determined by the "Managing Node".

The "Standard Ethernet" telegrams that are tunneled by the bus (e.g. TCP/IP traffic) are also transferred in the acyclic phase.

4.11.3 Diagnostic and status messages

Diagnostic possibilities

If Ethernet POWERLINK is used, several LEDs on the housing of the drive controller are available for diagnosing the current drive status. These can be used to diagnose the current state of the drive. The LEDs are activated according to the Ethernet POWERLINK Communication Profile Specification.

PHY LEDs on the housing

The PHY LEDs on the housing of the drive controller serve for diagnosis of the physical Ethernet POWERLINK connection. The LEDs S1 and S2 of HydraulicDrive are without function in conjunction with Ethernet POWERLINK. The green link LEDs L1 and L2 of HydraulicDrive signal links on the drive controller.

STATUS/ERROR LED on the housing

The bi-color bus LED on the housing of the drive controller is used for diagnosis of the Ethernet POWERLINK communication.

LED		Bus state	LED color
IAC	HMC		
S/E	NS	OFF, INITIALISATION, NOT_ACTIVE	LED off
		BASIC_ETHERNET	LED green, flickering
		PRE_OPERATIONAL_1	LED green, single flash pattern
		PRE_OPERATIONAL_2	LED green, double flash pattern
		READY_TO_OPERATE	LED green, triple flash pattern
		OPERATIONAL	LED green, ON
		STOPPED	LED green, flashing
		State machine error	LED red, ON
		No error	LED off

Tab. 4-78: Blinking codes of the drive controller with Ethernet POWERLINK

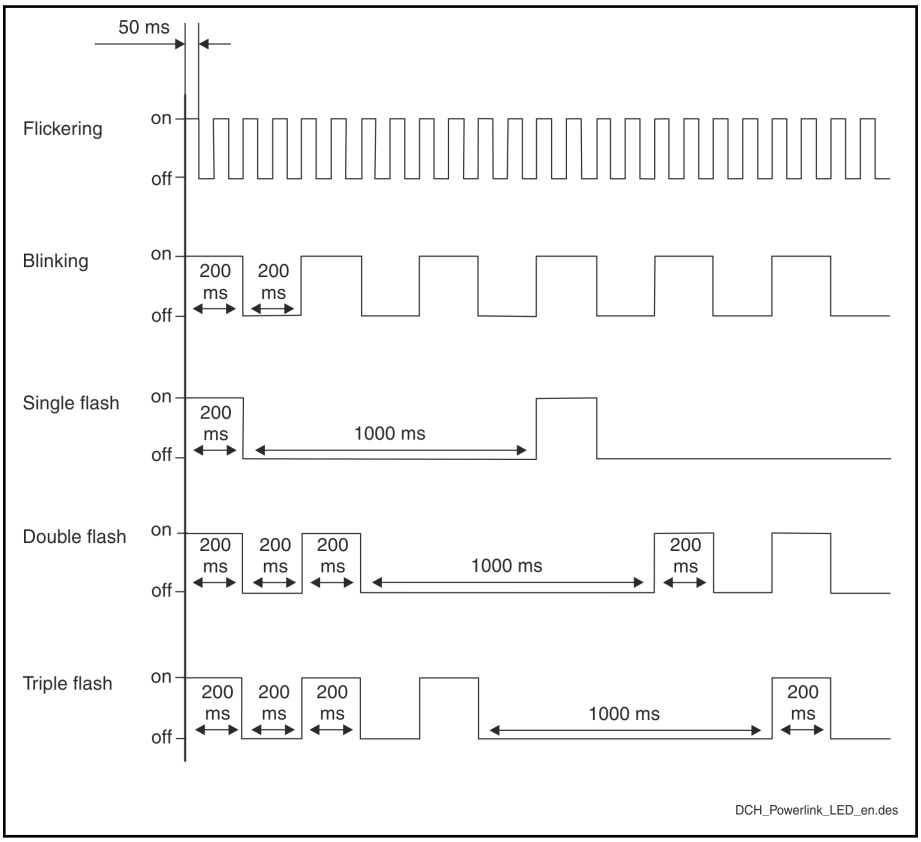


Fig. 4-68: Pulse/break ratio of blinking or S/E LEDs

MODULE STATUS LED on the housing

For internal diagnosis of the drive controller, the housing features a bi-color MODULE STATUS LED to indicate the drive-internal state.

Pertinent parameters

- P-0-1044, Master comm. engineering over IP: Status IP communication
- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4073, Field bus: Diagnostic message

- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4080, Field bus: Config. list of cyclic actual value data ch.
- P-0-4081, Field bus: Config. list of cyclic command value data ch.
- P-0-4082, Field bus: Length of cyclic actual value data channel
- P-0-4084, Application: Profile type
- P-0-4089.0.1, Master communication: Protocol
- P-0-4089.0.3, Device address
- P-0-4089.0.4, Active device address
- S-0-0001, NC cycle time (TNcyc)
- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address

Pertinent diagnostic messages

- A0004, Initialization
- A0005, Pre-Operational
- A0025, Basic ethernet mode
- A0026, Ready to Operate
- C0229, Field bus: IDN for cycl. command val. not configurable
- C0230, Field bus: Max. length for cycl. command val. exceeded
- C0231, Field bus: IDN for cycl. actual val. not configurable
- C0232, Field bus: Length for cycl. actual values exceeded
- C0233, Field bus: Tcyc (P-0-4076) incorrect
- E4005, No command value input via master communication
- E4006, Communication module overload
- E4011, Communication watchdog: Overload of cyclic communication
- F4009, Bus failure
- F4011, Communication watchdog: Overload of cyclic communication
- F4012, Incorrect I/O length
- C0201, Invalid parameters (->S-0-0423)
- C0299, Configuration changed. Restart

4.12 Analog interface

4.12.1 Brief description

Overview

Apart from digital master communication interfaces (Sercos, EtherCAT …), the drive controllers of the HydraulicDrive family also offer an interface for analog master communication (analog interface). This allows an analog command value to be assigned to a drive parameter (e.g. "S-0-0036, Velocity command value").

The following graphics show the structure of drive solutions with analog interface in open-loop-controlled and closed-loop-controlled operation.

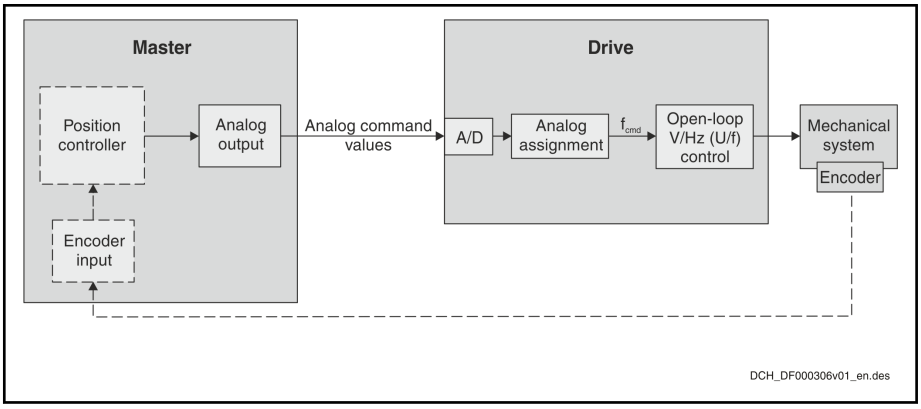


Fig. 4-69: Open-loop mode with analog interface (with optional position feedback to the control)

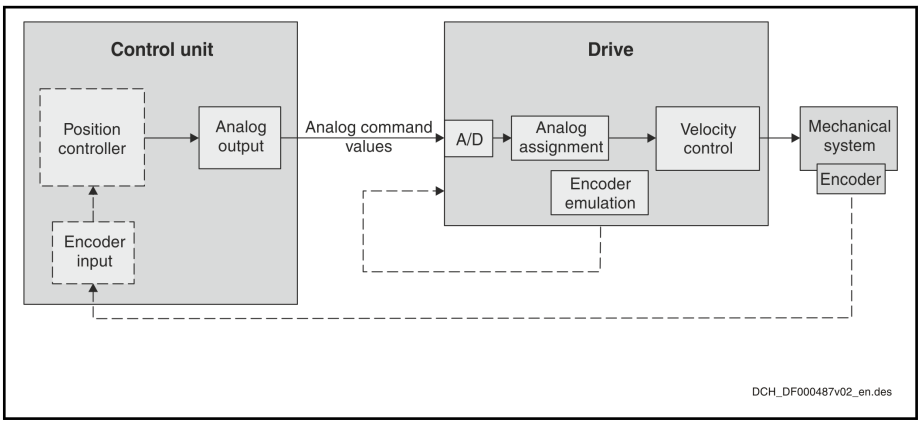


Fig. 4-70: Closed-loop mode with analog interface (with analog command value input and SSI emulation)

This section primarily describes the basic functions of the analog interface and gives notes on commissioning and parameterization. The individual function "analog inputs" is described separately.

See also "analog inputs"

Features

The analog interface is an interface for master communication with analog command values and digital inputs/outputs (controller enable, Drive Halt, …).

Features of **analog inputs**:

- Analog inputs with adjustable smoothing that can be assigned to parameters (number of analog inputs depends on type of drive controller)
- Sampling of the analog inputs in the velocity controller cycle $T_{velocity}$ (see "Performance data")

Features of **analog assignment**:

- Up to 5 assignments to parameters possible; for each assignment, offset and scaling of the analog input can be adjusted
- Sampling rate for analog input assignment:
  - Velocity controller cycle $T_{velocity}$
  - Position controller cycle $T_{position}$
  - Valve controller cycle T_{valve}

Features of **digital inputs/outputs**:

- Determination of digital control and status information via configuration of digital inputs of the control section:

- **Digital control inputs** for analog master communication:
  - Signals "drive enable" and "Drive Halt"
  - Reset switch, limit switch (+/-), clearing errors and E-Stop
  - Inputs for enable of output stage A and B
- **digital status outputs** for analog master communication:
  - Inputs for enable acknowledgement of output stage A and B

Availability

All drive controllers offer the option for analog operation. For this, it is necessary to deactivate master communication by means of "P-0-4089.0.1, Master communication: Protocol".

The Multi-Ethernet interface can still be used for engineering and diagnostic purposes.

Pertinent parameters

Control and status parameters

- P-0-0115, Device control: Status word
- P-0-0116, Device control: Control word
- P-0-4028, Device control word
- P-0-2945 Configuration of analog mode

Digital inputs/outputs:

- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device
- P-0-0310, Digital outputs, assignment list
- P-0-0311, Digital outputs, bit numbers

Analog inputs:

- P-0-2918.0.1, Hardware control word of analog inputs and outputs
- P-0-2918.0.2, Hardware control word of analog inputs and outputs
- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6
- P-0-0221, Analog input 7
- P-0-0256, Analog input 8

Analog outputs:

- P-0-0139, Analog output 1
- P-0-0140, Analog output 2
- P-0-0414, Analog output 3
- P-0-0415, Analog output 4

4.12.2 Functional description

Activation

With analog interface, the drive is activated via the digital inputs. The pins are assigned to the drive parameters via the list parameter "P-0-0300, Digital inputs, assignment list".

See parameter description "P-0-0300, Digital inputs, assignment list"

Drive enable

Activating the drive requires a positive edge of the "drive enable" signal. This can be adjusted by the additional parameter"P-0-2945, Configuration of analog mode", if necessary. It is also possible to configure automatic activation of the drive.

The "drive enable" signal is mapped in parameters "P-0-4028, Device control word" and "P-0-0116, Device control: Control word".

See also "Device control and state machines"

In order that the enable signal is accepted, the following conditions must be fulfilled:

- Under normal conditions, no drive error may be present. Depending on the configuration of the analog mode in P-0-2945, a drive error is automatically acknowledged.
- The drive has to be in operating mode (phase 4).
- Enable cable A or B is set (if available).

  The diagnostic message of the drive in parameter "S-0-0095, Diagnostic message" is "A0012 Drive ready".

Value	Configuration of analog mode
0	**Digital input, edge-controlled** "P-0-4028; bit 15" is configured to a digital input. With a positive edge of the digital input the drive switches to closed-loop control. In the case of an error, the error has to be acknowledged first, and the drive can then only be switched to closed-loop control operation with a new positive edge.
1	**Digital input, state-controlled** "P-0-4028; bit 15" is configured to a digital input. When the digital input is “1”, the drive attempts to switch to the closed-loop control mode. Any error that may be present prevents the changeover to the closed-loop control mode. When the error is acknowledged, the drive automatically switches to the closed-loop control mode as long as the digital input is set.
2	**Automatically after run-up** "P-0-4028; bit 15" has not been cyclically configured. After the drive has run up, it changes once to closed-loop control (after switching to OM). If an error occurs, the closed-loop control mode is terminated. Switching again to closed-loop control is possible by an OM->PM->OM change.
3	**Automatically after run-up or error reset** "P-0-4028; bit 15" has not been cyclically configured. After the drive started up and switched to OM, it changes to closed-loop control. If an error occurs, the closed-loop control mode is terminated. Switching again to closed-loop control is possible by clearing the error.

Value	Configuration of analog mode
4	**Enable cable, edge-controlled** "P-0-4028; bit 15" has not been cyclically configured. With a positive edge of the enable cable, command "C0500, Reset class 1 diagnostics" is executed first. Then bit 15 of "P-0-4028" is set and the drive switches to closed-loop control. If an error occurs, the drive exits the closed-loop control mode. By a repeated positive edge of the enable cable, the error present can be cleared and the drive be switched again to closed-loop control. Clearing the error in IndraWorks will not result in re-switching to closed-loop control When the drive is in closed-loop control and the enable is withdrawn, the drive signals "F2025 Drive not ready for control".
5	**Enable cable, state-controlled** "P-0-4028; bit 15" has not been cyclically configured. With a positive edge of the enable cable, command "C0500, Reset class 1 diagnostics" is executed first. Then, bit 15 of "P-0-4028" is set and the drive switches to closed-loop control. If an error occurs, the drive exits the closed-loop control mode. By a repeated positive edge of the enable cable, the error present can be cleared and the drive be switched again to closed-loop control. Alternatively, while the enable cable is set, the error can be acknowledged and the drive would then switch to closed-loop control again. When the drive is in closed-loop control and the enable is withdrawn, the drive signals "F2025 Drive not ready for control".

Tab. 4-79: Setting P-0-2945, bit 0-2

Signal "Drive Halt"

When the drive enable is set and the "Drive Halt" signal is active (P-0-4028 and P-0-0116, bit 13 = 0, respectively), the diagnostic message of the drive then is "A0010, Drive halt active", which signals the activation of "Drive Halt".

If the "Drive Halt" signal is subsequently deactivated (P-0-4028 or P-0-0116, bit 13 = 1, respectively), the diagnostic message of the drive then depends on the active operation mode (see description of the relevant diagnostic message in the separate documentation "Troubleshooting Guide; description of diagnostic messages")

☞ The signal "Drive Halt" is state-controlled and active when 0; that is, when the signal = 0 V the drive is in the "Drive Halt" state.

Clearing errors

A positive edge at the "clear error" input starts the command for error clearing. To this end, command C0500 must be assigned to a digital input:

- Configure parameter "S-0-0099, C0500 Reset class 1 diagnostics" in "S-0-0300, Digital inputs, assignment list"
- In parameter "P-0-0301, Digital inputs, bit numbers" set bit 0 for the element of S-0-0099

See also "Digital inputs/outputs"

☞ All drive errors are cleared by activating the command for error clearing!

Analog command value provision

The analog inputs and outputs are used for providing the analog command value.

On HydraulicDrives, the analog inputs are cyclically sampled and evaluated:

See "Analog inputs"

4.12.3 Notes on parameterization/commissioning

Analog inputs

The analog inputs available on HydraulicDrives are subject to certain restrictions despite their comprehensive functionality and performance. These restrictions are explained in more detail in the section "Analog inputs".

See also "Analog inputs"



If the drives with analog command value input have not been synchronized, beat effects can occur during sampling in spite of oversampling. Rexroth therefore advises not to use the analog interface in high-end applications, but to use digital interfaces in these cases.

4.12.4 Diagnostic and status messages

Information on general drive status

The most important status bits of the drive's state machine are mapped in parameter "P-0-0115, Device control: Status word". Reading and interpreting parameter P-0-0115 therefore provides information on the current state of the drive.



See parameter description "P-0-0115, Device control: Status word"

Status of digital inputs/outputs and analog inputs

All digital and analog input values can already be read via parameters before having been assigned to the internal drive parameters. The following is valid here:

- Digital inputs/outputs of the controllers are mapped to parameter "P-0-0303, Digital inputs, input image of device".
- Analog input values are displayed in the following parameters:
  - "P-0-0210, Analog input 1"
  - P-0-0211, Analog input 2
  - P-0-0228, Analog input 3
  - P-0-0229, Analog input 4
  - P-0-0208, Analog input 5
  - P-0-0209, Analog input 6
  - P-0-0221, Analog input 7
  - P-0-0256, Analog input 8

See also "Diagnostic and status messages" under the following sections:

- "Digital inputs/outputs"
- "Analog inputs"

5 Drive, mechanical axis system, measuring systems

5.1 General information

5.2 Hydraulic system data

5.2.1 Model-based data (system data)

Introduction

For all model-based controller functions, data for modeling are required. These data are the hydraulic system data. They are administrated centrally (since they are usually required by several functions). An example of hydraulic system data required for modeling are the properties of the lines (length, diameter, etc.). One function, which is realized by means of the system data, is the calculation of suggested values for the controller.

Suggested values for the controller

Based on the model data, suggested values for the operation mode of "position control" can be accepted.

Suggested data are to be understood merely as points of reference and will not guarantee that with these values the machine is operated in a safe condition. The values must be checked by experts and will therefore only be offered and not written directly to parameters. For permanent acceptance, the parameters need to be explicitly accepted.

Based on the entries for hydraulic system data (cylinder type, circuit type, pressures, etc.), values can be suggested for the position controller. The system data have to be established on the basis of electrical circuit diagrams and mechanical drawings of the system as well as on data sheets of the various components. The data required for the measuring systems have to be embedded in the corresponding dialogs. After thorough verification and acceptance of the suggested values the axis can be commissioned by specialist personnel. Optimizations/adjustments to the concrete process sequence may be necessary.

Pertinent parameters

- P-0-2875.0.1, Nominal flow
- P-0-2875.0.2, Nominal pressure delta p
- P-0-2875.0.5, Nominal flow
- P-0-2875.0.6, Nominal pressure delta p
- P-0-2902, Line length A
- P-0-2903, Line length B
- P-0-2904, Line diameter A
- P-0-2905, Line diameter B
- P-0-2906, System pressure 2
- P-0-2919, Inclination angle of axis
- P-0-2921, Load pressure
- P-0-2923, Configuration of system data
- P-0-2925, Natural frequency of valve
- S-0-0813, System pressure
- S-0-0814, Tank pressure
- S-0-0820, Piston area A

- S-0-0821, Piston area B
- P-0-2917.0.3, Natural frequency of axis
- P-0-2832.010, Moved mass

5.3 Position acquisition

5.3.1 Overview of position acquisition

Representation of position acquisition

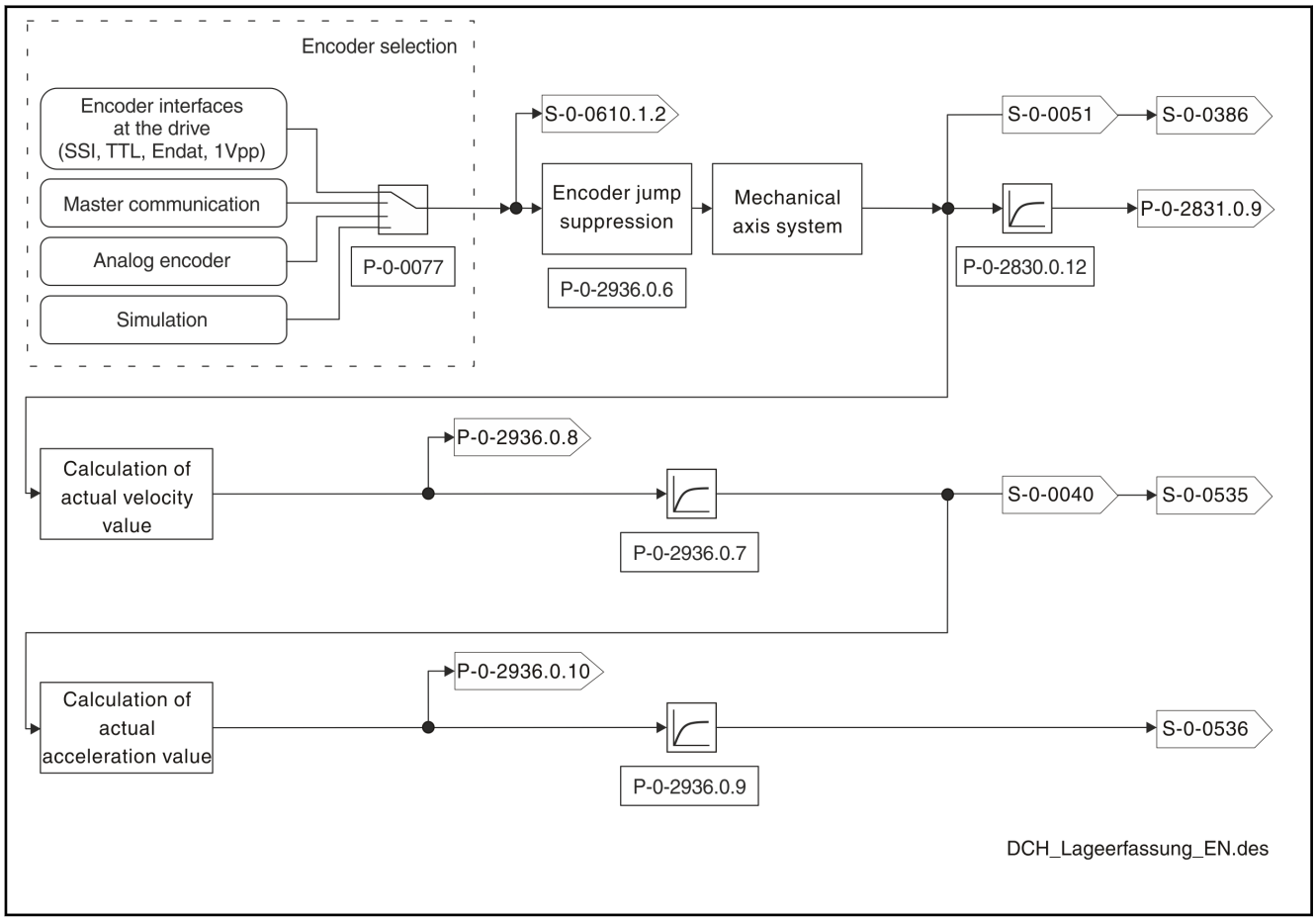


Fig. 5-1: Overview of position acquisition

Encoder selection

For detailed information on the encoder selection, see chapter 5.3.5 "Encoder types" on page 215.

Encoder jump suppression

The actual velocity value is monitored. If the actual velocity value exceeds the effective positive or negative velocity limit (see "S-0-0038, Positive velocity limit value", "S-0-0039, Negative velocity limit value", "S-0-0091, Bipolar velocity limit value" and "S-0-0113, Maximum velocity of the drive"), an encoder jump is recognized. Such an encoder jump can be suppressed by means of encoder jump suppression for a specific maximum number of velocity controller cycles ("P-0-2936.0.6, Maximum number of cycles of encoder jump suppression"). During this time, the old actual velocity value is used for further calculations and the actual position value is thus extrapolated. Only

when the time, which results from P-0-2936.0.6, has elapsed are the established encoder values used for calculations. Only then will the monitoring functions (e.g. actual velocity value, following error) work as usual.

Mechanical axis system

For detailed information on the mechanical axis system, see chapter 5.3.4 "Mechanical axis system and arrangement of measuring system" on page 209.

Calculation of the actual velocity value and the actual acceleration value

The values of velocity "S-0-0535, Active velocity feedback value" and acceleration "S-0-0536, Active acceleration feedback value" are derived from the actual position value.

These values are averaged by default. The average value filters can be adapted with the help of parameter "P-0-2936.0.7, Actual velocity filter time" (or "P-0-2936.0.9, Actual acceleration filter time", respectively). A filter time of 0 deactivates the individual filters.

Pertinent parameters

- P-0-0077, Assignment of encoder 1->interface
- P-0-2830.0.12, Filter time of position feedback value
- P-0-2831.0.9, Position feedback value, filtered
- P-0-2936.0.6, Maximum number of cycles of encoder jump suppression
- P-0-2936.0.7, Actual velocity filter time
- P-0-2936.0.8, Velocity feedback value, not filtered
- P-0-2936.0.9, Actual acceleration filter time
- P-0-2936.0.10, Acceleration feedback value, not filtered
- S-0-0040, Velocity feedback value of encoder 1
- S-0-0051, Position feedback value of encoder 1
- S-0-0386, Active position feedback value
- S-0-0535, Active velocity feedback value
- S-0-0536, Active acceleration feedback value
- S-0-0610.0.2, Position unscaled (input)

5.3.2 Measuring systems, general

Basics on measuring systems, resolution

General information

For acquiring the actual values of the velocity and position control loop, position measuring systems are available that can be configured by the user. For a HydraulicDrive the position measurement is always taken by an external position measuring system (encoder), which is mechanically coupled to the hydraulic axis to be controlled, see also " Mesauring systems, general".

Basic designs

Position measuring systems are available for the different kinds of motion in adapted designs. At present, HydraulicDrives support the following designs (with suitable signal specification):

- Linear encoders

  → Encoder systems, which map a linear movement

- Rotary encoders

  → Encoder systems, which map a rotary movement

Relative/absolute evaluation

Depending on their design and mechanical mounting to the hydraulic axis, position encoders can be evaluated as

- relative encoders (incremental encoders)
- absolute encoders (absolute value encoders)

Relative position measurement

In the case of relative position measurement, only position differences can be evaluated by means of the measuring system. The actual position values fed back by the measuring system refer to the (mostly undefined) position at the time the drive is switched on. To operate the drive within a limited travel range a position reference has to be established ("homing") each time after the drive is switched on again. To this end, these encoder types mostly have one or more reference marks for establishing a mechanical reference. Here, the following mark types have to be distinguished:

- Single mark (only one mark available over the entire travel range)
- Cyclic marks (always the same distance between two marks)

Typical relative measuring systems are incremental encoders with square wave signals or 1 Vpp encoders.

Absolute position measurement

In the case of absolute position measurement, the encoder signals the drive actual position values with a fixed encoder-dependent dedicated point. After the drive was switched on the correct actual position value is immediately available in any axis position. Due to the mostly undefined mounting situation of the encoder to the hydraulic axis, it is necessary to determine the position offset ("set position data reference") once during initial commissioning.

Typical absolute measuring systems are encoders with SSI or EnDat 2.2 interface.

Encoder types that can be used

The list below shows, which controller types are at present supported in conjunction with a HydraulicDrive:

Type of encoder	HDB	HDP	HDC	HDM	HDE
Sensorless operation (open-loop operation)	■	■	■	■	■
Simulation encoder	■	■	■	■	
SSI encoder	■	■	■	■	
1Vpp encoder	■	■			
EnDat 2.2 encoder	■	■	■	■	
Incremental encoders with square wave signals			■	■	
Analog encoder	■	■	■	■	

Tab. 5-1: Types of encoders

Resolution/accuracy

The accuracy of position measurement depends on:

- the resolution of the measuring system (defined by the manufacturer)

- the absolute accuracy of the measuring system (defined by the manufacturer)
- the differential accuracy of the measuring system (defined by the manufacturer)
- the digitization quality of analog encoder signals
- the set dimension of the travel range of the axis

Monitoring the measuring systems

Monitoring of physical encoders

The encoders are monitored depending on the encoder type at hand. The monitoring functions are explained in detail in the features of the various encoder types. The warnings generated in "Encoder-Basic" are forwarded as group message bit (bit 13) via the encoder status ("S-0-0600.x.1, Encoder status") to the Extended evaluation for evaluation. Further detail diagnostic messages are made possible by parameter "S-0-0600.x.136, Extended diagnostic message". Encoder monitoring can be switched off via parameter "S-0-0602.x.136, Phys. encoder evaluation configuration" (bit 15). If encoders are supplied from an external voltage source ("S-0-0602.x.136, bit 14"), monitoring of the supply voltage made available by the drive is deactivated.

Signal monitoring

Signal monitoring is realized differently depending on the concrete interface. Details can be found in the description of the individual encoder type.

Monitoring for loss of position

Absolute encoder systems can shift the zero point of the encoder via the position data reference and thus establish a reference to the mechanical axis system. To this end, the reference information last valid in parameter "P-0-0177, Encoder 1, absoute encoder buffer" is saved and utilized for establishing the current position when the position is initialized. In addition, configuration data are saved.

The monitoring function recognizes when it was impossible to save the last reference information correctly or if the configuration parameters were changed and signals error "F2174, Loss of encoder 1 reference". The error is also generated when the encoder has not yet had a reference. Detailed diagnostics show, which monitoring function has produced the error.

The position data reference of absolute encoders gets lost when:

- the parameter values of the mechanical drive train have been changed,
- the encoder resolutions have been changed
- scaling of the physical data has been changed
- the maximum travel range of an axis has been changed

Encoder jump suppression

The actual velocity value is monitored. If the actual velocity value exceeds the effective positive or negative velocity limit (see S-0-0038, Positive velocity limit value, S-0-0039, Negative velocity limit value, S-0-0091, Bipolar velocity limit value and S-0-0113, Maximum velocity of the drive), an encoder jump is recognized. Such an encoder jump can be suppressed with the help of encoder jump suppression for a maximum number of velocity controller cycles ("P-0-2936.0.6, Maximum number of cycles of encoder jump suppression"). During this time, the old actual velocity value is used for further calculations and the actual position value is thus extrapolated. Only when the time, which results from "P-0-2936.0.6, Maximum number of cycles of encoder jump suppression", has elapsed are the established encoder values used for cal-

culations. Only then will the monitoring functions (e.g. actual velocity value, following error) work as usual.

Absolute measuring systems

Absolute encoders

Absolute encoders can only display a limited position range in absolute values. For encoders that can be evaluated in absolute form, the drive, depending on the connection of the encoder to the axis and on position data scaling, calculates the travel range of the axis that can be displayed in absolute actual position values.

Encoders can be evaluated as absolute encoders if the travel range of the axis can be represented within the absolute actual position value range of the encoder:

The following parameters indicate the maximum extent of the travel range that may be selected so that an absolute encoder can be evaluated in absolute form:

- S-0-0378, Absolute encoder range, encoder 1

The user determines the travel range of the axis:

- S-0-0278, Maximum travel range

If the travel range is smaller than the absolute encoder range established by the drive, the relevant control encoder can be evaluated as absolute encoder.

This is indicated in the respective bits of the following parameters:

- S-0-0277, Encoder 1, type of position encoder

If absolute evaluation of an encoder is possible but not desired, absolute evaluation can be switched off by setting the respective bit in parameter "S-0-0277, Encoder 1, type of position encoder"! The encoder can then only be evaluated in relative form.

Establishing absolute position

The actual position values of an absolute encoder first only relate to the encoder itself. Due to the mostly undefined mounting situation of the encoder to the hydraulic axis, it is necessary to determine the position offset between the encoder zero point and the axis zero point once during initial commissioning.

See also:Establishing position data reference:

See also:Absolute measuring systems

Actual position value of encoders to be evaluated in absolute form after switching on

If only one absolute encoder is available, there are the following cases to be distinguished for the actual position value after the drive has been switched on:

Absolute evaluation (S-0-0277, bits 6 and 7)	Actual position value of encoder when switching on	Notes on the commissioning status
Active → Evaluation as absolute measuring system	Original position of encoder	Position data reference has not yet been set, encoder is not "in reference".
	Absolute encoder value	Position data reference has been set, the encoder is "in reference".

Absolute evaluation (S-0-0277, bits 6 and 7)	Actual position value of encoder when switching on	Notes on the commissioning status
Inactive → evaluation as relative measuring system intended	P-0-0019	Homing procedure has not yet been carried out, encoder is not "in reference".
Not possible → evaluation as relative measuring system, e.g. due to length of travel range	P-0-0019	Homing procedure has not yet been carried out, encoder is not "in reference".

The encoder's being "in reference" is signaled in parameter "S-0-0403, Position feedback value status", in bit 1 for encoder 1.

Relative measuring systems

Measuring systems

When the drive is switched on, the initial position value (P-0-0019) is written to the actual position values of relative encoders.

Actual position value when switching on	Notes on the operational state
P-0-0019	Axis has not moved after switching on, axis has not yet been homed.
Absolute encoder value → evaluation as relative measuring system intended	Axis has been homed via the encoder

The encoder's being "in reference" is signaled in parameter "S-0-0403, Position feedback value status", in bit 1 for encoder 1.

Pertinent parameters

- S-0-0277, Encoder 1, type of position encoder
- S-0-0378, Absolute encoder range, encoder 1
- S-0-0278, Maximum travel range
- P-0-0019, Initial position value
- P-0-0177, Encoder 1, absoute encoder buffer
- P-0-2936.0.6, Maximum number of cycles of encoder jump suppression

Pertinent diagnostic messages

- F2174, Loss of encoder 1 reference

Hardware requirements

Valve electronics (IAC-2X)

The valve electronics supports the following encoder types:

- Encoders with SSI interface
- Encoders with 1Vpp interface
- Encoders with EnDat 2.2 interface
- Encoder with analog interface

The encoder interfaces require different hardware characteristics, which have to be specified as order option "sensor interface" in the ordering code. The ordering code can be found in the data sheet of the relevant valve.

Control cabinet electronics (HMIC)

The control cabinet electronics supports the following encoder type via the multi-encoder interface:

- Encoders with SSI interface
- Encoders with EnDat 2.2 interface
- Encoders with TTL interface
- Encoder with analog interface

5.3.3 Encoder profile (Encoder-Basic and Encoder-Extended)

Encoder profile

Encoder Basic and Encoder Extended

The drive utilizes the Sercos encoder profile for evaluating position measuring systems (encoders). This encoder profile consists of two function groups, Encoder Basic and Encoder Extended.

The basic principle behind this profile is a two-level encoder evaluation. The function group Encoder Basic converts signals (analog and/or digital) of a physical encoder into normalized Basic output data. The output data correspond to the encoder profile defined in Sercos. The function group Encoder Extended computes Extended output data from the Basic output data and the scaling system (scaling and mechanical system). Parameterizing is carried out via structure instances in the individual function groups.

Output data

Basic output data	Standardized, encoder-related data (position and status) in the resolution defined for Basic
Extended output data	Function-related, mechanically scaled data with physical units (position, velocity, acceleration)

Interface Encoder Basic to Encoder Extended

The Basic output data (S-0-0600.x.y) are copied to the Extended input data (S-0-0610.1.y).

Structure instance (SI) with Encoder Basic

The instance defines the interface number. The Encoder-Basic profile is assigned to a slot via the SI number, with the slot number being defined in dependence on the device.

Type of HydraulicDrive	Number of encoder interfaces	Assignment SI ↔ connector
 *Fig. 5-2: WRxD (high-response valve as axis controller)*	1	SI = 1 ↔ X8M
 *Fig. 5-3: HMC (Hydraulic Motion Control)*	1 or 2	SI = 1 ↔ XG20 SI = 2 ↔ XC21

Encoder Basic

The Encoder Basic evaluation function generates a position and its related status from the signals of the physical encoder (analog, digital, or both). The position is evaluated in absolute or incremental form depending on the physical encoder system used. With absolute encoder systems, the numerical value of position is unambiguous over the entire measuring range. With incremental encoder systems, the reference to the mechanical system can be established via reference marks. The resolution of the position is established via the data of the encoder and represented via parameters within the Encoder Basic profile. The resolution of the position is established via the data of the encoder and represented via parameters within the Encoder Basic profile. If required, the resolution may be reduced.

The following encoder systems can be evaluated via the Encoder Basic profile.

- Encoders with TTL interface (square-wave encoders)
- Encoders with SSI interface
- Encoders with 1Vpp interface
- Encoders with EnDat 2.2 interface

Encoder Basic evaluation can be activated by parameterizing the relevant encoder type in parameter "S-0-0602.0.1, Phys. encoder type".

Encoder Extended

From normalized data of the Encoder Basic evaluation and from the mechanical components (gear and, if applicable, feed constant) the Encoder-Extended evaluation function generates the output data (actual values) in the internal format for closed-loop position control. Via scaling, these output data are generated in physical units by means of the relevant parameters for representation (position, velocity, acceleration). With the help of an assignment parameter ("P-0-0077, Assignment of encoder 1->interface") a Basic instance is assigned to Extended evaluation, which generates the input data.

Initialization of encoders by encoder profile

Encoder Basic is initialized before Encoder Extended is initialized. If an error is detected while Encoder Basic is being initialized, diagnostic message "C0209, Incorrect encoder configuration" is generated. If errors occur while Encoder Extended is being initialized, these are diagnosed by suitable error messages.

Evaluation of encoders by encoder profile

The encoders are evaluated in two stages and always in the same order. First, the Basic evaluation is run through. This is followed by the Extended evaluation, with the call frequency being not firmly defined. It has, however, to be made sure that the Basic evaluation is called at least as frequently (clock cycle time) as the Extended evaluation. Only in this way can a continuous generation of actual velocity values take place in the Extended evaluation.

→ Encoder Extended evaluation is activated by assignment to an interface (Encoder Basic evaluation)

→ Encoder Basic evaluation is activated by assignment to a physical encoder type

Applications

Due to the two-stage evaluation of encoders, the following applications can be realized:

Use within a drive

If used as a standard encoder, the Encoder Basic and the Encoder Extended profile are used within the drive. The encoder is connected to the drive via the encoder interface. In Encoder Basic the signals of the encoder are normalized and made available. Encoder Extended generates the Extended output data by means of the Basic data.

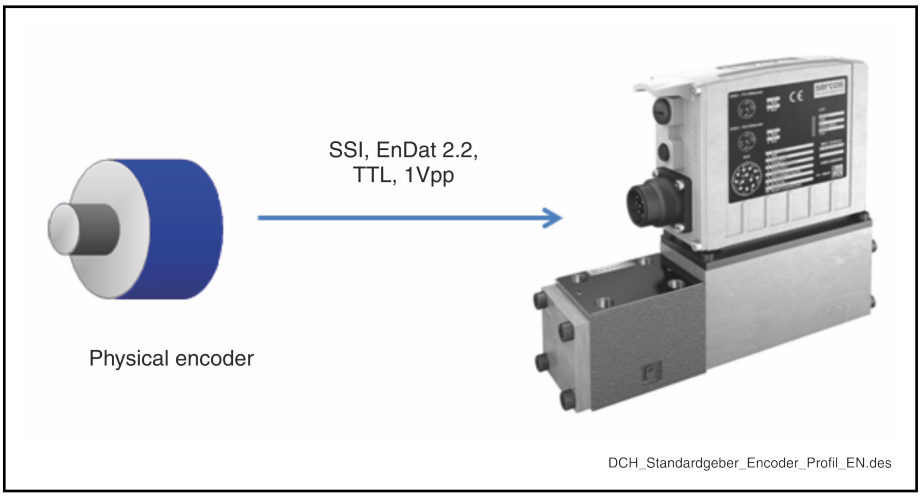


Fig. 5-4: Standard encoders evaluated via the encoder profile

Use of an encoder with "Sercos encoder profile"

If an encoder is used, which already contains the "Sercos encoder profile", it is possible to do without Basic evaluation in the evaluation device. The encoder is then evaluated directly via the Extended input parameters in the desired function.



Fig. 5-5: Encoder with "Sercos encoder profile"

The output data generated by the encoder are sent as process data via a communication network to the relevant evaluation unit, where they are processed further.

Encoder Basic profile as Sercos encoder emulator

The output data of Encoder Basic evaluation ("S-0-0600.x.y") can be stored in the process data (AT) and used by a further Sercos device (drive/control) as input data in an Encoder Extended evaluation ("S-0-0610.x.y")

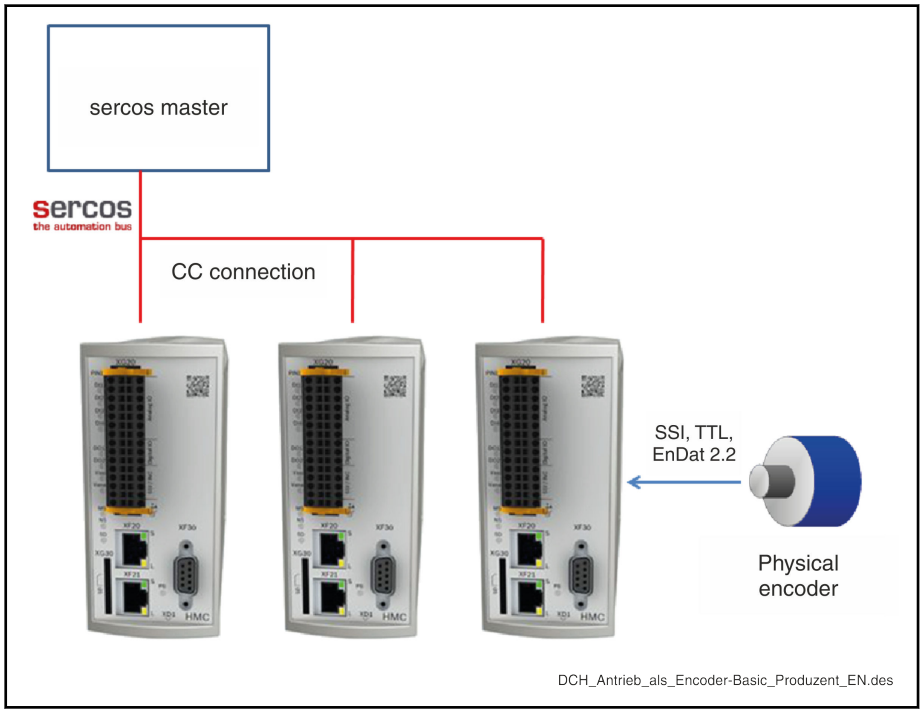


Fig. 5-6: Drive as Encoder Basic producer (example: SIII master communication)

If a physical encoder is used, which does not operate according to the Sercos encoder profile, the drive, which evaluates the encoder, can be utilized as "SIII encoder emulator" (producer). The data generated via Encoder Basic comply with the "Encoder Basic profile" and can thus be forwarded via a communication interface (process data "S-0-0600.0.1, Encoder status" and

"S-0-0600.0.2, Position") to further drives for evaluation. The Encoder Basic data of the producer (position and status) can be cyclically transferred via the interface to the Encoder Extended evaluation of further drives, where they can be evaluated. Apart from process data, configuration data are made available that are required by the consumer (Encoder Extended). These can be forwarded by the producer to the consumer as non-cyclical data.

☞ It has to be ensured that devices which serve as producer make their data available before devices which require these data are switched to OM.

Encoder Extended profile via process data

The output data of an Encoder Basic evaluation are provided to the process data channel and used by a further device (drive/control) in an Encoder Extended evaluation.

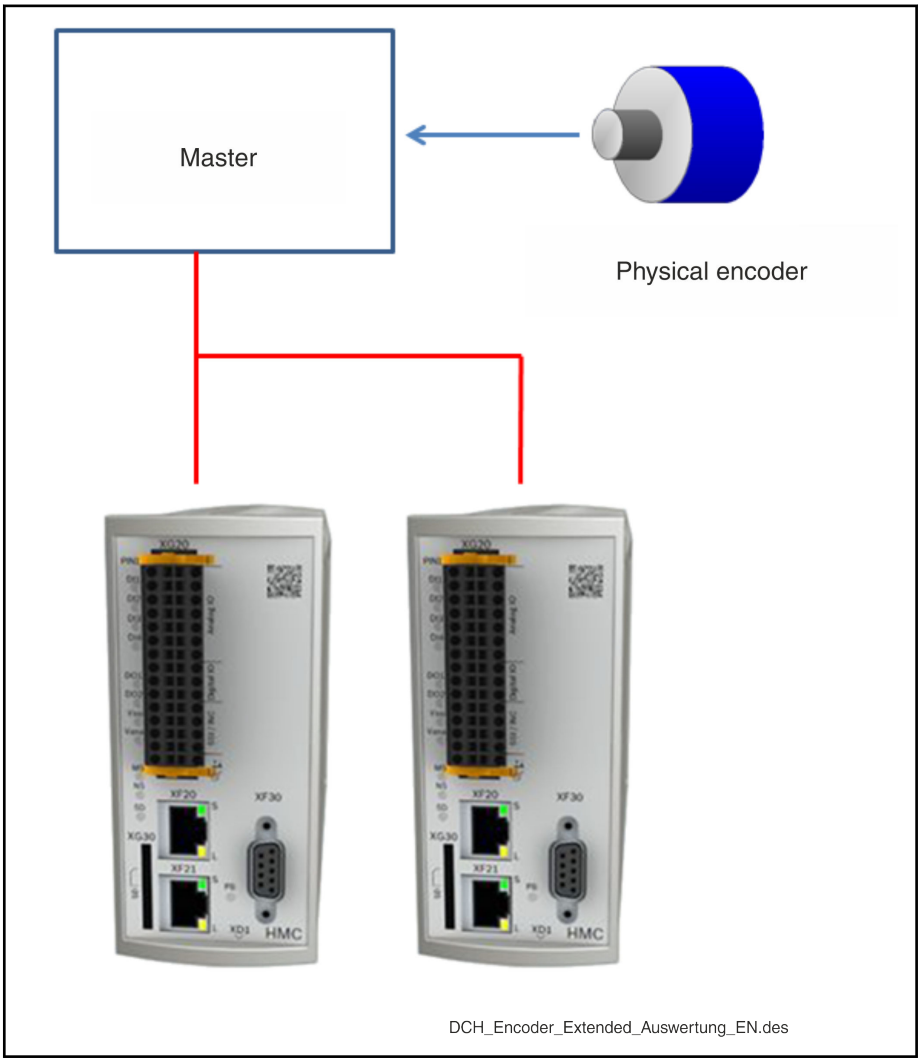


Fig. 5-7: Encoder Extended evaluation via master communication

The process data of the Encoder Basic evaluation are fed to the process data channel. In the slaves (Extended consumers) they are copied to the associated Encoder Extended evaluation, where they are evaluated. Apart from the process data, configuration data ("S-0-0601.x.y") are required. These have to be transferred to the consumers before the evaluation is started. The Encoder Extended evaluation checks the configuration data and monitors the proc-

ess data. If process data fail once, they are reproduced by extrapolation. If process data fail in succession (double failure), an error is generated.

Commissioning, parameters, diagnostic and status messages

Parameters

For parameters of Encoder Basic, see chapter "Encoder profile" on page 204

For parameters of Encoder Extended, see chapter "Encoder profile" on page 204

Diagnostic messages

For parameters of Encoder Basic, see chapter "Encoder profile" on page 204

For parameters of Encoder Extended, see chapter "Encoder profile" on page 204

5.3.4 Mechanical axis system and arrangement of measuring system

Mechanical axis system and measuring system

For acquiring the position of a drive, a position measuring system is required.

This position measurement is required for the:

- Velocity control loop
- Position control loop

The quality and resolution of position measurement is decisive for the quality of the feedback values.

Depending on the mechanical properties of the machine axis, the position can be measured directly at the cylinder/hydraulic motor or on the load side at the movable part of the axis

Position encoder with gear

Especially with rotary position measuring system, it is sometimes impossible to connect the position encoder directly to the shaft. HydraulicDrive offers the possibility to evaluate a position encoder connected via a gearbox.

Possibilities of arranging measuring systems

Measuring systems can be connected on the actuator side (e.g. in the cylinder) or on the load side. If the data acquisition in the scaling settings of position data differs from the place of mounting of the measuring system, the gear ratio ("S-0-0121, Input revolutions of load gear" and "S-0-0122, Output revolutions of load gear") and any transformations of the type of movement ("S-0-0123, Feed constant" or "S-0-0316, Inverse feed constant" have to be configured.

The place of mounting is determined by parameter "P-0-0188, Encoder 1 control word" bit 0.

Consequently, four cases can be distinguished:

1. Measuring system on the actuator, data reference on the actuator

   This is certainly the simplest structure of a mechanical axis system: there are no further components of the mechanical axis system. The movement of the actuator (cylinder rod or motor shaft) correspond to the movement of the load.

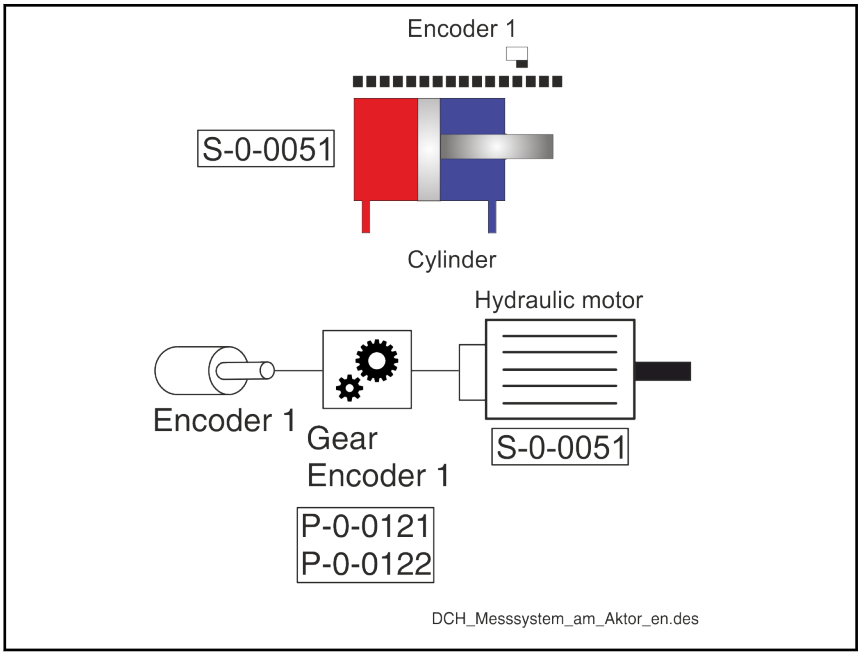


Fig. 5-8: Measuring system on the actuator, data reference on the load

2. Measuring system on the actuator, data reference on the load

   This arrangement allows the use of a load gear in the mechanical axis system as well as the transformation of the movement from linear to a rotary movement. To obtain correct position information, the existing components of the mechanic axis system (load gear and/or (inverse) feed constant) have to be parameterized.

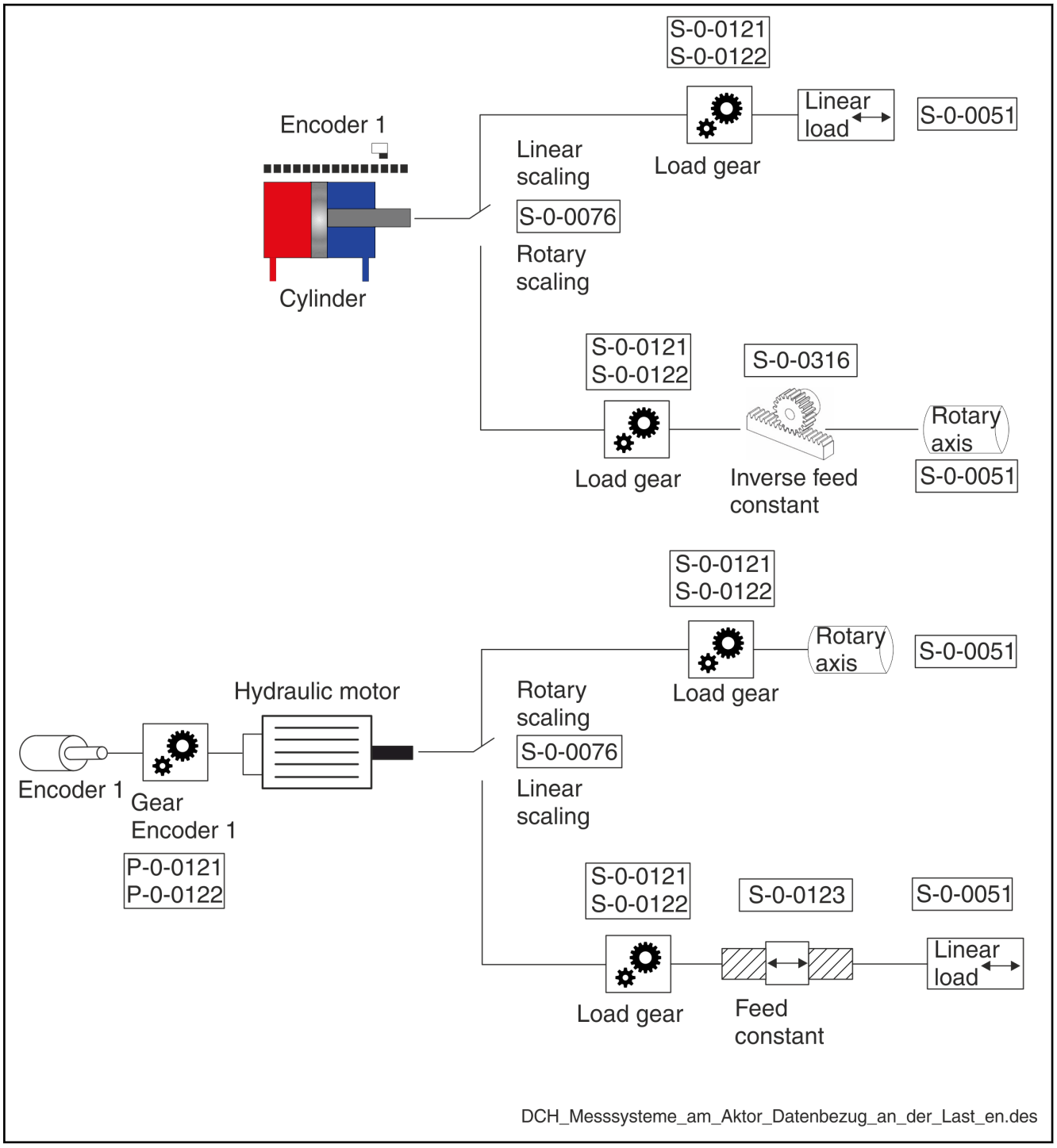


Fig. 5-9: Measuring system on the actuator, data reference on the load

3. Measuring system on the load, data reference on the load

   This arrangement allows the setup of more complex mechanical axis systems, the components of which need not to be parameterized in order to obtain correct position information at the load.

   In contrast to variant 2, measuring system at the actuator and data reference at the load, the dotted components of the mechanical axis sys-

tem need not to be parameterized and have no influence on position sensing.

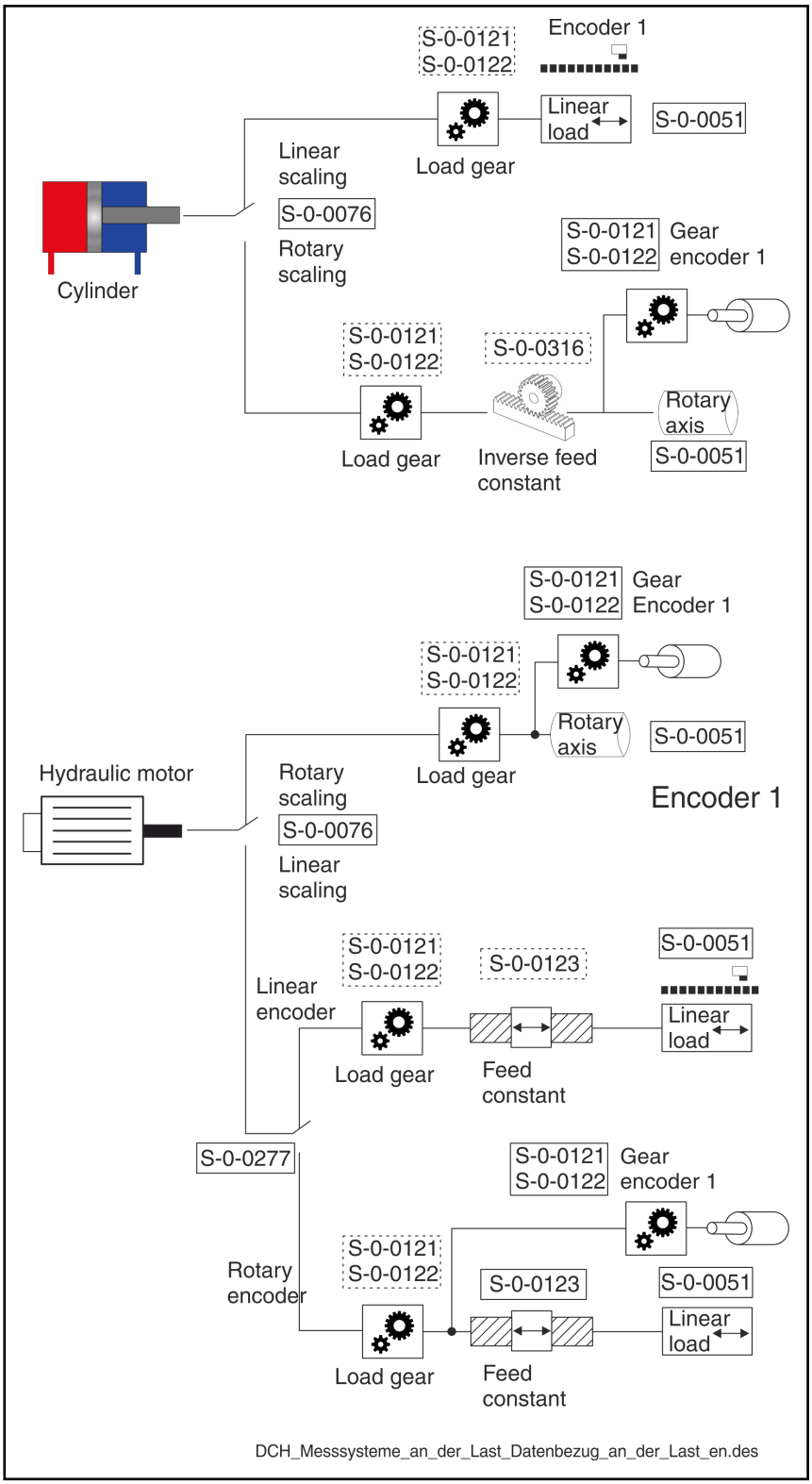


Fig. 5-10: Measuring system on the load, data reference on the load

4. Measuring system on the load, data reference on the actuator

   This arrangement is similar to variant 2, measuring system on the actuator, data reference on the load. Required components of the mechanical

axis system have to be parameterized completely in order to obtain correct position information.

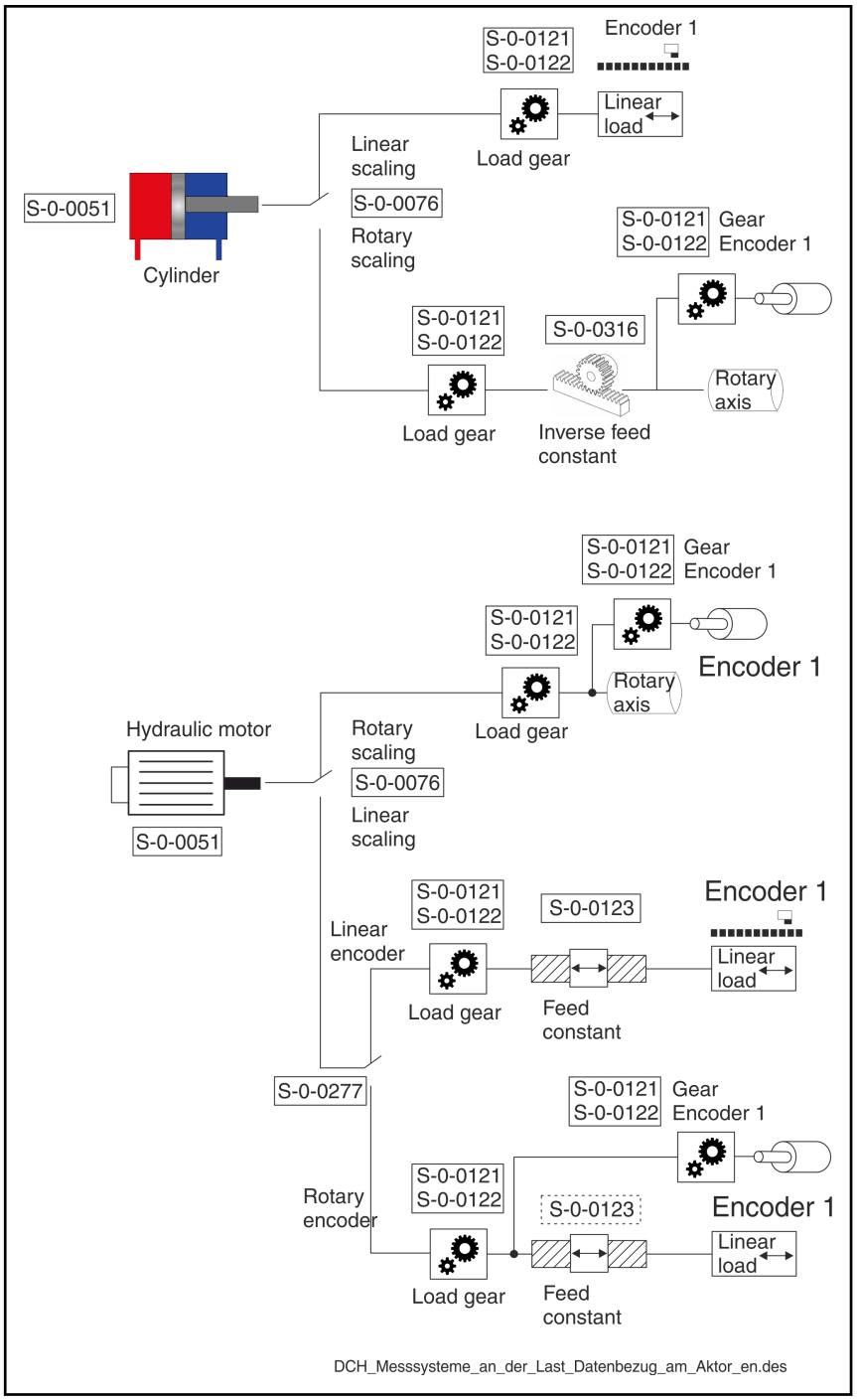


Fig. 5-11: Measuring systems on the load, data reference on the actuator

The arrangement of hydraulic motor with data reference on the actuator, linear measuring system on the load, is currently not supported.

Cyclic evaluation

The cyclic function utilizes the Encoder-Basic data (position, status) in order to convert them with the help of a conversion factor into the internal control format ("P-0-0129, Internal position data format"). Apart from that, velocity ("S-0-0040, Velocity feedback value of encoder 1") and acceleration ("S-0-0164, Acceleration feedback value encoder 1") are generated through multiple differentiation. The data are first always established with reference to the cylinder/hydraulic motor. By means of conversion factors from scaling, these data are converted into the format requested by the user with the corresponding data reference (cylinder/hydraulic motor or load).

There are two interfaces for influencing the direction of movement. By means of "S-0-0277, Encoder 1, type of position encoder" the direction of movement of the encoder can be inverted. This has therefore also an influence on the internally used functions of evaluation. The polarity, however, only inverts "S-0-0051, Position feedback value of encoder 1". The internal values remain unaffected.

"S-0-0051, Position feedback value of encoder 1" is limited to the desired limiting value "S-0-0103, Modulo value" or "S-0-0278, Maximum travel range".

Cyclic monitoring

The cyclic Encoder-Extended evaluation checks the status of Encoder-Basic evaluation ("S-0-0610.0.1, Encoder status (input)". In the status, a distinction is made between errors and warnings. In the Extended evaluation, these are assigned to the corresponding error messages (class) and, when an error occurs, issued. Encoder errors from the motor function generally result in a fatal error "F8022, Enc. 1: Enc. signals incorr. (can be cleared in PM)", since the function also has a direct influence on the error reaction. If the position of the encoder is no longer generated correctly, closed-loop-controlling is no longer possible.

Apart from the evaluation of Encoder-Basic errors, the Extended evaluation monitors the correct function of the "limitation function" for overflows of "S-0-0051, Position feedback value of encoder 1".

- With modulo scaling → "S-0-0103, Modulo value"
- With absolute scaling → ± "S-0-0278, Maximum travel range"

If the overflows cannot be processed correctly due to excessive velocity, error "F2177, Modulo limitation error of encoder 1" is issued. Since the resulting errors will not directly cause malfunction in the control, no fatal error needs to be activated. The motor can still be actively stopped.

Commissioning

For commissioning, all configuration parameters (mechanical system and scaling) of the axis at hand have to be set first. The Encoder-Extended is assigned to the relevant encoder via parameter "P-0-0077, Assignment of encoder 1->interface". Here, the corresponding structure instance index of Basic evaluation has to be entered. Then, Encoder-Extended evaluation can be activated.

Pertinent parameters and diagnostic messages

- S-0-0040, Velocity feedback value of encoder 1
- S-0-0051, Position feedback value of encoder 1
- S-0-0076, Position data scaling type
- S-0-0103, Modulo value
- S-0-0121, Input revolutions of load gear

- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0164, Acceleration feedback value encoder 1
- S-0-0277, Encoder 1, type of position encoder
- S-0-0278, Maximum travel range
- S-0-0316, Inverse feed constant
- S-0-0378, Absolute encoder range, encoder 1
- P-0-0610.0.1, Encoder status (input)
- P-0-0121, Encoder 1, gear turns, mechanical system side
- P-0-0122, Encoder 1, gear turns, encoder side
- P-0-0129, Internal position data format
- P-0-0188, Encoder 1 control word
- C0220, Error when initializing position of encoder 1
- C0221, Initialization velocity encoder 1 too high
- C0270, Error when reading encoder data -> encoder 1
- C271, Incorrect parameterization of encoder 1 (hardware)
- C272, Incorr. parameteriz. of encoder 1 (mechanical system)
- C273, Modulo value for encoder 1 cannot be displayed
- F2031, Encoder 1 error: Signal amplitude incorrect
- F2177, Modulo limitation error of encoder 1
- F8022, Enc. 1: Enc. signals incorr. (can be cleared in PM)

5.3.5 Encoder types

Encoder SSI

SSI encoder

SSI encoders are encoders, which use the **S**ynchronous **S**erial **I**nterface for transmitting a digital position. They provide serially digital absolute position information within the absolute measuring range of the respective encoder.

Depending on the evaluation principle of the encoder, various maximum sampling frequencies are permitted. For example, the measuring system length limits the permissible sampling frequency in the case of magnetostrictive sensors. Moreover, the sampling frequency defines the maximum controller cycle time.

Specification

Protocol specification of the SSI interface

Telegram length	Maximum number 31 bits
Coding	Gray- and binary-coded
Error/status bits	Maximum of 7 error/status bits (error, warning, etc.)
Protocol checksum bits	Maximum of 7 parity bits (CRC, parity, etc.)
Position bits	Maximum of 31 data bits
Baud rate	80 ... 1000 kHz

Rotary measuring systems

- The number of single-turn bits (bits per revolution) defines the resolution of the encoder
- The number of multi-turn bits defines the absolute measuring range of the encoder
- Unit of physical measuring system: Incr/rev is calculated internally via the number of single-turn bits
- The max. initialization velocity ("S-0-0602.0.8, Phys. max. initialization speed") can be optionally high (no limit given)
- Virtual reference marks (once per revolution) are not realized

Linear measuring systems

- The number of position bits describes the travel range of the encoder that can be represented in absolute terms
- Unit of physical measuring system mm or Incr/mm (see "S-0-0602.0.2, Phys. encoder properties")
- The max. initialization velocity ("S-0-0602.0.8, Phys. max. initialization speed") can be optionally high (no limit given)

Telegram structure

The telegram always starts with the MSB. Gray-coded data are converted by the multi-encoder interface into a binary character string.



It is always the entire telegram (position, error and checksum bits) which is converted.

The telegram type can be selected via the configuration of the physical transmission protocol ("S-0-0602.0.7, Phys. encoder protocol configuration". At the time of publication of this documentation, the following telegram types were supported:

Telegram type 1:

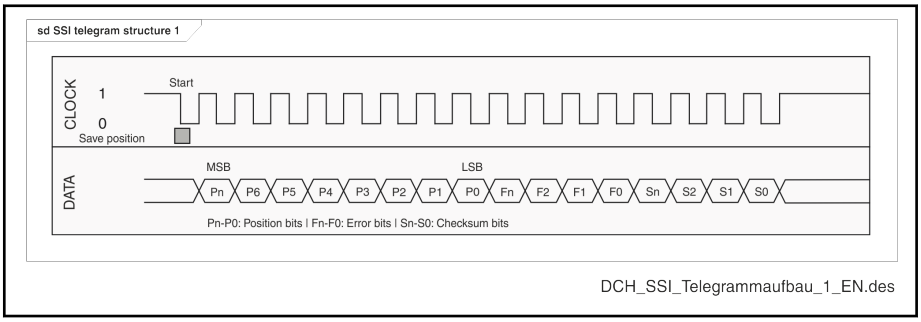


Fig. 5-12: Telegram type 1

Telegram type 2:

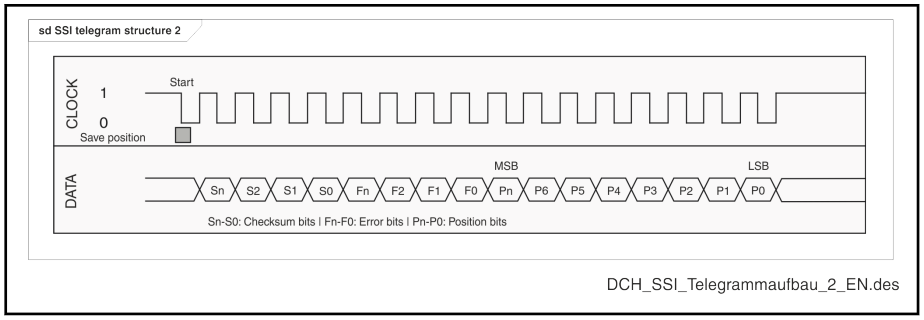


Fig. 5-13: Telegram type 2

Pn = position bit "n"

Fn = error bit "n"

Sn = checksum block "n"

Definition of state error bits

Error bits can define various states as error. In the current implementation, the following definition is utilized:

Bit = 0: No error

Bit = 1: Error

Definition of protocol checksum bits

At present, protocol checksum bits are not evaluated.

Monitoring functions

Protocol errors

If error bits were defined, they are monitored. If an error is detected, the error bit in the status is set when the second error occurs in succession. Simple incorrect telegrams (telegram failure, error bit sets) are discarded and extrapolation is carried out. Protocol errors are signaled in the respective bits in parameter "S-0-0600.0.136, Extended diagnostic message".

Wire break monitoring

By definition, the levels of the two SSI signal cables are set to logic "1" at the beginning of communication. If the circuitry is realized so that when the cable is not plugged the level is logic "0", it is possible to detect by data level check upon the first low signal (start) whether or not an encoder is connected. A cable break is signaled in bit 5 of parameter "S-0-0-0600.0.136, Extended diagnostic message".

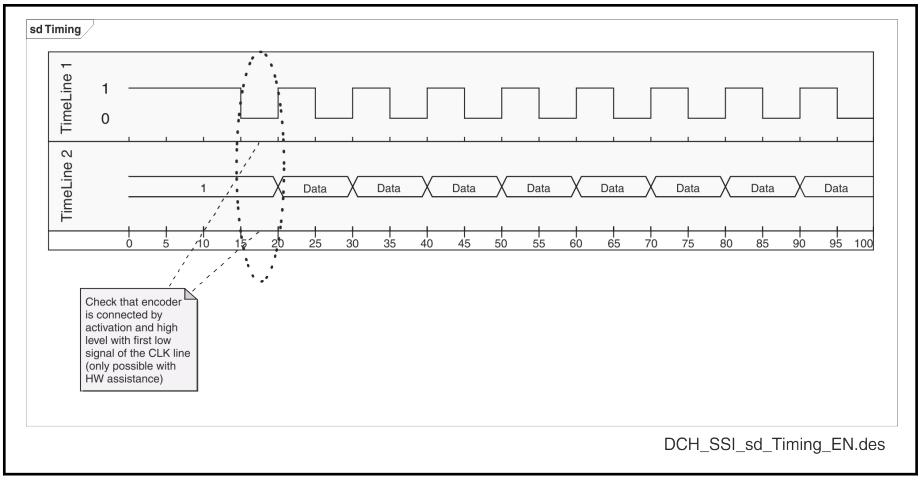


Fig. 5-14: sd Timing

Commissioning

During commissioning of the SSI encoder, various ENCB parameters have to be set. Following the selection of "S-0-0602.0.1, Phys. encoder type" = 102, the most essential parameters to be set are "S-0-0602.0.4, Phys. encoder resolution" (is set automatically in conjunction with rotary encoders) and "S-0-0602.0.7, Phys. encoder protocol configuration".

The parameters "S-0-0601.0.2, Resolution of position", "S-0-0601.0.6, Absolute position range" and "S-0-0601.0.10, Overflow threshold position" of the Encoder-Basic output data are established automatically via the protocol configuration parameter. The resolution is determined in view of a reasonable value for the absolute encoder range and can be increased by the user, if necessary.

Pertinent parameters

- S-0-0600.0.1, Encoder status
- S-0-0600.0.2, Position
- S-0-0600.0.136, Extended diagnostic message
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution of position
- P-0-0601.0.6, Absolute position range
- S-0-0601.0.10, Overflow threshold position
- S-0-0602.0.1, Phys. encoder type
- S-0-0602.0.2, Phys. encoder properties
- S-0-0602.0.4, Phys. encoder resolution
- P-0-0602.0.7, Phys. encoder protocol configuration
- S-0-0602.0.8, Phys. max. initialization speed

P-0-0602.0.7, Phys. encoder protocol configuration

This parameter serves to configure the encoder interface (transmission protocol) between the control section and the physical encoder.

Phys. encoder properties (encoders with SSI interface)

Bit	Designation/function	Comment
31-28	Reserved	

27-24	**Baud rate** **0x7:** 1000 kHz **0x6:** 500 kHz **0x5:** 400 kHz **0x4:** 250 kHz **0x3:** 200 KHz **0x2:** 125 kHz **0x1:** 100 kHz **0x0:** 80 kHz **0x8 .. 0xF:** Reserved	
22-23	**Telegram structure *** **00:** Telegram 1 **01:** Telegram 2 **10:** Reserved **11:** Reserved	
21	Reserved	
20	**Coding:** **1:** Binary code **0:** Gray code	
19	Reserved	
18-16	**Number of error bits** **111:** 7 bits **...** **001:** 1 bit **000:** 0 bits	
15	Reserved	
14-12	**Number of protocol checksum bits:** **111:** 7 bits **...** **001:** 1 bit **000:** 0 bits	
11-8	**Number of position bits, multi-turn** **1111:** 15 bits **...** **1100:** 12 bits **...** **0001:** 1 bit **0000:** 0 bits	

7	Reserved	
6-0	**Number of position bits** **...** **0100000:** 32 bits **...** **0001100:** 12 bits **...** **0000001:** 1 bit **0000000:** 0 bits	Rotary measuring systems: Number of position bits Single-turn + number of position bits, multi-turn Linear measuring systems: Number of position bits

*** Telegram structure**

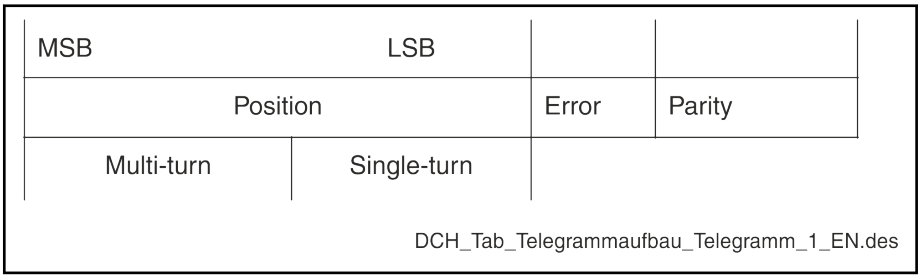


Fig. 5-15: Telegram 1

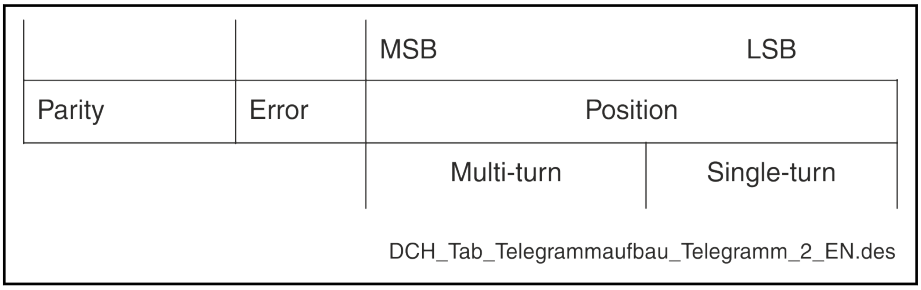


Fig. 5-16: Telegram 2

☞ The maximum telegram length is limited to 31 bits (position, checksum and error bits).

Encoder EnDat

EnDat 2.2 encoder

The EnDat interface is a digital, bidirectional interface for position measuring devices. This interface is capable of issuing position values from absolute measuring devices and reading out information stored in the measuring device. Moreover, information stored in the measuring device can be updated via the EnDat interface or new information stored.

Specification

Protocol specification of EnDat 2.2 interface

Telegram length	Variable
Coding	Binary
Error bits	2 error bits

Checksum	5 bits CRC
Baud rate	100 kHz during initialization 100 ... 1000 in cyclic operation

Tab. 5-2:

Due to the transmission protocol, the minimum baud rate depends on the controller cycle time of the velocity controller. If the set baud rate is too low, the diagnostic message "C0209, Incorrect encoder configuration" is generated when the parameter mode is exited.

Encoder nameplate

EnDat 2.2 encoders are provided with an encoder nameplate, in which all encoder type-relevant data such as design, resolution, series number, etc. are stored. With the help of the nameplate, the encoder can be identified and the relevant parameters of the firmware ("S-0-0602.x.y") can be set. A parameterization by the user is not necessary.

The following settings are automatically taken from the encoder nameplate: The details in angle brackets indicate the parameter of the measuring instrument manufacturer according to EnDat 2.2. specification which is used for determining the value.

Rotary measuring systems

- Position format (number of bits) <word 13>
- Type of design (rotary) <word 14>
- Absolute encoder range <word 17>
- Absolute encoder resolution [incr./rev] <word 20, 21>
- Direction of motion <word 30>
- Max. mechanically permissible velocity <word 32>
- Serial number <word 27, 28, 29>

Linear measuring systems

- Position format (number of bits) <word 13>
- Type of design (linear) <word 14>
- Absolute encoder resolution [nm] <word 20, 21>
- Direction of motion <word 30>
- Max. mechanically permissible velocity <word 32>
- Serial number <word 27, 28, 29>

Initializations

Position initialization

When encoder evaluation is activated, the encoder nameplate is read first and the associated parameters ("S-0-0602.x.y") are set. When the encoder evaluation is initialized, the resolution of the encoder and the absolute encoder range are read out. In the case of a position format greater than 32 bits, the absolute position is first shifted (to the right) so that it can be represented in a 32-bit register and adapted to the output data format ("S-0-601.0.2, Resolution of position").

Since the absolute position offers the maximum velocity only up to a defined velocity, the velocity is monitored during initialization. When the velocity is too high, no initialization is carried out. The maximum initialization speed is stored in the nameplate of the encoder.

Monitoring functions

In cyclic position sensing, the alarm bits and the integrity of the telegrams are monitored by means of the checksum (CRC). Simple, incorrect telegrams are discarded and extrapolation is carried out. In the case of two incorrect telegrams in succession, an encoder error is signaled and the cause is represented in the corresponding bits in parameter "S-0-0600.0.136, Extended diagnostic message".

Commissioning

For commissioning an EnDat 2.2 encoder only the clock rate of the transmission has to be set, since the encoder supplies all data in its nameplate. The encoder type is activated by selecting "S-0-0602.0.1, Phys. encoder type" = 102.

Pertinent parameters

- S-0-0600.0.1, Encoder status
- S-0-0600.0.2, Position
- S-0-0600.0.136, Extended diagnostic message
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution of position
- S-0-0601.0.6, Absolute position range
- S-0-0601.0.10, Overflow threshold position
- S-0-0602.0.1, Phys. encoder type
- S-0-0602.0.2, Phys. encoder properties
- S-0-0602.0.4, Phys. encoder resolution
- S-0-0602.0.7, Phys. encoder protocol configuration
- S-0-0602.0.8, Phys. max. initialization speed

S-0-0602.0.7, Phys. encoder protocol configuration

This parameter serves to configure the encoder interface (transmission protocol) between the control section and the physical encoder. The user can only set the baud rate The number of position bits is set automatically by the firmware from the encoder data.

Phys. encoder properties (encoders with EnDat 2.2 interface)

Bit	Designation/function	Comment
31-28	Reserved	
27-24	**Baud rate** **0x7:** 1000 kHz **0x6:** 500 kHz **0x5:** 400 kHz **0x4:** 250 kHz **0x3:** 200 kHz **0x2:** 125 kHz **0x1:** 100 kHz	
23-12	Reserved	

11-8	**Number of position bits, multi-turn** **1111:** 15 bits ... **1100:** 12 bits ... **0001:** 1 bit **0000:** 0 bits	Set by firmware!
7	Reserved	
6-0	**Number of position bits** **1001000:** 48 bits ... **0100000:** 32 bits **0001100:** 12 bits ... **0000001:** 1 bit **0000000:** 0 bits	Rotary measuring systems: Number of position bits Single-turn + number of position bits, multi-turn Linear measuring systems: Number of position bits Set by firmware!

Incremental encoders

Incremental encoder

Encoders with square wave signals (TTL) are encoders that furnish two position-related square wave signals that are offset by 90°. These signals recur per one revolution or over the length of the encoder depending on the encoder's design type. The number of recurrences per revolution or the interval of signals/division periods (linear) defines the resolution of the encoder. The signals have to be within defined limits. The mechanical construction does not play a role (rotary encoder or linear encoder).

In addition, these encoders supply reference signals, which have a fixed mechanical reference to the encoder shaft. The reference signals can be defined with an equidistance or distance-coded with reference to the position. Thanks to the reference signals it is possible to obtain position data with reference to the mechanical system.

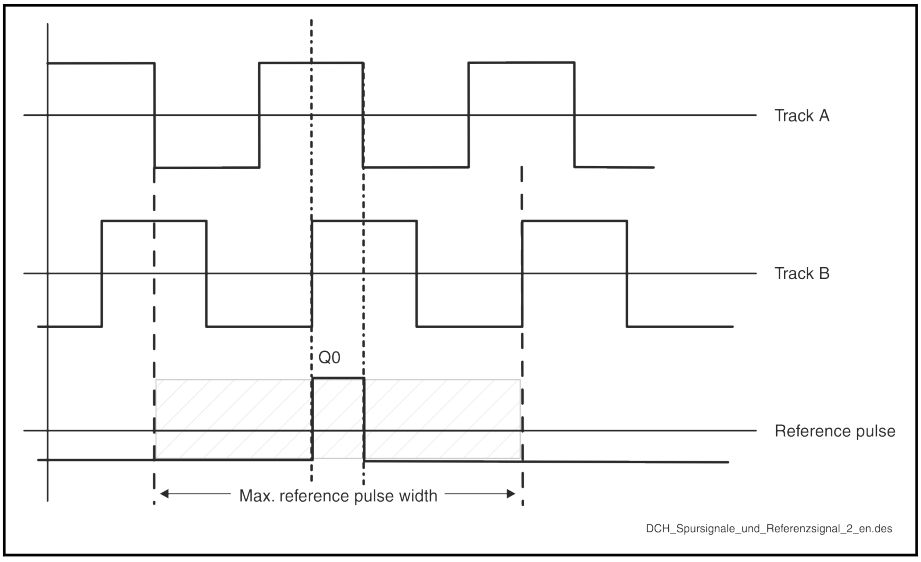


Fig. 5-17: Track signals and reference signal

Initializations

Position initialization

With TTL encoders, the position is initialized exclusively via the incremental tracks and thus relatively. "S-0-0600.0.2, Position" is always set to a firmly defined value (zero). "S-0-0602.0.8, Phys. max. initialization speed" is firmly defined at 2000 rev/min. or 2000 mm/min., respectively.

Evaluations

Cyclic position evaluation

The analog square wave signals (differential signals) are fed to a quadrature decoder in the drive controller. This decoder counts the division periods (DP) that were overrun per direction with correct quadrants with a resolution of 4 increments per division period [incr./DP] The counter data result in a certain position that is referred to the encoder. Die maximum resolution of the relative position with an encoder with analog square-wave signals amounts to 4 incr./DP.

Reference mark evaluation

Most of the incremental encoders feature a reference track apart from position tracks. This track supplies, at mechanically fixed points, a signal, which results in the immediate saving of the current count via the hardware of the encoder interface. On the basis of this count (reference) a reference position is determined, which can be used to establish the mechanical reference. "S-0-0600.0.1, Encoder status" signals when a valid reference mark has been detected. The reference position ("S- 0-0600.0.10, Marker position") is always referred to the starting point of encoder initialization and thus it is a relative position value which is, however, absolute with reference to the mechanical system.

Distance-coded reference marks

Apart from simple reference marks, encoders with distance-coded reference marks are supported. To this end, some parameters are required that allow the reference position to be correctly established. The function is selected in bit 1 in parameter "S-0-0602.0.2, Phys. encoder properties". In addition, parameters "S-0-0602.0.5, Phys. distance-coded reference offset A" (greater distance) and "S-0-0602.0.6, Phys. distance-coded reference offset B" (short-

er distance) are used. By overrunning the second mark, the evaluation function signals that the reference marks were recognized and converted. The subsequent evaluation function utilizes the two mark positions in order to establish the reference position.

Monitoring functions

Hardware

To recognize a cable break, tracks A and B are monitored. When an error is detected, the firmware signals an error in the encoder evaluation via bit 13 in "S-0-0600.0.1, Encoder status". The cause of error is shown in "S-0-0600.0.136, Extended diagnostic message".

Cyclic reference position monitoring

In addition, the validity of position can be checked using the cyclic reference position comparison. Here, the position difference between two equidistant reference marks from the counter is continuously established. This difference is compared with the nominal position difference of two marks $\Delta x_{(target)}$ = S-0-0601.x.3[TP] * 4[Q/TP]. In the case of a deviation of more than 1 quadrant, an encoder error is generated. The function can be activated using parameter "S-0-0602.0.136, bit 1, Phys. encoder evaluation configuration".

Commissioning

The encoder has to be completely parameterized during commissioning, that is, the user has to set all of the "S-0-0600.x.y" parameters. The encoder type is activated by selecting S-0-0602.0.1, Phys. encoder type = 2.

Pertinent parameters

- S-0-0600.0.1, Encoder status
- S-0-0600.0.2, Position
- S-0-0600.0.10, Marker position
- S-0-0600.0.136, Extended diagnostic message
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution of position
- S-0-0601.0.10, Overflow threshold position
- S-0-0602.0.1, Phys. encoder type
- S-0-0602.0.2, Phys. encoder properties
- S-0-0602.0.4, Phys. encoder resolution
- S-0-0602.0.5, Phys. distance-coded reference offset A
- S-0-0602.0.6, Phys. distance-coded reference offset B
- S-0-0602.0.8, Phys. max. initialization speed

Encoder 1Vpp

1Vpp encoder

Encoders with analog track signals are encoders that furnish two position-related sine signals (sine & cosine) that are offset by 90°. Depending on the design type these signals recur per one revolution or over the length of the encoder. The number of recurrences per revolution or the interval of signal/division periods (linear) defines the resolutions of the encoder. The signal amplitude has to be within defined limits. The signal form has to be within a specified framework. The mechanical construction does not play a role (rotary encoder or linear encoder).

In addition, these encoders supply reference signals, which have a fixed mechanical reference to the encoder shaft. The reference signals can be defined with an equidistance or distance-coded with reference to the position. Thanks to the reference signals it is possible to obtain position data with reference to the mechanical system.

Specification

Protocol specification of the 1Vpp encoder

HydraulicDrive supports all 1Vpp encoders with Heidenhain signal specification:

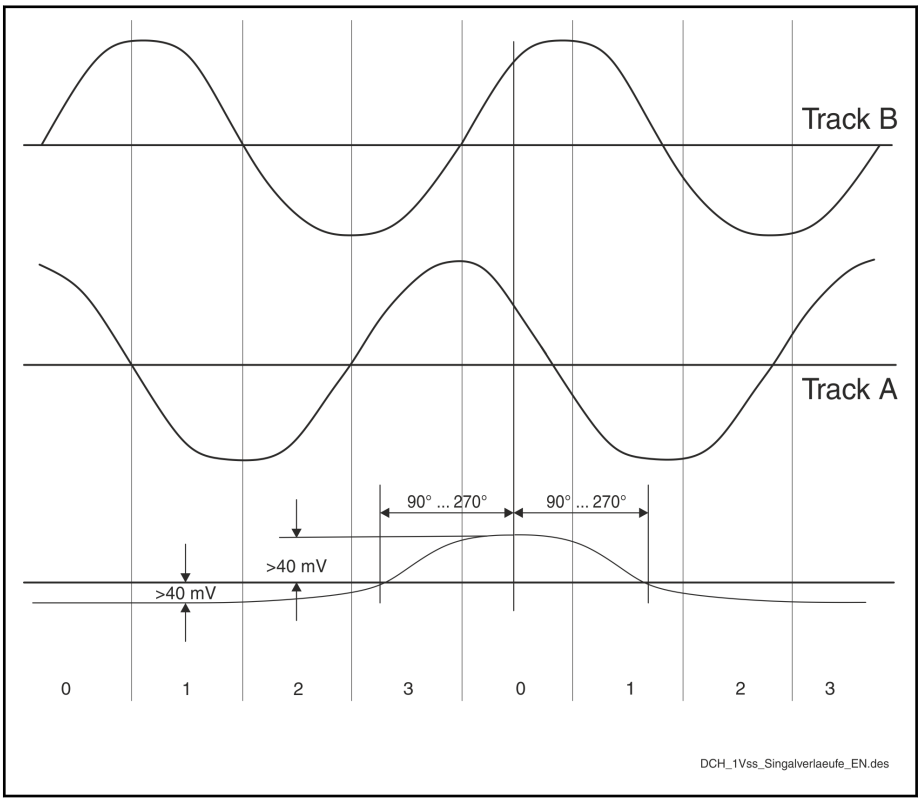


Fig. 5-18: Specification 1Vpp signals (Heidenhain standard)

Signal level	1Vpp (differential signal) (±20 % at 0 Hz; -60 % at 400 kHz)
Signal reference	0..400 kHz
Reference signal	See fig. 5-18 "Specification 1Vpp signals (Heidenhain standard)" on page 226 Active: > +40 mV, inactive: < -40 mV Zero crossings 90° ... 270° from center of quadrant 0

Initializations

Position initialization

With sine encoders, position initialization is carried out exclusively via the incremental tracks and thus relatively. The starting position ("S-0-0600.0.2, Position") is always set to a firmly defined value (zero).

The maximum initialization speed ("S-0-0602.0.8, Phys. max. initialization speed") is firmly defined at 2000 rpm or 2000 mm/min., respectively.

Evaluations

Position evaluation

The analog input signals (differential signals) are initially amplified in the drive controller and, after digitization, converted into an angle. In parallel, the analog input signals are digitized and fed to a quadrature counter. This counter counts the division periods (DP) that were overrun per direction with a resolution of 4 increments per division period [incr./DP] The angle and the count together result in a relative position, which is referred to the encoder. When combining the angle and count, the quadrant information of both values has to be identical (tolerance window 3/8DP) in order that the position can be correctly generated. Since the position is generated through integration, no overflow limitation by "S-0-0601.0.10, Overflow threshold position" is required. "S-0-0600.0.2, Position" overflows at 32 bits.

Signal correction

For acquiring the position it is essential that the signal shape of both signals is sinusoidal, if possible, that there are no offsets between the signals and that the amplitudes are identical. For this reason, an amplitude and offset comparison has been implemented in the software.

Reference mark evaluation

Most of the incremental encoders feature a reference track apart from position tracks. This track supplies at a mechanically firm point a signal, which is related to the encoder and results in the immediate saving of the current count in the input circuit of the encoder interface. On the basis of this count (reference) a reference position is determined, which can be used to establish the mechanical reference. The reference signal is defined so that the associated angle of the analog tracks always provides zero! This results in a highly accurately reproducible reference position! The reference position "S-0-0600.0.10, Marker position" is always referred to the starting point of encoder initialization and thus it is a relative position value which is, however, absolute with reference to the mechanical system.

Distance-coded reference marks

Apart from simple reference marks, encoders with distance-coded reference marks are supported. To this end, some parameters are required that allow the reference position to be correctly established. The function is selected in bit 1 in parameter "S-0-0602.0.2, Phys. encoder properties". In addition, parameters "S-0-0602.0.5, Phys. distance-coded reference offset A" (greater distance) and "S-0-0602.0.6, Phys. distance-coded reference offset B" (shorter distance) are used. By overrunning the second mark, the evaluation function signals that the reference mark was recognized and converted. The subsequent evaluation utilizes the two marker positions in order to establish the reference position.

Monitoring functions

Signal shape and level

The encoder signals are monitored for both, level and signal shape. Monitoring is based on the signal specification of a Heidenhain encoder. Taking account of the -3 dB cutoff frequency of the encoder, the theoretical minimum input amplitude is about 0.4 Vpp (the cutoff frequency of hardware is not taken into account here), for which the input signals have to be monitored. Since the signals are two orthogonal sine signals, monitoring can take place via the pointer length.

The following applies:

$R^2 = A^2 + B^2 \rightarrow R^2 = \sin^2(x) + \cos^2(x)$

By way of pointer length monitoring both, signal shape deviation and amplitude deviation are recognized. Monitoring is always carried out via the input signals, without any corrections. If deviations of the signals are detected, which are outside the monitoring thresholds (R(max< R < R(min)), these are registered. If the deviations occur three times in succession, this is regarded as error and signaled as encoder error.

The following monitoring thresholds are active in the firmware:

2*R > 1.4 Vpp or **2*R <0.5 Vpp**

Pointer length monitoring is only active, if the axis does not exceed a certain velocity. At too high velocities it was observed that amplitude checking did not work properly due to the conversion.

Cyclic reference position monitoring

In addition, the validity of position can be checked using the cyclic reference position comparison. Here, the position difference between two equidistant reference marks from the counter is continuously established. This difference is compared with the nominal position difference of two marks $\Delta x_{(target)}$ = S-0-0601.0.3[DP] * 4[Q/DP]. In the case of a deviation of more than 1 quadrant, an encoder error is generated. The function can be activated using parameter "S-0-0602.0.136, bit 1".

Commissioning

The encoder has to be completely parameterized during commissioning, that is, the user has to set all of the "S-0-0602.x.y" parameters. The encoder type is activated by selecting "S-0-0602.0.1, Phys. encoder type" = 1.

Pertinent parameters

- S-0-0600.0.1, Encoder status
- S-0-0600.0.2, Position
- S-0-0600.0.10, Marker position
- S-0-0600.0.136, Extended diagnostic message
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution of position
- S-0-0602.0.10, Overflow threshold position
- S-0-0602.0.1, Phys. encoder type
- S-0-0602.0.2, Phys. encoder properties
- S-0-0602.0.4, Phys. encoder resolution
- S-0-0602.0.5, Phys. distance-coded reference offset A
- S-0-0602.0.6, Phys. distance-coded reference offset B
- S-0-0602.0.8, Phys. max. initialization speed

Encoder simulation

Simulation encoder

The simulation encoder allows a hydraulic axis to be simulated. It can be used to carry out tests without any hydraulic system connected. The actual values (position, velocity, force) can be calculated using a simplified model.

Within the set limit stops, only the active position feedback value and the active velocity feedback value are generated. If the simulated position feedback

value exceeds one of the two limit stops, a force with a linear increase from 0 to max. torque/force is generated on the basis of the spring length entered.

During the simulation, the valve output is set to the standstill value.

Pertinent parameters

- P-0-0077, Assignment of encoder 1->interface
- P-0-0078, Assignment of encoder 2->interface
- P-0-2917.0.1, Simulation of control word
- P-0-2917.0.3, Natural frequency of axis
- P-0-2917.0.4, Simulation of positive limit stop
- P-0-2917.0.5, Simulation of negative limit stop
- P-0-2917.0.6, Simulation of spring length
- P-0-2832.0.10, Moved mass

Encoder analog

Analog encoder

Encoders with analog interface provide absolute position information, which is issued proportional to the position as analog voltage or current signal. Typically, the output signal corresponds to the measuring length, e.g. output 0...10 V = 0...200 mm.

Specification

Signal specification

The maximum signal range for the analog interface depends on the analog input actually used:

- Voltage interface: -10...10 V or 0...10 V
- Current interface: 0...20 mA

Resolution

The position resolution depends on the physical resolution of the analog/digital converter (ADC) and the signal range of the analog input used.

Example

An encoder with analog voltage interface, output 0...10 V = 0...100 % measuring length, is operated at an analog input, -10...10 V, 14-bit ADC. The ADC resolves the signal range of the analog input in 2^{14} = 8192 steps. Since the analog signal of the encoder utilizes only half of the signal range of the analog input, the available resolution is halved to 4096 steps. This results in a maximum resolution of about 0.025 % of the measuring length (100 % / 4096) for the position resolution.

Signal filtering

Analogously to force/pressure sensing, a PT1 filter can be used with an adjustable filter time to filter the signal.

Monitoring functions

Wire break monitoring

Wire break monitoring is only available, if a signal range was selected, the lower limit of which is greater than 0. Monitoring responds when the signal is below half the value of the lower limit.

Example

Signal range 4...20 mA → wire break message in the case of signals of less than 2 mA.

Commissioning

The analog encoder is selected with the value “22” in "P-0-0077, Assignment of encoder 1->interface" or "P-0-0078, Assignment of encoder 2->interface".

In "P-0-2910.0.1, Analog encoder, control word", the analog input of the device to be used has to be selected. This determines the physical boundary conditions of the interface: Current/voltage and maximum signal range.

In a next step, the two pairs of values "P-0-2910.0.2, Analog encoder, lower limit of signal range" and "P-0-2910.0.4, Analog encoder, lower limit of position range" as well as "P-0-2910.0.3, Analog encoder, upper limit of signal range" and "P-0-2910.0.5, Analog input, assignment, filter time" have to be entered according to the mechanical structure of the axis. These value pairs can either be taken from the nameplate of the encoder or established by means of measurements at the axis.

Pertinent parameters

- P-0-2910.0.1, Analog encoder, control word
- P-0-2910.0.2, Analog encoder, lower limit of signal range
- P-0-2910.0.3, Analog encoder, upper limit of signal range
- P-0-2910.0.4, Analog encoder, lower limit of position range
- P-0-2910.0.5, Analog encoder, upper limit of position range
- P-0-2910.0.6, Analog encoder, filter time
- P-0-2910.0.130, Analog encoder, compact

The configuration parameters of the analog encoder are all assigned to the subdevice.

5.3.6 Establishing the position data reference

General information on establishing the position data reference

For the actual position values fed back by the measuring systems, a reference to the machine axis must be established. This applies to

- relative measuring systems each time when the drive is switched on
- absolute measuring systems during initial commissioning

Absolute measuring systems

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning, after a replacement of the encoder or changes in the mechanical axis system. The position data reference is maintained and the actual position values are axis-related immediately after the drive is switched on.

Procedures for establishing the position data reference:

- "Set absolute position" for encoders that can be evaluated absolutely

By means of bit 1 in "P-0-0188, Encoder 1 control word" the drive can be configured so that when switching to the operating mode the reference is always available, provided that absolute evaluation of the absolute measuring system is possible.

Relative measuring systems

The position data reference of a relative measuring system to the axis has to be re-established each time the drive is switched on or after the position data reference is lost (switching to PM). For this it is necessary to move to a defined axis position and set the actual position value to an axis-related value in a defined position.

Procedures for establishing the position data reference:

- "Drive-controlled homing procedure" for relative encoders

- or -

- "NC-controlled homing procedure" for relative encoders

Indicating the position data reference

The position status parameter "S-0-0403, Position feedback value status" signals whether the position data reference of a measuring system has been established.

Actual position value offset

The difference of the actual position value before and after having established the position data reference is shown in offset parameter "S-0-0175, Offset of position feedback value of encoder 1", encoder 1.

The respective values are written to the offset parameter each time the position data reference is established. After the drive was switched on, the value, however, is undefined, even if the position data reference has already been established!

Clearing the position data reference

By activating parameter "S-0-0191, C1500 Cancel reference point procedure command" it is possible to clear the position data reference of the encoder selected via bit 3 of "S-0-0147, Homing parameter". The respective bits of parameter "S-0-0403, Position feedback value status" are thereby reset (cleared), too.

Pertinent parameters

- P-0-0014, C1400 Command Get marker position
- P-0-0153, Optimum distance home switch-reference mark
- P-0-0188, Encoder 1 control word
- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance of encoder 1
- S-0-0146, C4300 NC-controlled homing procedure command
- S-0-0147, Homing parameter
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0150, Reference offset of encoder 1
- S-0-0165, Distance-coded reference offset A
- S-0-0166, Distance-coded reference offset B
- S-0-0171, C4400 Calculate displacement procedure command
- S-0-0172, C4500 Displacement to referenced system procedure command
- S-0-0173, Marker position A
- S-0-0175, Offset of position feedback value of encoder 1
- S-0-0177, Absolute offset encoder 1
- S-0-0191, C1500 Cancel reference point procedure command
- S-0-0298, Reference cam shift
- S-0-0299, Home switch offset
- S-0-0400, Home switch
- S-0-0403, Position feedback value status
- S-0-0404, Position command value status
- S-0-0407, Homing enable
- S-0-0408, Reference marker pulse registered
- S-0-0447, C0300 Set absolute position procedure command
- S-0-0448, Set absolute position control

Pertinent diagnostic messages

- C0300, Set absolute position procedure command
- C0301, Measuring system unavailable
- C0302, Absolute evaluation of measuring system impossible
- C0303, Absolute encoder offset cannot be saved
- C0304, Command cannot be executed under drive enable
- C0600, Drive-controlled homing procedure command
- C0601, Homing only possible with drive enable
- C0602, Distance home switch - reference mark erroneous
- C0604, Homing impossible with absolute encoder
- C0606, Reference mark not detected
- C0607, Reference cam input not assigned
- C0608, Pos. stop a. HW lim. switch not allowed f. modulo axes
- C0609, Different travel directions parameterized
- C0610, Absolute encoder offset could not be saved
- C1400, Command Get marker position
- C1402, Faulty reference mark signal
- C1500, Cancel reference point procedure command
- C4300, NC-controlled homing procedure command
- C4302, Distance home switch - reference mark erroneous
- C4304, Homing impossible with absolute encoder
- C4306, Reference mark not detected
- C4307, Reference cam input not assigned
- C4308, Pos. stop a. HW lim. switch not allowed f. modulo axes
- C4400, Calculate displacement procedure command
- C4500, Displacement to referenced system procedure command

Interrelationships

Establishing the position data reference is provided by the functional package "Closed Loop“.

Establishing the position data reference with absolute measuring systems

Brief description



Base package of all variants with **closed-loop** characteristic.

See also section "General information on establishing the position data reference"

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning, after a replacement of the encoder or changes in the mechanical axis system.

By means of bit 1 in "P-0-0188, Encoder 1 control word" the drive can be configured so that when switching to the operating mode the reference is always available, provided that absolute evaluation of the absolute measuring system is possible.

Irrespective of this, the actual position data reference of the axis is established by the available commands "C0300, Set absolute position procedure command" and "C0600, Drive-controlled homing procedure command". They

also result in persistent storing of the position data reference in "P-0-0177, Encoder 1, absoute encoder buffer".

Establishing position data reference via drive commands

In the case of measuring systems to be evaluated in absolute form, the position data reference can be automatically established by the drive by starting the command

- "C0300, Set absolute position procedure command"

- or -

- "C0600, Drive-controlled homing procedure command".

Once established, the position data reference is maintained until one of the two commands is executed again. The actual position values therefore are axis-related ("homed") immediately after the drive is switched on.

Command "Set absolute position"

It is recommended that the "set absolute position" command be started when the axis is at a standstill without drive enable. In cases in which the axis, for establishing the position data reference, is to be brought to a defined position on the master side and held in this position by the drive, "set absolute position" can also be executed with active drive.

Command "drive-controlled homing procedure"

Upon the start of command "C0600, Drive-controlled homing procedure command" without a reference, the drive moves the axis automatically as defined in parameter "S-0-0147, Homing parameter", thus establishing the position data reference. If the position system of the drive is already referenced when command "C0600, Drive-controlled homing procedure command" is started, the reference point already established is approached and then the command is positively acknowledged.

For absolute encoders, the command "drive-controlled homing procedure" is useful in the case of loss of position data reference after:

- encoder replacement in conjunction with a home switch or
- encoder error with peripheral causes in the case of modulo-scaled axes (e.g. encoder cable damage).

☞ "Active drive" means the drive that is in control. The drive enable ("AF") has been set.

Assigning the axis-related actual position value with "set absolute position"

By starting the command "set absolute position", the previous actual position value of an encoder at a dedicated position of the axis is set to a new dedicated position value. This value is the current axis position related to the coordinate system of the machine.

The dedicated position is defined by:

- the current axis position

- or -

- positioning of the axis at a "striking" axis position (e.g. value "0").

The required assignments and configurations for "setting absolute measuring" are realized via parameter settings.

Assigning the axis-related actual position value with "drive-controlled homing"

By starting the command "drive-controlled homing", the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. This value is the current axis position related to the coordinate system of the machine.

The necessary assignments and configurations for "drive-controlled homing procedure" are made via parameter settings (see details on "drive-controlled homing procedure").

Pertinent parameters

- S-0-0052, Reference distance of encoder 1
- S-0-0148, C0600 Drive-controlled homing procedure command

- S-0-0447, C0300 Set absolute position procedure command
- S-0-0448, Set absolute position control
- P-0-0177, Encoder 1, absoute encoder buffer
- P-0-0188, Encoder 1 control word

Pertinent diagnostic messages

- C0300, Set absolute position procedure command
- C0301, Measuring system unavailable
- C0302, Absolute evaluation of measuring system impossible
- C0303, Absolute encoder offset cannot be saved
- C0304, Command cannot be executed under drive enable
- C0600, Drive-controlled homing procedure command
- C0601, Homing only possible with drive enable
- C0602, Distance home switch - reference mark erroneous
- C0606, Reference mark not detected
- C0607, Reference cam input not assigned
- C0608, Pos. stop a. HW lim. switch not allowed f. modulo axes
- C0609, Different travel directions parameterized
- C0610, Absolute encoder offset could not be saved

Functional description

"Drive-controlled homing procedure command" with absolute measuring systems

Application-related aspect

The command "drive-controlled homing procedure" is mainly used for homing relative measuring systems. The position data reference of a relative encoder must be re-established each time the drive is switched on again (or when changing from communication phase "P2" to "bb" or "Ab" or when switching from PM to OM).



The function "drive-controlled homing procedure" is described in section "Establishing position data reference for relative measuring systems".

In the case of absolute measuring systems, the position data reference to the axis only has to be established once during initial commissioning (or after encoder replacement or encoder error, for example).

If "S-0-0148, C0600 Drive-controlled homing procedure command" is to be used for homing an absolute measuring system, the relevant bit in parameter "S-0-0448, Set absolute position control" has to be set.

Absolute offset

When "C0600, Drive-controlled homing procedure command" was successfully completed, an absolute offset value was determined. This value is used for calculation together with the encoder-side absolute values, stored in the encoder and the reference bit is set in parameter "S-0-0403, Position feedback value status". The position data reference has now been established and the actual position value is valid. This is also valid immediately each time the drive is switched on again.

Command "set absolute position"

Dedicated position

By starting the "C0300, set absolute position procedure command", the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. The dedicated position corresponds to the current axis position at the start of the command.

The new actual position value at the dedicated position after "set absolute position" is the value of parameter

- "S-0-0052, Reference distance of encoder 1"

$$\text{Encoder 1 S-0-0051}_{new} = \text{S-0-0052}$$

S-0-0051 Position feedback 1 value
S-0-0052 Reference distance 1

Fig. 5-19: Actual position values after "set absolute position"

Storing the absolute encoder offset

In order that an encoder, which can be evaluated in absolute form, maintains the position data reference to the axis after "set absolute position", the absolute encoder offset is stored in the parameter memory (P-0-0177).

Possible operational states before "set absolute position"

The "C0300, set absolute position procedure command" can be activated in the following operational states:

- Drive is ready for operation, but not active ("OM", "bb", "Ab")
- Drive is active in position control ("AF")
- Drive is active and in "Drive Halt" ("AH")

☞ In the last two cases, when the drive is active, bit 2 "set absolute position procedure command allowed with drive enable (AF)" of parameter "S-0-0448, Set absolute position control" has to be set.

Sequence for "set absolute position" while the drive is inactive ("OM", "bb", "Ab") or in "Drive Halt (AH)"

When the "C0300, set absolute position procedure command" is started, the reference of the selected encoder is cleared first (S-0-0403).

After the reference was cleared while the drive is inactive ("OM", "bb" or "Ab") and when the drive is in "Drive Halt (AH)", the new position feedback value (S-0-0051) is set according to the preselected dedicated position (see fig. 5-19 " Actual position values after set absolute position" on page 235). The new position reference takes immediate effect.

Sequence of "set absolute position" when the drive is enabled ("AF")

When the "C0300, set absolute position procedure command" is started, the reference of the selected encoder is cleared first (S-0-0403).

After the reference was cleared and when the drive is active, there are the following possibilities regarding the changeover of the actual position value to the new position reference:

- Deactivating the drive enable

  → When the drive goes to the inactive state, the new actual position value (S-0-0051) is set according to the preselected dedicated position (see fig. 5-19 " Actual position values after set absolute position" on page 235) .

- Starting the "drive-controlled homing procedure" command:

  → The drive no longer follows the command values. The new position feedback value (S-0-0051) is set (see formula fig. 5-19 " Actual position values after set absolute position" on page 235), and the drive signals that the "drive-controlled homing" command was executed. The master now has to "synchronize" with the new position feedback value of the encoder used in the active operation mode. After the master cleared the "drive-controlled homing procedure" command, the drive returns to master-controlled operation.

Sequence of "set absolute position" after position reference has been established

When the "C0300, set absolute position procedure command" is started, the reference of the selected encoder is cleared first (S-0-0403).

When the new position reference of the encoder has been established, the reference of the respective encoder is displayed in "S-0-0403, Position feedback value status" and the absolute encoder offset is stored. Finally, the "set absolute position" command has to be cleared by the master!

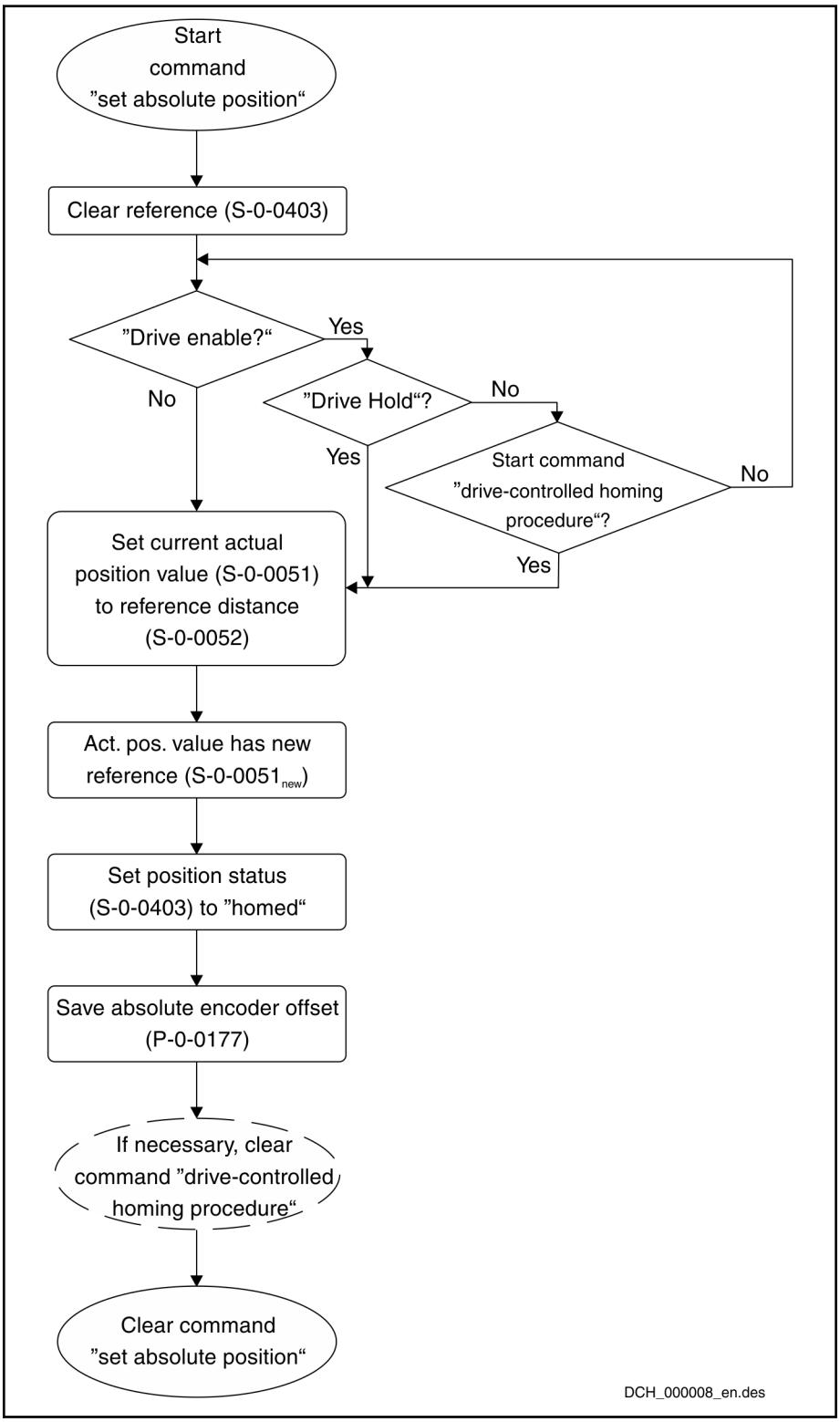


Fig. 5-20: Sequence of "set absolute position" command execution

Notes on commissioning

See also notes on commissioning for "General information on establishing the position data reference"

Checking the possibility of absolute encoder evaluation

The possibility of absolute evaluation of encoder 1 is displayed by the respective bits of

- "S-0-0277, Encoder 1, type of position encoder"

See also "absolute measuring systems" and "relative measuring systems"

Presetting

In "S-0-0448, Set absolute position control" presettings must be made for "set absolute position":

- The encoder for "set absolute position" has to be determined.
- It has to be determined, whether the execution of command "C0300, Set absolute position procedure command" is also allowed when the drive enable (AF) is given, and whether the execution of "S-0-0148, C0600 Drive-controlled homing procedure command" is to be possible with an absolute measuring system.

See commissioning notes on "drive-controlled homing procedure".

Starting "set absolute position"

Start the command "S-0-0447, C0300 Set absolute position procedure command".

See also section "Command processing"

Starting "Drive-controlled homing procedure" if necessary

If "set absolute position" is to be carried out with active drive, you either have to start the command "S-0-0148, C0600 Drive-controlled homing procedure command" or bring the drive to the status "Drive Halt" (AH) to switch the actual position value over. Withdrawing the drive enable (inactive drive) also results in a changeover of the actual position value (see chapter "Command set absolute position" on page 234).

Procedure:

Set the drive to drive enable (AF) and start "S-0-0447, C0300 Set absolute position procedure command"; the further proceeding is as follows:

- Start "S-0-0148, C0600 Drive-controlled homing procedure command"

  or

- trigger "Drive Halt" (AH)

  or

- withdraw the drive enable (AF)

Any of the above options results in the actual position value being set to a new value:

- According to the interrelationships with "C0600, Drive-controlled homing procedure command"
- According to "S-0-0052, Reference distance of encoder 1" or "S-0-0054, Reference distance of encoder 2" with "AH" or withdrawal of "AF"

After the changeover of the actual position value, command C0300 is to be reset.

See also section "Command processing"

Checking whether position data reference was established

The respective bit of parameter "S-0-0403, Position feedback value status" displays whether the encoder selected via "S-0-0448, Set absolute position control" has been homed.



If the absolute encoder had already been homed, the respective bit only changes briefly during command execution!

When "set absolute position" was executed again for an absolute encoder, a value for the "offset" of the actual position values before and after command execution is entered in:

- S-0-0175, Offset of position feedback value of encoder 1

Clearing the executed commands

After the commands have been executed (diagnosis possible via parameter "S-0-0403, Position feedback value status"), the commands started have to be cleared again in reverse order when "set absolute position" is carried out via command "drive-controlled homing procedure".

Change of encoder

If an absolute encoder was replaced, the position data reference has to be established again.

Establishing position data reference for relative measuring systems (homing)

Brief description



Base package of all firmware variants with **closed-loop** characteristic.

See also section "General information on establishing the position data reference"

Actual position value of relative measuring systems when switching on

After the drive has been switched on, the actual position values signaled by relative measuring systems do not yet have any reference to the machine axis.

For the arrangement of encoders and the mechanical axis system, see also "Mechanical axis system and arrangement of measuring system"

The position data reference of relative measuring systems to the axis has to be re-established each time the drive was switched on or after all procedures that cause the position data reference to get lost (homing procedure).

Establishing the position data reference, drive-controlled

After start of the respective command by the master, the drive can automatically establish the position data reference.

To do this, the drive moves the axis until the controller can detect a dedicated point. The actual position values are then automatically switched to axis reference. The presettings for the sequence for establishing the position data reference are made via assigned parameters.

Establishing the position data reference, NC-controlled

As an alternative to establishing the position data reference in a drive-controlled way, the NC ("master") can control the homing procedure.

In this case the master provides the command values for moving the axis to the dedicated point and controls the homing procedure via commands and assigned parameters.

The NC-controlled homing procedure can be advantageous for drives with a rigid mechanical connection, because the master can input coordinated command values for the drives for the homing motion.

Dedicated point for establishing the position data reference

In the case of linear axes, the dedicated point for establishing the position data reference is at one end of the travel range. This allows finding the dedicated point from any axis position (situation when switched on) by moving in a defined direction. Rotary axes do not have an axis end position; the dedicated point is at a defined position within the travel range.

Reference mark for relative measuring systems

The precision with which this dedicated point is detected has a considerable influence on the absolute precision of the axis. Apart from the signals for po-

sition detection, relative measuring systems therefore also provide a signal for exact determination of a dedicated point. This signal is called "reference mark". Depending on their type, relative measuring systems have one or several reference marks over the range of measurement.

Reference mark and home switch

Especially in the case of rotary measuring systems on axes performing a linear movement, the reference mark of the encoder can occur several times over the entire travel range. In this case it is required to identify **one** reference mark signal by activation of a switching contact on the axis side at the end of the travel range. This defines an unequivocal dedicated point that can be found with reproducible precision. This switching contact is called "home switch". A travel range limit switch, if available, can be used like a home switch, too.

In addition, a reference mark signal can be identified by detecting axis blocking when the positive stop at the end of the axis has been reached.

Irrespective of the number of reference marks over the travel range, an axis-side additional device (home switch or travel range limit switches or positive stop) is indispensable for linear axes for detecting the axis end position!

If only one reference mark occurs over the travel range in the case of rotary axes, a home switch is not required in most cases!

Dedicated point and reference point of an axis

The dedicated point identified by an encoder reference mark and, if necessary, by a home switch, is in most cases not identical with the reference point of the axis. The distance between reference point and zero point normally is determined on the machine side. Especially in the case of serial machines, this distance should be equal for axes of the same kind. The position of the dedicated point, however, is influenced by the kind of encoder arrangement and therefore differs from axis to axis.

Reference offset

The position difference between the dedicated point and the reference point of the axis can be compensated by an offset value (reference offset).

See also section "General information on establishing the position data reference"

Pertinent parameters

Parameters for relative measuring systems:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance of encoder 1
- S-0-0108, Feedrate override
- S-0-0147, Homing parameter
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0150, Reference offset of encoder 1
- S-0-0173, Marker position A
- S-0-0191, C1500 Cancel reference point procedure command
- S-0-0298, Reference cam shift
- S-0-0299, Home switch offset
- S-0-0349, Bipolar jerk limit
- S-0-0400, Home switch
- S-0-0403, Position feedback value status
- P-0-0153, Optimum distance home switch-reference mark

Parameters for NC-controlled homing:

- S-0-0146 C4300 NC-controlled homing procedure command
- S-0-0171, C4400 Calculate displacement procedure command
- S-0-0172, C4500 Displacement to referenced system procedure command
- S-0-0175, Offset of position feedback value of encoder 1
- S-0-0404, Position command value status
- S-0-0407, Homing enable
- S-0-0408, Reference marker pulse registered

Parameters for relative measuring systems, distance-coded:

- S-0-0165, Distance-coded reference offset A
- S-0-0166, Distance-coded reference offset B
- S-0-0177, Absolute offset encoder 1

Parameters for homing at travel range limit switches:

- S-0-0532, Travel range limit parameter
- P-0-0222, Travel range limit switch inputs

Parameters for homing at positive stop:

- S-0-0092, Bipolar torque/force limit value (2 bytes)
- S-0-0124, Standstill window
- S-0-0331, Status "v_feedback = 0"
- S-0-0333, Status "T >= Tx"

Pertinent diagnostic messages

Diagnostic messages for drive-controlled homing:

- C0600, Drive-controlled homing procedure command
- C0601, Homing only possible with drive enable
- C0602, Distance home switch - reference mark erroneous
- C0606, Reference mark not detected
- C0607, Reference cam input not assigned

Diagnostic messages for NC-controlled homing:

- C4302, Distance home switch - reference mark erroneous
- C4304, Homing impossible with absolute encoder
- C4306, Reference mark not detected
- C4307, Reference cam input not assigned
- C4308, Pos. stop a. HW lim. switch not allowed f. modulo axes
- C4400, Calculate displacement procedure command

Functional description

General information

Type and arrangement of reference marks

Relative measuring systems can have one or several reference marks in terms of type and arrangement:

Action of the axis drive to establish position data reference

In order to establish the position data reference of relative measuring systems, the drive has to be able to identify an unequivocal dedicated point within the travel range of the axis. To do this, the axis has to move over the dedicated point (drive-controlled or NC-controlled):

Identifying a dedicated point

To identify a dedicated point of an axis the following signals can be used:

- Reference marks of the encoder
- Home switch at the axis
- Travel range limit switches
- Axis blocking when positive stop at the end of travel range has been reached (positive stop detection)

The reference mark signal of an encoder is generally used for detecting the position of the dedicated point because this signal allows detecting the position within the framework of the encoder precision.

Depending on the encoder type and the mechanical arrangement of the encoder in the mechanical drive system, reference mark signals can occur **once or several times** within the travel range of an axis.

If the reference marks occur several times, only one reference mark signal may determine the dedicated point at an unequivocal axis position. Identifying a mark signal requires one of the following additional devices on the axis side:

- Travel range limit switches
- Home switch (if no travel range limit switch is available)
- Positive stop at the end of the axis (if no switches are to be used)

☞ The mentioned axis-side additional devices are also used for detecting the end of the axis during the homing procedure.

Encoder	Number of reference mark signals occurring over the travel range			
	One signal		Several signals	
	Rotary axis	Linear axis	Rotary axis	Linear axis
Rotary encoder	AD: No	AD: Yes	AD: Yes (home switch)	AD: Yes
Linear encoder:	---	AD: Yes	---	AD: Yes

AD Additional device

Tab. 5-3: Recommendation for axis-side additional devices (AD) for determining the dedicated point

In "S-0-0147, Homing parameter" select, which signals are to be evaluated by the controller for determining the dedicated point (reference marks and/or home switches, travel range limit switches or positive stop).

☞ If there is no reference mark signal available on the encoder side, the edge reversal of the home switch signal or the travel range limit switch signal or the detection of the positive stop can also be used for detecting the dedicated point. This has to be set in parameter S-0-0147 by deactivating the reference mark evaluation (only possible with drive-controlled homing!).

Reference point, axis zero point and dedicated point

The axis zero point and the reference point are positions determined on the machine side. The position of the dedicated point ideally is identical to the reference point; the position of the dedicated point, however, is mostly influenced by the encoder arrangement. The position difference between reference point and dedicated point is transmitted to the controller via the so-called reference offset.

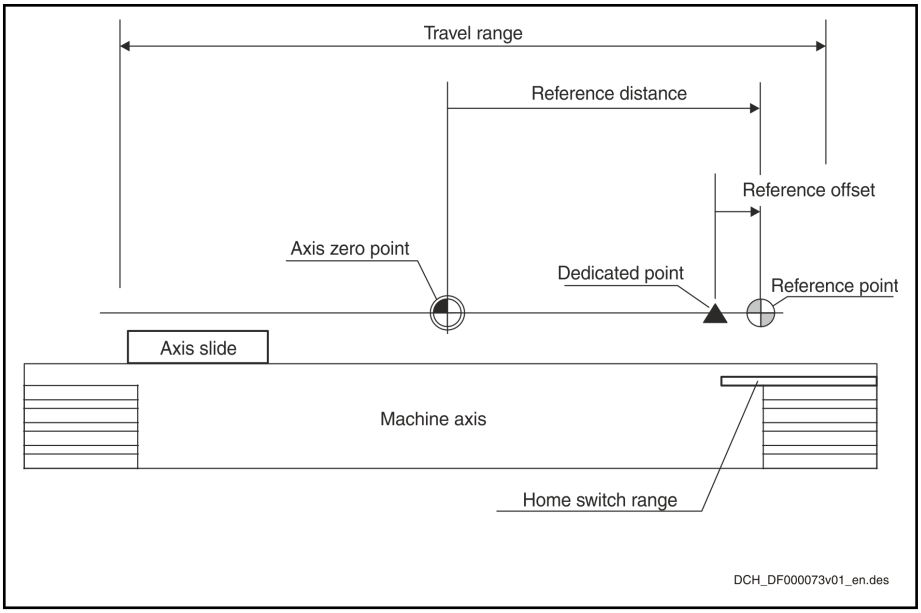


Fig. 5-21: Example of positions of axis zero point, dedicated point and reference point

The reference offset is specified in parameter S-0-0150, Reference offset of encoder 1.

The reference distance S-0-0052, Reference distance of encoder 1 is the distance of the reference point from the axis zero point.

Detecting the end of the travel range

When homing relative measuring systems, the axis always has to be moved in a defined direction (to be determined) so that the dedicated point can be reliably identified. As a prerequisite the axis has to be within the allowed travel range.

But the axis, when the search for the dedicated point is started, can also already be at that end of the axis at which the dedicated point is situated. For a reliable detection of the dedicated point the drive has to be able to recognize this situation. This is only possible by means of additional devices (AD) on the axis side:

- Home switch at end of axis
- Travel range limit switches
- Positive stop at end of axis for axis blocking (detection of positive stop)

One of these devices has to be mounted at the end of the axis with the dedicated point, and its signals have to be evaluated by the drive controller.

For NC-controlled homing a home switch is obligatory! For NC-controlled homing, travel range limit switches and positive stop can neither be used for detecting the end of the travel range nor for identifying the dedicated point.

The status "activated" (switching logic) of home switch and travel range limit switch is set in the following parameters:

- "S-0-0147, Homing parameter" for the home switch ("edge evaluation...")
- "P-0-0090, Travel range limit parameter" for the travel range limit switch ("signal behavior")

Identifying the dedicated point by means of reference mark and home switch

Home switch for selecting a reference mark

If several reference mark signals can occur over the travel distance of an axis and the dedicated point is to be determined by one of the marks, for drive-controlled homing a home switch can be used as axis-side additional device for selecting a reference mark.

For NC-controlled homing, a home switch on the axis side is obligatory!

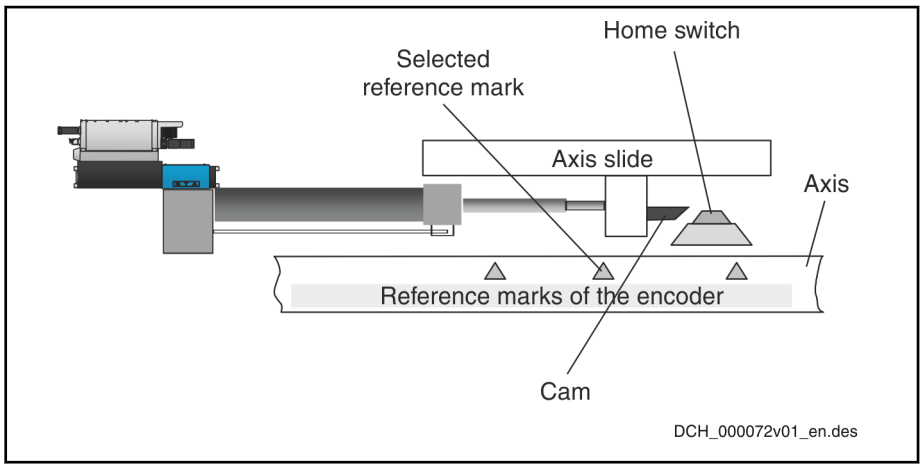


Fig. 5-22: Selecting a reference mark via home switch using the example of a linear axis

After the start of drive-controlled or NC-controlled homing, the dedicated point is detected when the first reference mark signal occurs after the "activated" signal of the home switch.

Arranging the home switch

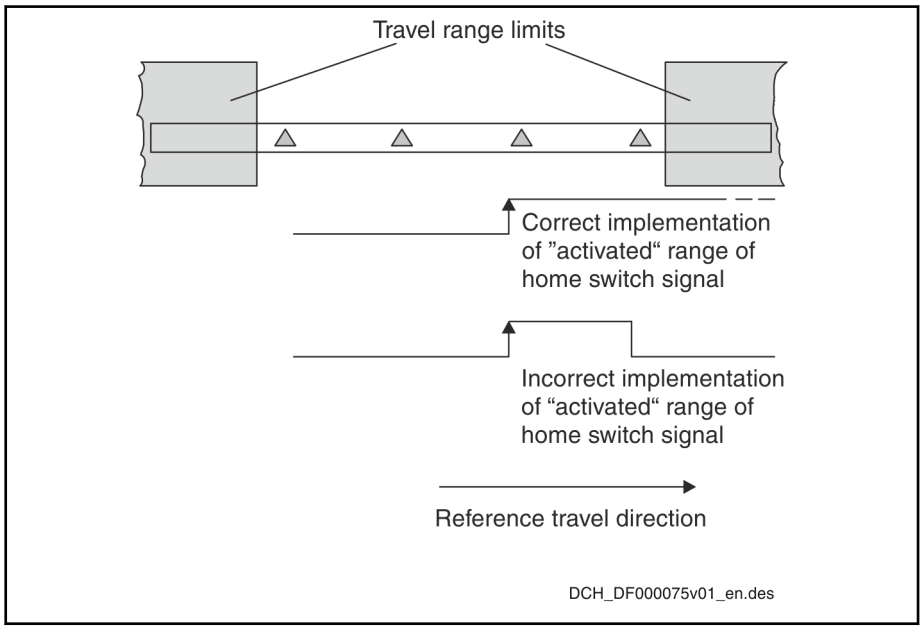


Fig. 5-23: Arrangement of the home switch with regard to travel range limits using a linear axis as an example

In the case of linear axes, the "activated" range of the home switch has to reach beyond the next travel range limit. The home switch signal thereby indicates the proximity to the end of the travel range if the reference travel direction was appropriately selected. The travel range limit is not passed during the homing procedure when the "activated" range of the home switch signal begins with sufficient distance to the travel range limit!

Distance between dedicated point and travel range limit for linear axes with home switch

The distance between dedicated point (first reference mark after home switch signal) and travel range limit is sufficient, if the drive can safely shut down the axis out of maximum homing velocity (S-0-0041 for drive-controlled homing) with homing acceleration (S-0-0042 for drive-controlled homing) within the travel range. The following requirement applies to the minimum distance between home switch and travel range limit:

$$x_{HS_TrLimit} \geq x_{RefMarks} + \frac{v^2}{2 \times a}$$

$x_{RS_VbLimit}$	minimum distance to travel range limit
$x_{RefMarks}$	distance between the reference marks on the axis
v	Homing velocity (value of S-0-0041 or preset by NC)
a	Homing acceleration (value of S-0-0042 or preset by NC)

Fig. 5-24: Minimum distance of home switch signal to travel range limit

☞ Generally, several reference marks may occur in the "activated" range of the home switch signal!

☞ For rotary axes a home switch is only required when a gear with a gear ratio unequal to "1" was installed between the axis and the drive!

Axis position when switching on, detection of end of travel range

When the axis drive is switched on, the real axis can be at any position within the travel range, also at the end of the travel range. The home switch mounted at the end of the axis can be activated.

It must be possible to carry out the homing procedure successfully also from this start position:

- In the case of drive-controlled homing, the drive automatically passes the dedicated point depending on the signal status and the settings for the "activated" signal of the home switch.
- In the case of NC-controlled homing, the master has to set the required command values so that the dedicated point can be unequivocally detected.

Searching for the dedicated point in the case of an axis with home switch

The drive must move the axis in the determined homing direction to the end of the axis to start the search for the dedicated point after having recognized the "activated" signal. The end of the travel range is also detected via the signal status of the home switch.

Determination of edge evaluation (S-0-0147)	Signal status of home switch (bit in S-0-0400)	Drive action
Positive	0 ("not actuated")	Motion in reference travel direction until home switch is actuated, then search for dedicated point after positive signal edge was detected
Negative	1 ("not actuated")	Motion in reference travel direction until home switch is actuated, then search for dedicated point after negative signal edge was detected

Determination of edge evaluation (S-0-0147)	Signal status of home switch (bit in S-0-0400)	Drive action
Negative	0 ("actuated")	Motion against reference travel direction until home switch is not actuated, then reversal of motion; search for dedicated point after negative signal edge was detected
Positive	1 ("actuated")	Motion against reference travel direction until home switch is not actuated, then reversal of motion; search for dedicated point after positive signal edge was detected

Tab. 5-4: Movements of the drive for searching the dedicated point, depending on the axis position (drive-controlled or NC-controlled)

Connecting the home switch

For drive-controlled homing, the home switch has to be connected to the assigned digital input of the HydraulicDrive. Observe the allowed signal levels! The signal status of the home switch is shown in parameter "S-0-0400, Home switch".

For "NC-controlled homing", the obligatory home switch can be connected either to the drive controller or to the master (NC control unit)!

See "Digital inputs/outputs"

Activating the evaluation of reference marks and home switch

The evaluation of the reference marks and the home switch signal have to be activated in the relevant bit of "S-0-0147, Homing parameter". The evaluation of the travel range limit switch and positive stop must not be activated at the same time!

☞ If the evaluation of the reference marks has not been activated, the dedicated point is determined only by the signal of the home switch!

Identifying the dedicated point by means of reference mark and travel range limit switch

Travel range limit switch for selecting a reference mark

A travel range limit switch can also be used as axis-side additional device (AD) for selecting a reference mark, if several reference mark signals can occur over the travel distance of an axis and the dedicated point is to be determined by one of the marks.

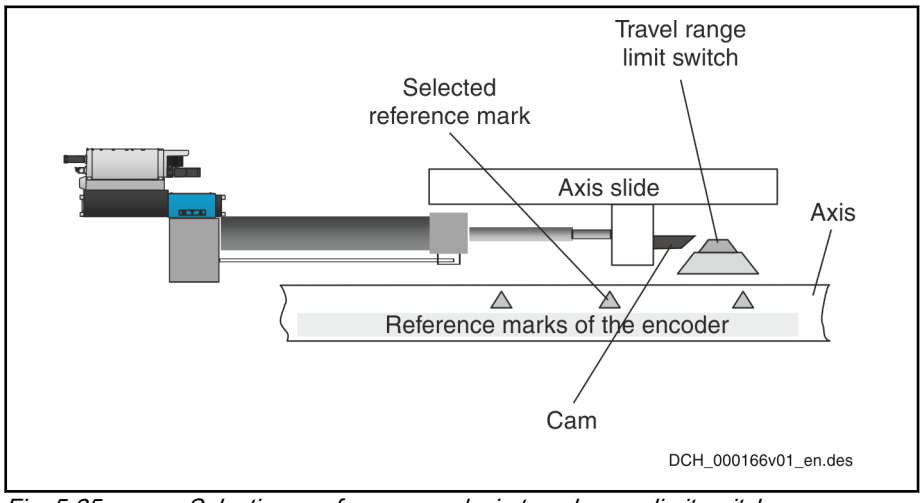


Fig. 5-25: Selecting a reference mark via travel range limit switch

After the start of drive-controlled homing (command C0600), the axis is moved in the determined direction of motion until the travel range limit switch is actuated. The drive then changes the direction of motion, the dedicated point is detected when the first reference mark signal occurs.

If the travel range limit switches for hardware-side limitation of the allowed travel range have been actuated, this monitoring function is deactivated during the homing procedure!

Axis position when switching on; detecting the end of the travel range

When the axis drive is switched on, the real axis can be at any position within the travel range, also at the end of the travel range. The travel range limit switch mounted at the end of the axis can be activated.

It must be possible to carry out the homing procedure successfully also from this start position. In the case of drive-controlled homing, the drive automatically passes the dedicated point depending on the signal status and the settings for the "activated" signal of the travel range limit switches.

Searching for the dedicated point on axis with travel range limit switch

The drive must move the axis in the determined reference travel direction to the end of the axis to start the search for the dedicated point after a signal change of the travel range limit switch.

Determination of signal behavior of travel range limit switch (P-0-0090)	Determination of signal state of travel range limit switch (P-0-0222)	Drive action
Not inverted	0 ("not actuated")	Movement in reference travel direction when limit switch activated, with reversal of motion and search for dedicated point
Inverted	1 ("not actuated")	Like line above
Inverted	0 ("actuated")	Movement against reference travel direction until limit switch is not activated, then search for dedicated point
Not inverted	1 ("actuated")	Like line above

Tab. 5-5: Drive movements for search for dedicated point at the start of command C0600 (in the case of use of travel range limit switches), depending on the axis position

Connecting the travel range limit switches

The travel range limit switches have to be connected to the assigned digital inputs of the control section of the drive controller. Observe the allowed signal levels! The signal status of the respective travel range limit switch is displayed in parameter "P-0-0222, Travel range limit switch inputs".

See "Digital inputs/outputs"

Activating the evaluation of reference marks and travel range limit switch

The evaluation of the reference marks and the travel range limit switch as additional devices for homing has to be activated in the respective bits of "S-0-0147, Homing parameter".

The evaluation of the home switch and/or positive stop must not be activated at the same time!

If evaluation of the reference marks has not been activated, the dedicated point is determined only by the signal of the travel range limit switch!

Identifying the dedicated point by means of reference mark and positive stop

Positive stop for selecting a reference mark

A positive stop of an axis, too, can be used as axis-side additional device (AD) for selecting a reference mark, if several reference mark signals can oc-

cur over the travel distance of an axis and the dedicated point is to be determined by one of the marks.

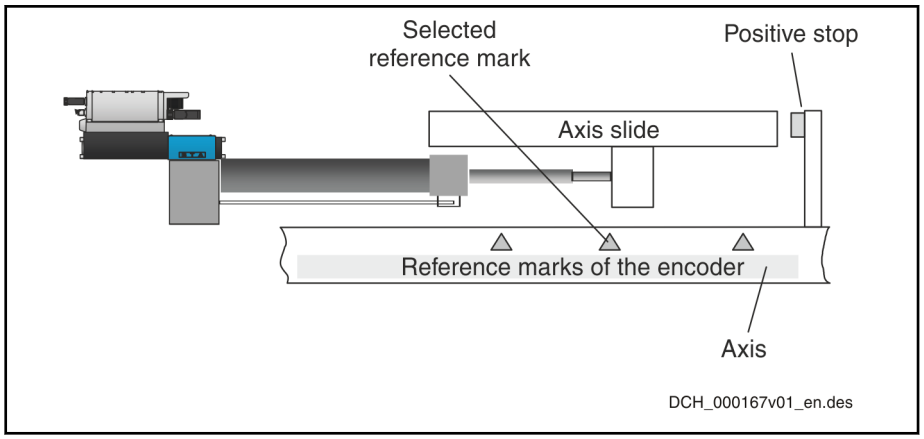


Fig. 5-26: Selecting a reference mark via positive stop at the end of the axis

Detecting the end of travel range by axis blocking (positive stop)

After the start of drive-controlled homing (command C0600), the drive first moves in the determined reference travel direction (see S-0-0147). There is no switching signal required for identifying the end of the axis!

Search for dedicated point

The axis continues to move until it is blocked by a positive stop.

When the positive stop was recognized,

- **Condition 1:** Standstill of the drive was recognized ("-0-0331, Status "v_feedback = 0"“) and
- **Condition 2:** Actual force value >= force limit value **or** following distance > monitoring window
  - "S-0-0552, Torque/force feedback value" has reached "S-0-0092, Bipolar torque/force limit value (2 bytes)".

    If the value of "S-0-0530, Clamping torque" is unequal to 0 and if the value of "S-0-0530" is less than the value of "S-0-0092, Bipolar torque/force limit value (2 bytes)", the "S-0-0530" acts as force limit value.
  - If the following distance (S-0-0189) is greater than the monitoring window (S-0-0159),

the drive changes the direction of motion; the dedicated point is determined by the occurrence of the first reference mark signal.

Activation of axis blocking detection (positive stop) for homing procedure

The evaluation of the reference marks and the positive stop as additional devices for homing has to be activated in the respective bits of "S-0-0147, Homing parameter". The evaluation of the home switch and/or travel range limit switch must not be activated at the same time!

☞ Monitoring of position command value, actual position value and acceleration is switched off during the homing procedure!

☞ If travel range limit switches for hardware-side limitation of the allowed travel range have been activated, monitoring of this limitation is deactivated during the homing procedure!

Requirements for selecting a reference mark

If an axis-side additional device (AD), such as a home switch, travel range limit switch, or positive stop at the end of the axis, is to be used for selecting a reference mark signal (in the case of signals occurring several times over the travel range), you have to make sure that it is always the same reference

mark signal that is evaluated by the controller for detecting the position of the dedicated point!

Activation of the home switch or the travel range limit switch or recognition of positive stop is detected by the controller with a position inaccuracy inherent in the system. This inaccuracy depends on the following factors:

- The reading cycle of the digital input via which the home switch or the travel range limit switch is evaluated (corresponding to the position controller cycle when command C0600 is executed)
- Position controller clock cycle when using a positive stop while command C0600 is being executed
- Actual velocity value at which the axis moves during the homing procedure

Within the range of inaccuracy of position detection there must not occur any encoder reference mark, because a reliably reproducible detection of the dedicated point is impossible within this range!

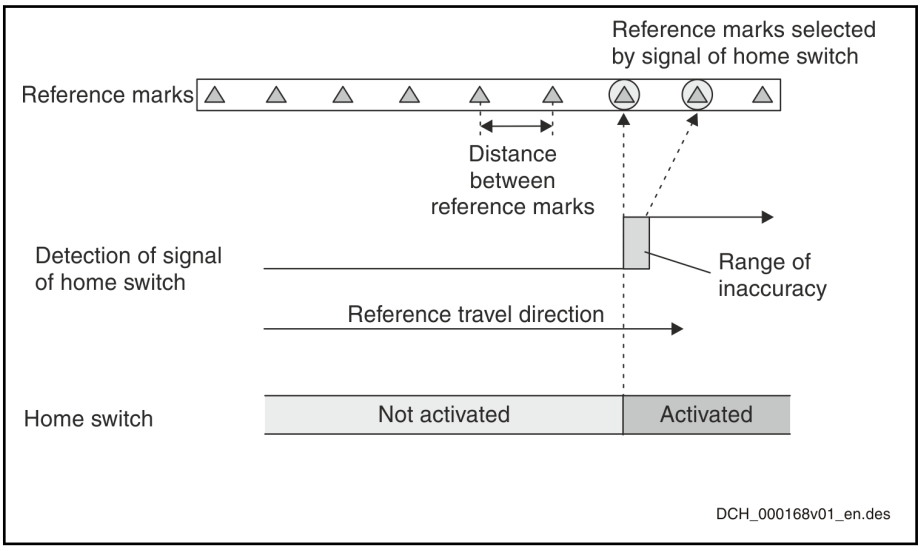


Fig. 5-27: Ambiguous detection of reference marks within the inaccuracy range of home switch detection

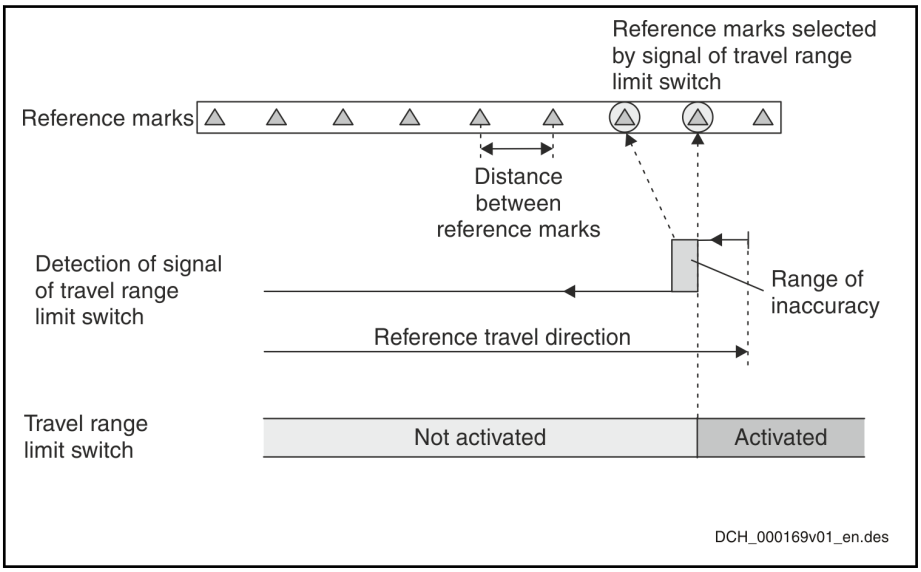


Fig. 5-28: Ambiguous detection of reference marks within the inaccuracy range of travel range limit switch or positive stop detection

Distance monitoring switch edge detection or positive stop detection/reference mark

Due to the range of position inaccuracy of the switch edge or positive stop detection, the distance to the position of the next reference mark is monitored. If the distance falls below a certain value, the error message "C0602, Distance home switch - reference mark erroneous" is generated.

Classification of distance	Distance	Drive reaction
Critical distance	< 0.25 × reference mark distance	Shutdown with message C0602
Optimum distance	0.5 × reference mark distance	--
Allowed distance range	(0.25 - 0.75) × reference mark distance	--

Tab. 5-6: Data regarding the distance between switch edge or positive stop detection and reference mark

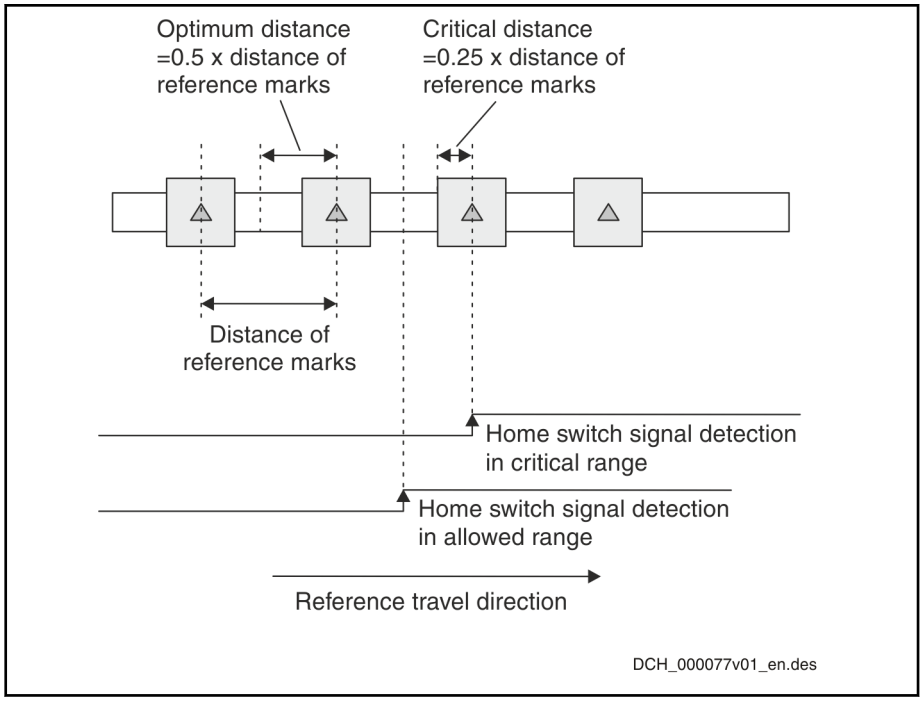


Fig. 5-29: Critical and optimum distance of switch edge and reference mark in the case of the home switch

To monitor the distance, the optimum distance has to be preset in parameter "P-0-0153, Optimum distance home switch-reference mark".

For input values of P-0-0153 for distance monitoring to the next reference mark in the case of switch edge or positive stop detection, see separate documentation "Parameter description"

Distance correction

For each homing procedure with home switch, travel range limit switch or positive stop detection as well as reference mark evaluation, the difference between the actual distance to the next reference mark and the optimum distance is monitored. The difference is stored in parameter "S-0-0298, Reference cam shift". For optimum setting of the home switch or travel range limit switch, these switches can be mechanically shifted by the value of S-0-0298.

The distance can also be optimized purely drive-internally without mechanical shifting. In this case, the controller shifts the activation of the reference mark

evaluation by the value specified in parameter "S-0-0299, Home switch offset" after having detected the switch edge or axis blocking (positive stop). To this end, the value of S-0-0298 has to be entered in parameter S-0-0299.

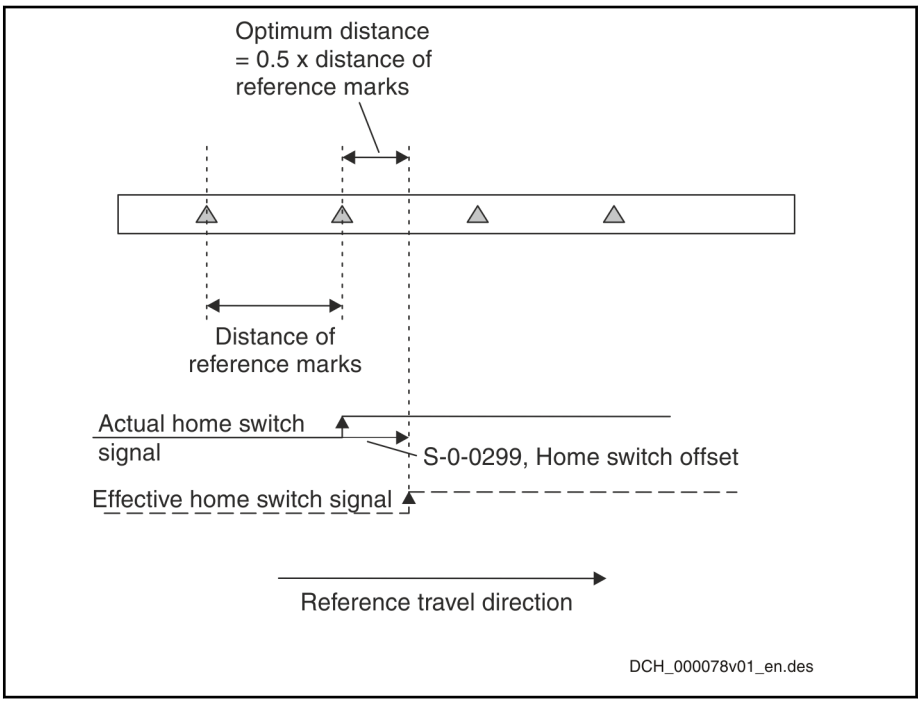


Fig. 5-30: Operating principle of parameter S-0-0299 using the home switch signal as an example

Distance monitoring of reference mark signals

The position distance of the reference mark signals is monitored during the homing procedure. The position distance to be expected is determined by the drive controller depending on the type of the individual encoder used and the value in "P-0-0153, Optimum distance home switch-reference mark". This allows detecting:

- Parameter values for reference mark evaluation have been correctly set

- or -

- Reference mark signals are correctly read in

Parameter P-0-0153 refers to the encoder to be homed according to the setting in "S-0-0147, Homing parameter".

Notes on commissioning

See also notes on commissioning for "General information on establishing the position data reference"

Settings for connected encoders

The required settings with regard to the encoders used must have been made so that the position data reference can be established.

See also notes on commissioning for "Basics on measuring systems, resolution"

General settings for drive-controlled homing

In "S-0-0147, Homing parameter", it is necessary to make basic settings regarding encoder selection and use of axis-side additional devices:

- Activation/deactivation of reference mark evaluation

  → Select whether the dedicated point is determined by an encoder reference mark (to be selected with drive-controlled homing, automatically active with NC-controlled homing).

- Determinations for utilizing an additional device on the axis side for identification of the dedicated point:
  - Home switch

  - or -
  - Travel range limit switch as a replacement for home switch (optional with drive-controlled homing, not possible with NC-controlled homing)

  - or -
  - Activation of detection of axis blocking with positive stop drive procedure (optional for drive-controlled homing, not possible for NC-controlled homing)

Settings for axis-side additional devices (if available)

Depending on whether axis-side additional devices are used, further settings have to be made.

Home switch:

- Activation of home switch evaluation in "S-0-0147, Homing parameter"
- Setting for edge evaluation of home switch signal in "S-0-0147, Homing parameter"

Travel range limit switch:

- Activation of travel range limit switch evaluation in "S-0-0147, Homing parameter"
- Determination of switching behavior in "S-0-0532, Travel range limit parameter"

Detection of axis blocking (positive stop):

- Determination of torque/force threshold for detection of blocking via parameter "S-0-0092, Bipolar torque/force limit value (2 bytes)". If the value of "S-0-0530, Clamping torque" is unequal to 0, and if this value of "S-0-0530" is less than the value of "S-0-0092, Bipolar torque/force limit value (2 bytes)", the "S-0-0530" acts as torque/force threshold.
- Setting of standstill threshold for detection of blocking in "S-0-0124, Standstill window"
- Determination of monitoring window for the following distance in "S-0-0159, Monitoring window of following distance"

Distance monitoring of reference mark signals

With active reference mark evaluation (obligatory for NC-controlled homing, optional for drive-controlled homing), encoder-specific values for monitoring of the reference mark signals have to be entered in "P-0-0153, Optimum distance home switch-reference mark". Monitoring takes place during the homing procedure (see parameter description P-0-0153).

NOTICE **Property damage to the installation caused by incorrect setting of the home switch edge!**

⇒ Make sure the home switch edge was correctly set and is within the travel range!

Checking the distance between home switch edge - travel range limit

In the case of home switch evaluation, first check whether the minimum distance between home switch edge and travel range limit has been complied with:

- Search for switching point of home switch, e.g. by jogging the axis to switch cams; check switching state in "S-0-0400, Home switch"; note actual position value (S-0-0051)

- Jog axis to travel range limit, note actual position value (S-0-0051)

The minimum distance has to be calculated on the basis of the values for velocity and acceleration intended for the homing procedure (see section above "Identifying the dedicated point by means of reference mark and home switch"):

- For drive-controlled homing, determine the minimum distance with "S-0-0041, Homing velocity" and "S-0-0042, Homing acceleration"
- For NC-controlled homing determine the minimum distance while taking the homing velocity and homing acceleration into account

If the distance between home switch edge and travel range limit is smaller than the calculated minimum distance, the home switch has to be mechanically brought to the proper distance!

Checking and, if necessary, correcting the distance to the reference mark

When using axis-side additional devices (optional) such as home switches, travel range limit switches or positive stop (setting in parameter S-0-0147), you have to check whether the distance switch edge - reference mark or positive stop - reference mark is within the allowed range.

How to proceed for checking the distance:

- Make presettings for activating the reference marks for use of axis-side additional devices and for encoder selection in "S-0-0147, Homing parameter"
- Make settings for the relevant axis-side additional device that might be used (see above)
- Check whether the encoder-specific value was entered in parameter "P-0-0153, Optimum distance home switch-reference mark"
- Execution of the drive-controlled homing procedure (command C0600) with "S-0-0299, Home switch offset" = 0 and the setting "Hold" in parameter S-0-0147. If the distance lies within the allowed range (0.25… 0.75 × (2 × P-0-0153)), the drive will not generate a corresponding error message after standstill.

If the message "C0602, Distance home switch - reference mark erroneous" is generated, the distance has to be corrected:

1. Enter value from parameter "S-0-0298, Reference cam shift" in parameter "S-0-0299, Home switch offset"
2. Check: When homing is repeated, the value "0" should be displayed for parameter S-0-0298.

Drive-controlled homing

Brief description

Basic sequence of "search for dedicated point"

After activation of "S-0-0148, C0600 Drive-controlled homing procedure command", the drive moves the axis according to the reference travel direction set in "S-0-0147, Homing parameter" for searching the dedicated point. When the controller has detected the position of the dedicated point, e.g. by reference mark detection of the encoder selected in S-0-0147, the position data reference of the actual position values in relation to the axis can be established.

Determining the appropriate homing procedure for the existing axis type (settings in S-0-0147) ensures that during the search for the dedicated point the axis only moves within the allowed travel range!

For information on the actual position value after the position reference was established, see section "General information on establishing the position data reference"

Functional description

Functional sequence "drive-controlled homing procedure"

Command value profile for homing procedure

After activation of "S-0-0148, C0600 Drive-controlled homing procedure command", the drive moves the axis according to the reference travel direction set in "S-0-0147, Homing parameter". The command value profile generated by the controller depends on:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0108, Feedrate override

The controller ignores command values of the control master during the execution of command C0600!



If, at the start of command C0600, the respective encoder should already have been homed, the reference is cleared first!

See also parameter description "S-0-0403, Position feedback value status"

Homing motion

At the start of command C0600, two situations have to be distinguished with regard to the initial position of a linear axis. The moving part of the axis is

- within the travel range, the home switch or travel range limit switch has not been activated,

- or -

- near the end of the travel range, the home switch or travel range limit switch has been activated, the positive stop, possibly used for homing, has almost been reached.

If the switch has not been activated or the positive stop has not yet been reached, the drive moves the axis in reference travel direction.

When the home switch has already been activated, the drive moves the axis against the reference travel direction.

The drive reverses the direction of movement for searching for the dedicated point as soon as the home switch is recognized as "Not actuated".

When a positive stop is used for homing, the search for the dedicated point, after axis blocking has been detected, is always carried out against the reference travel direction!



If the dedicated point is the current actual position value of the encoder to be homed, no homing movement takes place.

This means that for the identification of the dedicated point

- neither reference mark evaluation
- nor an axis-side additional device was selected

Jerk limitation

To limit acceleration jumps it is possible to additionally activate a jerk limit. This is done by entering a value in parameter "S-0-0349, Bipolar jerk limit".

Motion range for homing

The process for searching the dedicated point requires axis motion. The axis motion to be expected depends on the selected measuring system and on the position of the axis at the start of drive-controlled homing (for information on axis motion, see chapter "Functional description" on page 240).

Maximum velocity

As with all drive-controlled functions, the maximum velocity can be directly influenced with a feedrate factor when executing the homing procedure. The

effective maximum velocity then results from the product of the values of "S-0-0041, Homing velocity" and "S-0-0108, Feedrate override".

Shutdown

After the controller has detected the dedicated point of the axis as a result of the homing procedure, the actual position values are switched to axis-related values. The drive then shuts down the axis with homing acceleration (S-0-0042). The shutdown can be carried out as:

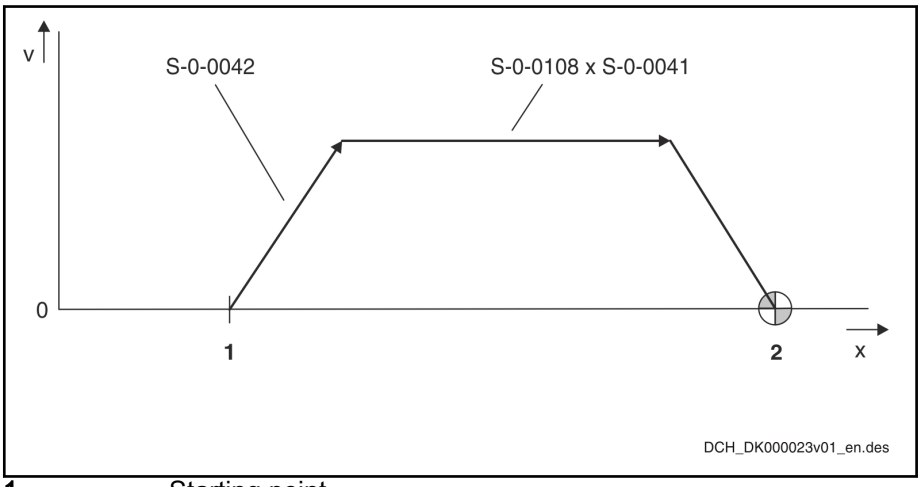
- "Stop"

  → Non-target-oriented immediate braking motion that possibly is of shorter duration

- or -

- "Positioning"

  → Target-oriented movement to the reference point (axis-related value in parameter "S-0-0052, Reference distance of encoder 1"), provided that the reference point is within the allowed travel range



1 Starting point
2 Reference point
S-0-0041 Homing velocity
S-0-0042 Homing acceleration
S-0-0108 Feedrate override

Fig. 5-31: Command value profile for drive-controlled homing with constant feedrate factor and "positioning" shutdown type

☞ If the parameter "S-0-0108, Feedrate override" starts at zero, the warning "E2055, Feedrate override S-0-0108 = 0" is generated.

Actions of the control unit in the case of "drive-controlled homing"

Starting command C0600

The control master starts the command by writing data to parameter "S-0-0148, C0600 Drive-controlled homing procedure command". The command has to be set and enabled. The command acknowledgment has to be taken from the data status of the same parameter. The command execution is completed when the command change bit in parameter"S-0-0135, Drive status word" has been set and the acknowledgment changes from "in process" to "command executed" or to "command error".

Interrupting command C0600

If the command is interrupted by the control master while being executed, the drive reacts by activating the "Drive Halt" function. The command execution is continued by removing the interruption.

Completing command C0600

When the control master is to operate the drive in position control after command C0600 was reset, it has to read the drive-internal position command

value from "P-0-0047, Position command value of control" and preset it as the position command value. By resetting the command the control master takes over the axis without jerk or position offset occurring.

Notes on commissioning

General information

Settings for homing motion

For drive-controlled homing motion, settings for kinematics have to be made:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration

Settings for drive-controlled homing

Apart from general settings, further settings for drive-controlled homing have to be made in "S-0-0147, Homing parameter":

- Reference travel direction

  → determine direction of motion in which search for dedicated point takes place, if axis is not at end of axis
- Activation/deactivation of reference mark evaluation

  → determine, whether dedicated point is determined by an encoder reference mark
- Determinations for utilizing an additional device on the axis side for identification of the dedicated point:
  - Use of a home switch and setting for edge evaluation of home switch signal

  - or -

  - Use of a travel range limit switch as a substitute for home switch

  - or -

  - Activation of blocking detection for positive stop drive procedure

  Note: Only one of the possible axis-side additional devices for drive-controlled homing may be selected!
- Setting for shutting the axis down after detection of dedicated point ("stop", "positioning" or "run path")

Axis-related settings for establishing the position data reference

Depending on the kind of reference marks of the encoder, the axis-related parameter settings for establishing the position data reference are explained in the following sections.

Commissioning notes with relative encoder

Settings for axis-side position data reference of actual position values

To establish the position data reference of an encoder to the axis, the distance between the dedicated point identified on the drive side and the reference point of the axis as well as the position of the reference point in relation to the axis zero point have to be entered.

To do this the following steps have to be carried out:

1. First set the parameters below to value "0":
   - S-0-0052, Reference distance of encoder 1
   - S-0-0150, Reference offset of encoder 1
2. If encoder reference marks are not to be evaluated, make corresponding settings in "S-0-0147, Homing parameter" (default setting: Encoder reference marks are evaluated!).
3. For initial commissioning set parameters for homing procedure to low values:
   - S-0-0041, Homing velocity

- S-0-0042, Homing acceleration

4. Execution of "C0600, Drive-controlled homing procedure command" (S-0-0148), if drive in "AF"

NOTICE **Property damage caused by step change of actual position value!**

⇒ By clearing the command, the original operation mode becomes active again. When the "drive-internal interpolation" mode was set, for example, the drive immediately moves to the position according to the value in parameter "S-0-0258, Target position". Take note of the change in actual position value!

Axis zero point and dedicated point

After the command was executed the axis zero point is at the same axis position as the dedicated point, because the reference distance (S-0-0052) and the reference offset (S-0-0150) were set to the value "0". The actual position value in parameter "S-0-0051, Position feedback value of encoder 1" now has an absolute reference to this preliminary axis zero point.

Settings for the reference point

The reference point normally has an actual position value, which is determined on the axis side and related to the axis zero point. Ideally, the dedicated point identified on the drive side has the same position as the reference point. As the dedicated point position is considerably influenced by the mounting situation of the encoder, dedicated point and reference point are different. The distance between the dedicated point and the reference point must be entered in the parameter for reference offset 1.

To determine the reference offset the following steps have to be carried out, based on the initial status after the proposed identification of the dedicated point:

- Jog the axis to the determined reference point and enter the actual position value shown here with the identical sign in parameter "S-0-0150, Reference offset of encoder 1".

To establish the position reference, the desired axis-related actual position value of the reference point must be entered in parameter "S-0-0052, Reference distance of encoder 1". This can be directly done by entering the value defined on the axis side if this value is known. If not, the axis-related actual position value of the reference point has to be determined:

- Jog axis to desired axis zero point. Enter displayed actual position value in the respective reference distance parameter with inverted sign.

- or -

- Jog axis to actual position value = 0; axis then is at reference point. The axis-related position of the reference point can be determined by measuring the distance between the current position and the determined axis zero point. Enter measured distance with the correct sign as axis-related actual position value for the reference point in the respective reference distance parameter.

After repeated execution of the command C0600 ("drive-controlled homing procedure command") the actual position values refer to the axis zero point.

Settings for drive-controlled homing motion

Set the parameter values reduced for initial commissioning to their definite values:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration

For checking purposes, execute "C0600, Drive-controlled homing procedure command" again!

Drive-controlled homing can be completed with "stop" or "positioning":

"Stop" after detecting the dedicated point

If in "S-0-0147, Homing parameter" the setting "stop" is made after the dedicated point was detected (default setting), the drive stops the axis after the dedicated point was recognized.

"Positioning" after detecting the dedicated point

If the axis is to position to the reference point after the dedicated point was detected, this must be determined in parameter S-0-0147. The position can be preset via "S-0-0150, Reference offset of encoder 1".

NOTICE

The system may be damaged, if the reference point is outside the allowed travel range and the position limit has not been activated yet!

⇒ Make sure that the reference point is within the travel range and activate the position limit!

Possible error messages during drive-controlled homing

While command C0600 is being executed, the following command errors can occur:

- C0601, Homing only possible with drive enable
- C0602, Distance home switch - reference mark erroneous
- C0606, Reference mark not detected
- C0607, Reference cam input not assigned

NC-controlled homing

Brief description

Sequence of NC-controlled homing

With NC-controlled homing the master (NC control) controls the homing motion for searching for the dedicated point of the axis. To do this, the master activates the parameter

- S-0-0146, C4300 NC-controlled homing procedure command

and presets the command value for axis motion according to the active operation mode.

When the drive has detected the dedicated point, it informs the master of this fact and stores the position of the dedicated point. The master then completes the execution of command C4300 and afterwards activates the parameter

- S-0-0171, C4400 Calculate displacement procedure command.

The required displacement of the actual position values is now calculated in the drive controller in order to establish the reference of the actual position value to the axis zero point.

When the displacement of the actual position value required for establishing the position data reference has been determined, the master completes the execution of command C4400 and then activates the parameter

- S-0-0172, C4500 Displacement to referenced system procedure command.

The actual position value now is changed drive-internally by the calculated absolute displacement value and thereby the reference of the actual position value to the axis zero point is established. The master has to adjust its command value input to the changed actual position value, before it completes the NC-controlled homing procedure by deactivating command C4500.

Functional sequence "NC-controlled homing procedure"

Searching the dedicated point, basic procedure

After the master has started NC-controlled homing by activating "S-0-0146, C4300 NC-controlled homing procedure command", it has to preset an axis motion command value for the drive for identifying the dedicated point.

The dedicated point can only be identified, if "S-0-0407, Homing enable" has been set on the master side. If a home switch was connected to the drive controller (setting in parameter S-0-0147), it has additionally to be recognized as "activated".

For details on the search for the dedicated point in the case of NC-controlled homing, see section above "Identifying the dedicated point by means of reference mark and home switch"!

When the drive has found the dedicated point of the encoder selected in "S-0-0147, Homing parameter", this is displayed in parameter "S-0-0408, Reference marker pulse registered". The position of the dedicated point is stored in parameter "S-0-0173, Marker position A".

To provide for a correct and time-optimized sequence of the execution of command C4300, the following assignments are required:

- Bit "homing enable" (S-0-0407) in real-time control bit of "S-0-0134, Master control word"
- reference markBit "Reference mark pulse registered" (S-0-0408) in real-time status bit of "S-0-0135, Drive status word"

When the bit "Reference mark pulse registered" (S-0-0408) has been set, the master can complete the execution of command C4300.

Calculation of the actual position value shift by the drive for zero point reference

By master-side activation of parameter "S-0-0171, C4400 Calculate displacement procedure command", the actual position value displacement for the encoder selected in "S-0-0147, Homing parameter" is calculated.

The calculation of displacement is based on the non-homed actual position value at the dedicated point (S-0-0173) and the values of reference distance 1 (S-0-0052) and reference offset 1 (S-0-0150).

The calculated displacement value is shown in S-0-0175, Offset of position feedback value of encoder 1 (encoder)

When the required displacement of the actual position value has been determined, the master can complete the execution of command C4400.



It would also be possible to calculate the displacement on the master side and directly preset it for the drive via parameter S-0-0175. In this case the execution of command C4400 would not be required!

Shifting of actual position value for zero point reference

To switch the actual position values to axis reference, the master now activates parameter "S-0-0172, C4500 Displacement to referenced system procedure command". The displacement of the actual position value for the encoder selected in "S-0-0147, Homing parameter" is thereby carried out.

The calculated displacement value (S-0-0175) is now added to the non-homed actual position value; the new actual position value is displayed in S-0-0051, Position feedback value of encoder 1

The homing status of the encoders connected to the drive is also displayed in "S-0-0403, Position feedback value status". By means of this parameter the master recognizes when the position command value is to be switched to axis reference. The master signals the completed changeover to the homed position command value in parameter "S-0-0404, Position command value status". The drive then signals the execution of command C4500 to have

been completed and the master on its part can complete the execution of command C4500.

The correct, time-optimized execution of command C4500 requires the following assignments:

- Position command value status bit (S-0-0404) in real-time control bit of "S-0-0134, Master control word"
- Reference encoder status bit (S-0-0403) in real-time status bit of "S-0-0135, Drive status word"

For information on the actual position value after the position reference was established, see section "General information on establishing the position data reference"

Notes on commissioning

Settings for NC-controlled homing

Apart from general settings (encoder selection, "activated" signal of home switch), further specific settings for NC-controlled homing have to be made in parameter"S-0-0147, Homing parameter":

- Setting for whether the home switch is connected to drive or master (NC control unit)
- Setting for activation of dedicated point detection:
  - Master-side homing enable

  - or -

  - Master-side homing enable and "activated" signal of home switch (for this purpose, the home switch has to be connected to the drive)

Axis-related settings for establishing the position data reference

The following axis-related parameter values have to be determined for relative, distance-coded measuring systems:

- S-0-0052, Reference distance of encoder 1
- S-0-0150, Reference offset of encoder 1

The following axis-related parameter values have to be determined for relative, distance-coded measuring systems:

- S-0-0177, Absolute offset encoder 1



The axis-related settings for establishing the position data reference are basically the same for drive-controlled and NC-controlled homing! For determining the axis-related parameter values it is advantageous to use "drive-controlled homing"!

Searching for the dedicated point

The master starts "C4300, NC-controlled homing procedure command" (S-0-0146) and sets the command value for the homing motion (if drive in "AF").

Detection of dedicated point takes place when:

- Homing enable (S-0-0407) is set

- or -

- "S-0-0407, Homing enable" has been set and the home switch is in the "activated" status (S-0-0400)

The non-homed position of the acquired dedicated point is stored in:

- S-0-0173, Marker position A

When the dedicated point was detected, this is displayed by a bit in parameter "S-0-0408, Reference marker pulse registered" and the master then completes the execution of command C4300.

Drive-side calculation of actual position value shift for zero point reference

The master starts "C4400, Calculate displacement procedure command" (S-0-0171).

The calculated displacement value is displayed in the following parameters:

- S-0-0175, Offset of position feedback value of encoder 1

When the required displacement of the actual position value has been determined, the master completes the execution of the command C4400.



It would also be possible to calculate the displacement on the master side and directly preset it for the drive via the parameter S-0-0175. In this case the execution of the drive command C4400 is not required!

Actual position value shift for zero point reference

The master starts "C4500, Displacement to referenced system procedure command" (S-0-0172).

The calculated displacement value (S-0-0175) is now added to the non-homed actual position value; the new actual position value is displayed in the following parameters:

- S-0-0051, Position feedback value of encoder 1

The actual position values thereby change from a non-homed to a homed value, because the corresponding displacement value was taken into account.

When the reference of the encoder selected in parameter S-0-0147 is displayed in "S-0-0403, Position feedback value status", the master changes the position command value from the non-homed value to the homed value:

- P-0-0047, Position command value control

In parameter "S-0-0404, Position command value status", the master simultaneously signals the homed status of the position command value to the drive and completes the execution of command C4500.

Possible error messages during NC-controlled homing

While NC-controlled homing is executed, the following command errors can occur:

- C4302, Distance home switch - reference mark erroneous
- C4304, Homing impossible with absolute encoder
- C4306, Reference mark not detected
- C4307, Reference cam input not assigned

Shifting the position data reference for absolute and relative measuring systems (shift coordinate system procedure)

Brief description

Fields of application



Base package of all firmware variants with **closed-loop** characteristic.

The existing position data reference of the measuring systems to the axis can be shifted if a corresponding command was activated by the master. It is possible to shift the data reference in standstill or while the axis is moving. This does not affect the position reference of the axis because it is only the actual position values output for the master that are displayed in "shifted" form. Internally the original ("non-shifted") position data reference is maintained.

Pertinent parameters

- S-0-0197, C3300 Set coordinate system procedure command
- S-0-0198, Initial coordinate value
- S-0-0199, C3400 Shift coordinate system procedure command
- S-0-0275, Coordinate offset value
- S-0-0283, Current coordinate offset

Pertinent diagnostic messages

- C3300, Set coordinate system procedure command
- C3400, Shift coordinate system procedure command
- C0600, Drive-controlled homing procedure command

Functional description

Operating principle of function "Shifting the position data reference"

Shifting of the position data reference has an effect on the current actual position value. Whether the current actual position value has a position data reference to the axis or not is irrelevant for the shifting of the position data reference! Shifting is carried out on the drive-side by means of a command started by the master.

☞ The reference status of the actual position values is not affected by shifting of the position data reference!

If the position data reference is shifted several times in succession without the drive having been switched to communication phase 2, the shifted values act in an additive way! The total offset with regard to the original actual position value is stored in parameter"S-0-0283, Current coordinate offset".

Resetting "shifting the position data reference"

Shifting of the position data reference is reset by switching the drive to communication phase 2. Therefore, no shifted position data reference can be active when the drive is switched on the first time, because former offsets are cleared when the drive is switched off.

☞ After resetting the shifted position data reference by switching to communication phase 2 the position data reference has to be established again for relative measuring systems, if necessary!

Establishing the position data reference with "shifted" measuring system

If the position data reference of the encoders to the axis ("C0300, Set coordinate system procedure command" or "C0600, Drive-controlled homing procedure command") is established after the actual position values have been shifted (value in parameter "S-0-0283, Current coordinate offset" unequal to "0"), the current offset of the coordinate system is cleared and in parameter S-0-0283 the value "0" is shown.

"Set coordinate system" procedure command

When the control master triggers "C3300, Set coordinate system procedure command" (S-0-0197), the drive becomes independent of the command values preset by the master and goes to a standstill under drive control. Deceleration takes place according to the function "A0010, Drive halt active"".

 See also description of diagnostic messages "A0010, Drive halt active"

In standstill, the actual position value is set to "S-0-0198, Initial coordinate value" and the difference between the new and original actual position value is stored in parameter S-0-0283. The command then is acknowledged as having been "executed".

"Shift coordinate system" procedure command

When the control master triggers "C3400, Shift coordinate system procedure command" (S-0-0199), the drive also becomes independent of the command values preset by the master but maintains the current velocity by internal input of the previous velocity command value. The actual position values now

are shifted by addition of "S-0-0275, Coordinate offset value". The difference between the new and the original actual position values is stored in parameter S-0-0283. The command then is acknowledged as having been "executed".

Action of control unit after command acknowledgment

After the command acknowledgment the control master has to adjust to the shifted actual position values. This can be done by means of the actual position values of the encoder active for position control (S-0-0051) or the current offset value (S-0-0283). When the control master has adjusted its command values to the new actual position values, it can clear the command. The master then sets the command values again. In spite of the actual position value having been shifted with the drive active, there is no jerk when activated!

Change in position data by "shifting position data reference"

Measured position values refer to the actual position value system in which they were measured, i.e.:

- When measured after shifting, they refer to the "shifted" measuring system.
- When measured before shifting, they refer to the original measuring system.

Command values (cyclic command values, target position, etc.) have to refer to the current actual position value system, i.e. to the possibly shifted position data reference.

Unchanged position data by "shifting position data reference"

Travel range limit values (S-0-0049 or S-0-0050) and **position correction values** (e.g. axis error correction values) are always in their original position data reference, i.e. the control unit, before writing these parameters, has to take the current offset into account and calculate the original position reference again.

Notes on commissioning

Shifting the position data reference during commissioning involves the risk of incorrect command value provision after shifting has been completed! Commissioning basically makes sense only in conjunction with the control master. Check whether command value handling of the master is correct!

NOTICE

Property damage caused by error in command value input after shifting the position data reference!

⇒ Protect the travel range of the axis, activate axis limit switches and make sure they are working!

"Set coordinate system procedure"

It is recommended to begin with "set coordinate system procedure". But first the parameter "S-0-0283, Current coordinate offset" should be read. When shifting of the position data reference has not yet been carried out after the transition from "P2" to "AF", the value has to be "0"!

With master-side command value input, the "S-0-0197, C3300 Set coordinate system procedure command" command has to be started by the master.

See also section "Command processing"

Checking the offset of position data reference

When the command was acknowledged by the drive, the offset of the position data reference has to be checked:

- The position feedback value (S-0-0051) must be identical to "S-0-0198, Initial coordinate value".
- Parameter "S-0-0283, Current coordinate offset" must be read out. With a value unequal to "0" shifting took place; with value "0" either no shift-

ing has taken place or the actual position value of the axis approximately equaled the value of S-0-0198 when the position data reference was shifted.

Checking the command value input and clearing the command

To check the command value input the master has to preset a position command value that corresponds to the value of parameter S-0-0198. Before the master resets the executed command, it is necessary to check whether the master-side command value corresponds to the current actual position value of the encoder active in position control (S-0-0051, shifted position data reference). If not, do not clear the command but reset "AF", if necessary, and search for the cause of the incorrect command value!

"Shift coordinate system procedure"

With "shift coordinate system procedure" it is recommended that the axis be controlled on the master side with velocity command value "0" or at very low velocity. The parameter "S-0-0283, Current coordinate offset" must be read. When shifting of the position data reference has not yet been carried out after the transition from "P2" to "AF", the value has to be "0"!

Then start "C3400, Shift coordinate system procedure command" on the master side.

See also section "Command processing"

Checking the offset of position data reference

When the command was acknowledged by the drive, the offset of the position data reference has to be checked:

- The values of "S-0-0283, Current coordinate offset" and "S-0-0275, Coordinate offset value" must correspond to each other.

Checking the command value input and clearing the command

Before the master resets the executed command, it is necessary to check whether the master-side command value corresponds to the current actual position value of the encoder active in position control (S-0-0051, shifted position data reference). If not, do not clear the command but reset "AF", if necessary, and search for the cause of the incorrect command value!

Detecting the marker position

Brief description



Base package of all firmware variants with **closed-loop** characteristic.

With the "detect marker position" function, which is activated via the corresponding command, it is possible to check whether the reference mark of an incremental measuring system is detected without error.



A possibly available home switch is not evaluated with this function!

Pertinent parameters

- S-0-0173, Marker position A
- P-0-0014, C1400 Command Get marker position

Pertinent diagnostic messages

- C1400, Command Get marker position

Functional description

After the start of "P-0-0014, C1400 Command Get marker position", the following actions are carried out:

- The diagnostic message "C1400, Command Get marker position" is generated.

- If a relative measuring system was selected, the search for reference marks is activated and the drive waits for reaching the next reference mark.
- When a reference mark is detected (i.e. the drive passes the position of a reference mark), the actual position value of this mark is stored in parameter "S-0-0173, Marker position A" and then the command execution is signaled to be completed.

☞ The drive does not generate any command values. The operation mode active at the start of the command remains unchanged. In order to pass the reference mark the control master has to preset such command values (e.g. by means of jogging) that lead to a movement in the direction of the reference mark to be detected.

☞ In parameter "S-0-0173, Marker position A", the position of the reference mark is also stored during execution of the "C0600, Drive-controlled homing procedure command" (S-0-0148). This position, however, refers to the "old" coordinate system (before switching the coordinate system when executing the homing procedure).

5.4 Force acquisition

5.4.1 Actual force value

The actual force value can be acquired in different ways:

- Calculation: pressures acting on piston area
- Direct establishment by a force sensor (not with p/Q devices)

Pressures and also the force sensor are read in via analog inputs. The respective actual pressure or force value is created by means of the corresponding analog assignment.

The method for establishing the actual force value is selected by means of P-0-2937.0.1, Force acquisition control word.

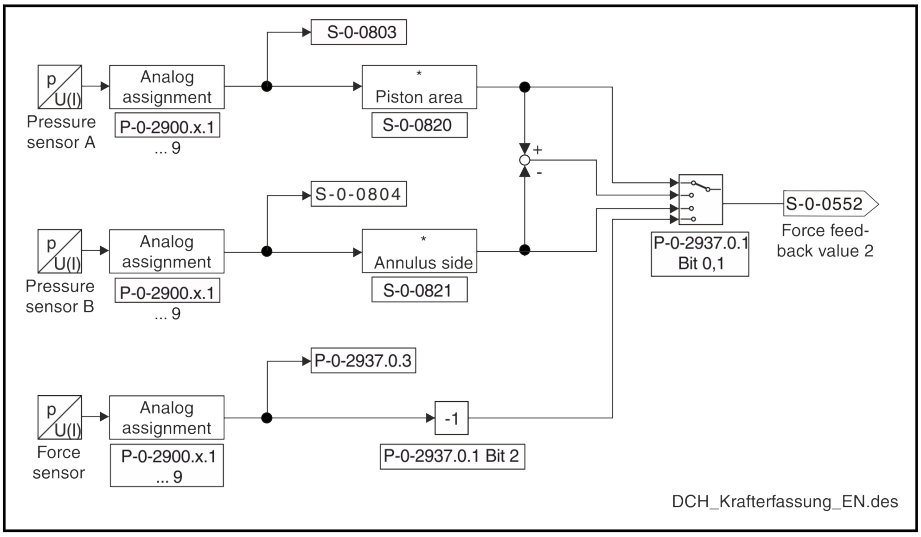


Fig. 5-32: Force acquisition

☞ Alternatively, the actual values can also be transmitted using the respective master communication.

☞ The actual force value is entered in both, parameter "S-0-0084, Torque/force feedback value (2 bytes)" and parameter "S-0-0552, Torque/force feedback value". Parameter S-0-0084 represents, however, only actual force values up to max. 2 bytes. For this reason, you should always use S-0-0552.

Establishment of force from pressure in chamber A and/or pressure in chamber B

The force is the product of the area and the pressure acting on it (F = p * A). The cylinder type and the effective areas are determined by the system data.

Pressure sensors typically have an analog output signal.

The required pressure sensors (one or two) have to be connected to the analog inputs of the controller. The sensor values are transmitted to "S-0-0803, Pressure feedback value A" and "S-0-0804, Pressure feedback value B" by means of analog assignments.

The value range is set and the analog interface is normalized by means of the respective analog assignment.

Differential pressure

The differential pressure from chamber A and B is used for establishing the actual force value.

$F_{act} = p_A * F_A - p_B * F_B$

Pressure in chamber A

The actual force is calculated only from the pressure in chamber A

$F_{act} = p_A * F_A$

Pressure in chamber B

The actual force is calculated only from the pressure in chamber B

$F_{act} = p_B * F_B$

Establishing the force by means of a force sensor

The force sensor typically has an analog output signal. It is to be connected to the analog input of the controller and is transmitted to "P-0-2937.0.3, Input of force feedback value" by way of an analog assignment.

The value range is set and the analog interface is normalized by means of an analog assignment.

This type of force determination cannot be selected when p/Q devices are used.

Pertinent parameters

- S-0-0803, Pressure feedback value A
- S-0-0804, Pressure feedback value B
- S-0-0820, Piston area A
- S-0-0821, Piston area B
- S-0-0552, Torque/force feedback value
- P-0-2937.0.1, Force acquisition control word
- P-0-2937.0.3, Input of force feedback value

5.5 Scaling of physical data

5.5.1 Brief description

The controller maps the drive via data to an internal mathematical model. The status variables of the drive are determined on the basis of the following measurements:

- Position measurement
- Pressure measurement
- Force measurement
- Temperature measurement

The measured values collected in this way are converted into physical data:

- Position, velocity, acceleration, and jerk data
- Torque and force data
- Temperature data

The master transmits command values to the drive, which are used by the controller as input values for implementation. The drive in return registers and transmits actual values, signals operational and command states and, if necessary, generates error messages and warnings.

Communication between drive and master also takes place by exchanging data.

Scaling

An operating datum (numerical value) can only be evaluated as a physical value, if the numerical value is connected to a physical unit and the position of the decimal point (decimal places). The datum thereby is "scaled" in qualitative and quantitative terms.

Parameters

All data are saved in parameters and transmitted as parameter values. Scaling of parameters containing data of the following physical values can be defined by the customer:

- Position
- Velocity
- Acceleration
- Torque/force
- Pressure and flow
- Temperature

Preferred scaling/parameter scaling

To simplify the determination of scaling so-called "preferred scalings" were predefined. But physical data can also be exchanged in the control-internal format, i.e. without specific reference to physical units. To do this, scaling for certain data can be freely set ("parameter scaling").

Linear and rotary data

Depending on the kind of motion of the drive or load, the data can be displayed as follows:

- linear (linear axis movement)

- or -

- rotary (rotary axis movement)



Scaling is not supported at present.

Cylinder reference/load reference

The drive firmware contains mechanical transmission elements between the cylinder and load, which are mapped by means of mathematical models. The physical data can thereby be referred to

- the load action point (load-side data reference)

- or -

- the force introduction point (cylinder-side data reference).

Absolute/modulo evaluation

For technical reasons, the value range of the position data the controller can display is limited.

In the case of axes with limited travel range (e.g. linear axes), the current axis position within the controller-side value range can be unequivocally displayed (see "Basics on measuring systems, resolution"



When the scaling system (metric/imperial) is switched, the system needs to be reconfigured, since the parameter values cannot be converted automatically.

Pertinent parameters

- S-0-0043, Velocity polarity parameter
- S-0-0044, Velocity data scaling type
- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent
- S-0-0055, Position polarities
- S-0-0076, Position data scaling type
- S-0-0077, Linear position data scaling factor
- S-0-0078, Linear position data scaling exponent
- S-0-0079, Rotational position resolution
- S-0-0085, Torque/force polarity parameter
- S-0-0086, Torque/force data scaling type
- S-0-0093, Torque/force data scaling factor
- S-0-0094, Torque/force data scaling exponent
- S-0-0103, Modulo value
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0160, Acceleration data scaling type
- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent
- S-0-0208, Temperature data scaling type
- S-0-0806, Pressure data scaling type
- S-0-0807, Pressure data scaling factor
- S-0-0808, Pressure data scaling exponent
- S-0-0845, Flow data scaling type
- S-0-0846, Flow data scaling factor
- S-0-0847, Flow data scaling exponent
- S-0-0848, Flow polarities

5.5.2 Scaling of flow

For flow data you can select from

- Percentage-based scaling
- Preferred scaling

- Preferred scaling [l/min]
- Preferred scaling [l/s]
- Preferred scaling [gal/min]
- Preferred scaling [gal/s]
- Parameter scaling

If percentage-based scaling is selected, parameter scaling is not allowed.

S-0-0846 (binary)	Scaling type	Preferred scaling	S-0-0846 (factor)	S-0-0847 (exponent)	Unit	Attribute decimal places	Attribute scaling factor
..xx00.0000	In percent	Yes	1	-3	%	3	1
..xx00.0001	Flow	Yes	1	-3	l/min	3	1
..xx01.0001	Flow	Yes	1	-4	gal/min	4	1
..xx10.1001	Flow	Yes	1	-3	l/s	3	1
..xx00.1001	Flow	Yes	1	-4	gal/s	4	1
..xx00.1001	Flow	No	1...2^{16}-1	-15...0	l/min	(S-0-0847)	(S-0-0846)
..xx01.1001	Flow	No	1...2^{16}-1	-15...0	gal/min	(S-0-0847)	(S-0-0846)
..xx10.1001	Flow	No	1...2^{16}-1	-15...0	l/s	(S-0-0847)	(S-0-0846)
..xx11.1001	Flow	No	1...2^{16}-1	-15...0	gal/s	(S-0-0847)	(S-0-0846)

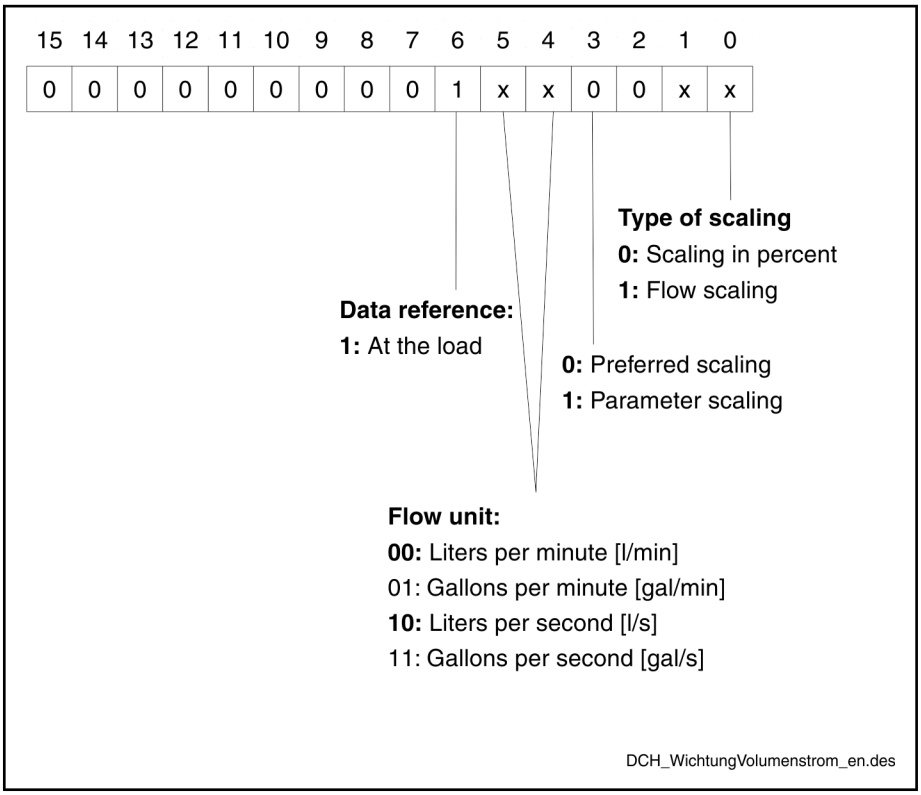


Fig. 5-33: Flow data scaling type

Percentage-based scaling refers to "P-0-2875.0.3, Maximum flow".

Parameter

IDN	Alias IDN	Name	Module	DocuObj
S-0-0845		Flow data scaling type	CALC	S-0-0845_V1.0.xml
S-0-0846		Flow data scaling factor	CALC	S-0-0846.000.000_V01.xml
S-0-0847		Flow data scaling exponent	CALC	S-0-0847.000.000_V01.xml
S-0-0848		Flow polarities	CALC	S-0-0848.000.000_V01.xml
P-0-2875.0.3	P-0-3473	Maximum flow	HYDR	P-0-2875.000.003_VH01.xml

5.5.3 Scaling of pressure

General information

For pressure scaling, you can select from

- Percentage-based scaling
- Preferred scaling [bar]
- Preferred scaling [psi]
- Parameter scaling

If percentage-based scaling is selected, parameter scaling is not allowed.

S-0-0806 (binary)	Scaling type	Preferred scaling	S-0-0807 (factor)	S-0-0808 (exponent)	Unit	Attribute decimal places	Attribute scaling factor
..xx00.0000	In percent	Yes	1	-1	%	1	1
..xx00.0001	Pressure	Yes	1	-3	bar	3	1
..xx01.0001	Pressure	Yes	1	-2	psi	4	1
..xx00.1001	Pressure	No	1...2^{16}-1	-15...0	bar	(S-0-0808)	(S-0-0807)
..xx01.1001	Pressure	No	1...2^{16}-1	-15...0	psi	(S-0-0808)	(S-0-0807)

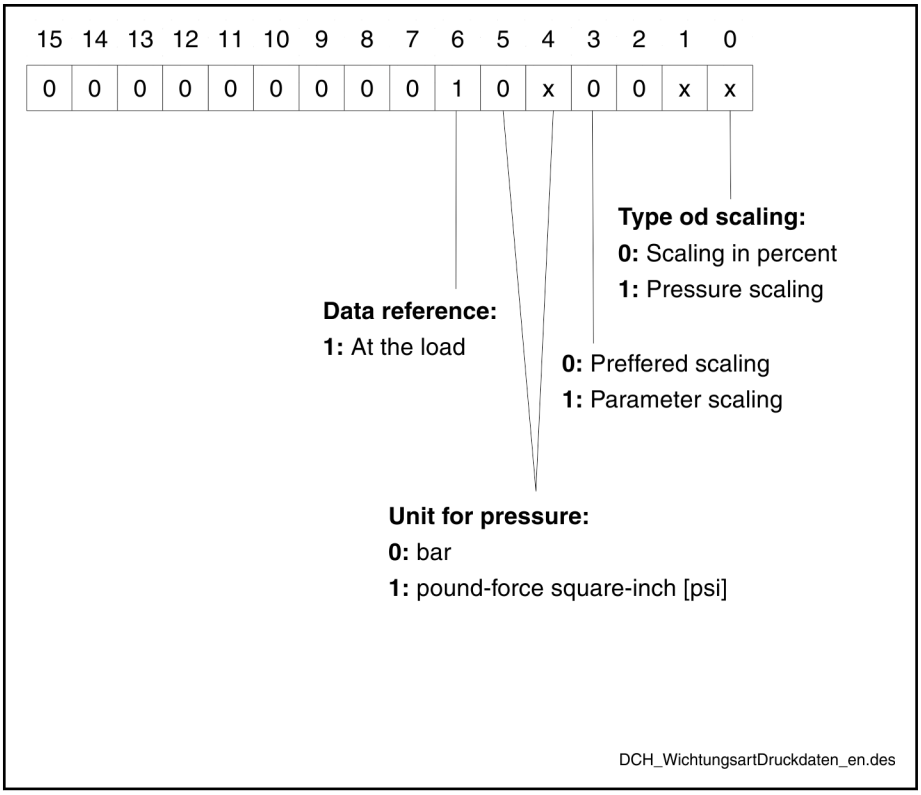


Fig. 5-34: Pressure data scaling type

Percentage-based scaling refers to "P-0-2875.0.4, Maximum pressure".

Pressure scaling with time reference

Pressure scaling an also be used in conjunction with a time reference. In this case, bar/s or psi/s, for example, can be specified as unit in the relevant parameters.

Pressure parameters with time reference have the same attributes as other parameters with pressure scaling without time reference, i.e. the number of decimal places is identical, the type of scaling is identical, etc. With parameter scaling, the same scaling parameters S-0-0806, S-0-0807 and S-0-0808 are effective as well.

Pertinent parameters

- S-0-0805, Pressure polarity parameter
- S-0-0806, Pressure data scaling type
- S-0-0807, Pressure data scaling factor
- S-0-0808, Pressure data scaling exponent
- P-0-2875.0.4, Maximum pressure

5.5.4 Scaling of position, velocity and acceleration

For position, velocity and acceleration data there are the following basic scaling types:

- Linear
- Rotary

It is possible to choose between preferred scaling (predefined scaling) and parameter scaling (scaling can be individually defined).

Preferred scalings (predefined)

Depending on the scaling type setting, the following predefined preferred scalings are available:

Physical data Data	Preferred scaling		
	Linear	Linear	Rotary
	with unit "m"	with unit "inch"	
Position data	0.0001 mm	0.000001 inch	0.0001 dgr
Velocity data	0.001 mm/min	0.00001 inch/min	0.0001 1/min or 0.000001 1/s

Tab. 5-7: Overview: Preferred scalings for position data and velocity data

Physical data Data	Preferred scaling			
	Linear	Linear	Rotary	Ramp time
	with unit "m"	with unit "inch"	Unit:"rad"	Unit:"s"
Acceleration data	0.001 mm/s^2	0.00001 $inch/s^2$	0.001 rad/s^2	0.001 s
Jerk data	0.000001 mm/s^3	0.00001 $inch/s^3$	0.001 rad/s^3	0.001 s^2

Tab. 5-8: Overview: Preferred scalings for acceleration data and jerk data

☞ Jerk data scaling is derived from acceleration data scaling.

To be noticed: Ramp time scaling type

The acceleration data can also be scaled with reference to a velocity ramp:

$$\text{reference vel. ramp} = \frac{\text{S-0-0446}}{\text{ramp reference time}} = \frac{\text{S-0-0446}}{1.0\ \text{ms}} \text{ (with preferred scaling)}$$

S-0-0446 Ramp reference velocity for acceleration data

Fig. 5-35: Definition of the velocity reference ramp for scaling acceleration data in the case of preferred scaling

Determinations for preferred scaling

The scaling types, units and the selection of preferred scaling are determined in the respective bits of the following parameters:

- S-0-0076, Position data scaling type
- S-0-0044, Velocity data scaling type
- S-0-0160, Acceleration data scaling type

When using preferred scaling, the parameter values for scaling type, unit, scaling factor, and scaling exponent as well as the number of decimal places are automatically set for the respective data. The following tables contain an overview.

Physical data Data	Scaling type	Unit	S-0-0076	S-0-0077	S-0-0078	Attribute number of decimal places
Position data	Linear	mm	..xx00.0001	1	-7	4
	Linear	inch	..xx01.0001	1	-6	6
	Rotary	grd	..xx00.0010	1	-4	4

S-0-0076 Position data scaling type
S-0-0077 Position data scaling factor
S-0-0078 Position data scaling exponent

Tab. 5-9: Values of scaling parameters and decimal places of position data determined by preferred scaling

Physical data Data	Scaling type	Unit	S-0-0044	S-0-0045	S-0-0046	Attribute number of decimal places
Velocity data	Linear	mm/min	..0x00.0001	1	-6	3
	Linear	inch/min	..0x01.0001	1	-5	5
	Rotary	1/min	..0x00.0010	1	-4	4
	Rotary	1/s	..0x10.0010	1	-6	6

S-0-0044 Velocity data scaling type
S-0-0045 Velocity data scaling exponent
S-0-0046 Velocity data scaling exponent

Tab. 5-10: Values of scaling parameters and decimal places of velocity data determined by preferred scaling

Physical data Data	Scaling type	Unit	S-0-0160	S-0-0161	S-0-0162	Attribute number of decimal places
Acceleration data	Linear	mm/s^2	..0x00.0001	1	-6	3
	Linear	$inch/s^2$	..0x01.0001	1	-5	5
	Rotary	rad/s^2	..0x00.0010	1	-3	3
	Ramp time	s	..0x00.0011	1	-3	3

S-0-0160 Acceleration data scaling type
S-0-0161 Acceleration data scaling factor
S-0-0162 Acceleration data scaling exponent

Tab. 5-11: Values of scaling parameters and decimal places of acceleration data determined by preferred scaling

☞ For practical reasons, the metric measures of length in the case of preferred scaling are scaled in "mm". This can also be seen from the corresponding "unit" data element when a respective parameter is being read. The decimal places are adjusted to the current unit.

Parameter scaling (can be individually defined)

As an alternative to preferred scaling it is also possible to activate parameter scaling. For parameter scaling the least significant bit (LSB) of the respective operating datum can be individually defined.

☞ By means of parameter scaling it is possible to modify the range of values of physical data!

Example: The maximum value for "S-0-0278, Maximum travel range" can be increased by reducing the number of decimal places of the position data.

position data, linear	LSB =	$\text{unit}^{1)} \times \text{scaling factor}^{1)} \times 10^{SE}$
position data, rotary	LSB =	$\frac{360}{\text{rotational pos. resolution}^{2)}} \times \text{unit}^{2)}$
velocity data	LSB =	$\frac{\text{unit (position data)}}{TU} \times \text{scaling factor} \times 10^{SE}$
acceleration data (linear, rotary)	LSB =	$\frac{\text{unit (position data)}}{TU^2} \times \text{scaling factor} \times 10^{SE}$
acceleration data (ramp time scaling)	LSB =	$\frac{\text{S-0-0446}}{\text{scaling factor} \times 10^{SE}}$
jerk data	LSB =	$\frac{\text{unit (position data)}}{TU^3} \times \text{scaling factor} \times 10^{SE}$

1) With a scaling factor ≠ 1 the unit is no longer indicated as in S-0-0076, but only "incrementally" (control-dependent unit reference).

2) With rotational position resolutions (S-0-0079) which do not result in powers of 10 of 360, the unit is no longer angular degrees (acc. to S-0-0076) but only "incremental" (control-dependent unit reference).

LSB least significant bit
WE scaling exponent
ZE unit of time
S-0-0446 Ramp reference velocity for acceleration data

Fig. 5-36: Defining the least significant bit (LSB) for parameter scaling

☞ Jerk data scaling is derived from acceleration data scaling.

Respective units of measurement and time defined in the parameters:

- S-0-0076, Position data scaling type
- S-0-0044, Velocity data scaling type
- S-0-0160, Acceleration data scaling type

The respective scaling factor and the scaling exponents are determined in the following parameters:

- S-0-0077, Linear position data scaling factor
- S-0-0078, Linear position data scaling exponent
- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent
- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent

For rotary position data the value of the following parameter must be determined for defining the LSB with parameter scaling:

- S-0-0079, Rotational position resolution

5.5.5 Scaling of torque and force

For torque/force data there are the following basic scaling types:

- Linear

- Rotary (scaling is not supported at present)
- Percentage-based

It is possible to choose between preferred scaling (predefined scaling) and parameter scaling (scaling can be individually defined). If percentage-based scaling is selected, parameter scaling is not allowed.

Preferred scalings (predefined)

Depending on the scaling type setting, the following predefined preferred scalings are available:

Physical quantity	Preferred scaling, decimal places and value ranges		
	Linear	Rotary	Percentage-based
Torque	--	0.01 Nm...327.67 Nm or 0.1 inlbf...3276.7 inlbf	0.1%
Force	1 N...32767 N or 0.1 lbf...3276.7 lbf	--	0.1%

Tab. 5-12: Preferred scalings for torque/force data

The scaling types and units can be determined in the respective bits of parameter

- S-0-0086, Torque/force data scaling type

Respective scaling factor and scaling exponent defined in the following parameters:

- P-0-0093, Torque/force data scaling factor and
- S-0-0094, Torque/force data scaling exponent

Parameter scaling (can be individually defined)

As an alternative to preferred scaling it is also possible to activate parameter scaling. For parameter scaling the least significant bit (LSB) of the respective operating datum can be individually defined.

Torque/force data LSB = unit x scaling factor x 10^{WE}

= unit of measure x S-0-0093 x $10^{S\text{-}0\text{-}0094}$

This results in the following maximum value ranges for SI units:

Physical quantity	Parameter scaling with S-0-0093 ="1", S-0-0094 = -2....6; decimal places and value ranges	
	Linear	Rotary
Torque	--	0.01 Nm...327.67 MNm
Force	1 N...32767 MN or	--

Tab. 5-13: Parameter scaling for torque/force data, SI unit system

This results in the following maximum value in the imperial system:

Physical quantity	Parameter scaling with S-0-0093 = "1", S-0-0094 = -2....6; decimal places and value ranges	
	Linear	Rotary

Torque	--	0.1 inlbf...3276.7 kinlbf
Force	0.1 lbf...3276.7 klbf	--

Tab. 5-14: Parameter scaling for torque/force data, imperial system

☞ The number of decimal places remains constant, the symbol for the power of 10 of 1000 (kilo or mega) depends on the amount of the value to be represented.

5.5.6 Scaling of temperature

For temperature data only the following units can be selected:

- Degree Celsius (°C)
- Fahrenheit (F)

☞ For temperature data is it only possible to select preferred scaling (predefined scaling)!

	Preferred scaling	
Physical quantity	**Celsius**	**Fahrenheit**
Temperature	0.1 °C	0.1 F

Tab. 5-15: Preferred scalings for temperature data

5.6 Activation of non-return valve

5.6.1 Activation

For some applications it may be necessary to realize a delay when activating or deactivating the drive enable. Parameters S-0-0206, " Drive on delay time" and S-0-0207, " Drive off delay time" are provided for this purpose. The drive enable is only activated or deactivated when the set delay has elapsed.

Parameter P-0-0115 bit 1, "drive ready" indicates that the drive is to be or was stepped up or down.

Drive enable and delay

When the drive enable is set, P-0-0115, bit 14 becomes equal to 1. In addition, bit 1, "drive ready" is set. The **switch-on delay** is started. Only when the delay has elapsed are P-0-0115, bit 7 "Operation mode initialized", and bit 1, "Drive ready", reset, but the drive still remains in **AF**. The **switch-off delay** is started. Only after the delay time elapsed is P-0-0115, bit 14 reset. The drive is in status “drive ready” **(Ab)**.

Switch-on delay

a) Axis in Ab	P-0-0115: 0b10xx.xxxx.0xxx.xx0x
b) Enable on, delay active A4007	P-0-0115: 0b11xx.xxxx.0xxx.xx1x
c) Delay elapsed, axis in AF	P-0-0115: 0b11xx.xxxx.1xxx.xx1x

Switch-off delay

a) Axis in AF	P-0-0115: 0b11xx.xxxx.1xxx.xx1x
b) Enable off → best possible deceleration	P-0-0115: 0b11xx.xxxx.1xxx.xx1x
c) Axis stopped, delay active A4008	P-0-0115: 0b11xx.xxxx.0xxx.xx0x
c) Delay elapsed, axis in Ab	P-0-0115: 0b10xx.xxxx.0xxx.xx0x

Pertinent parameters

- P-0-0115, Device control: Status word

Pertinent diagnostic messages

- S-0-0206, Drive on delay time
- S-0-0207, Drive off delay time
- A4007, "Drive on" delay time
- A4008, "Drive off" delay time

5.7 Actual value acquisition of pump

Actual swivel angle value acquisition

Pilot valve for pump controller (VT-DFPD/HS5E)

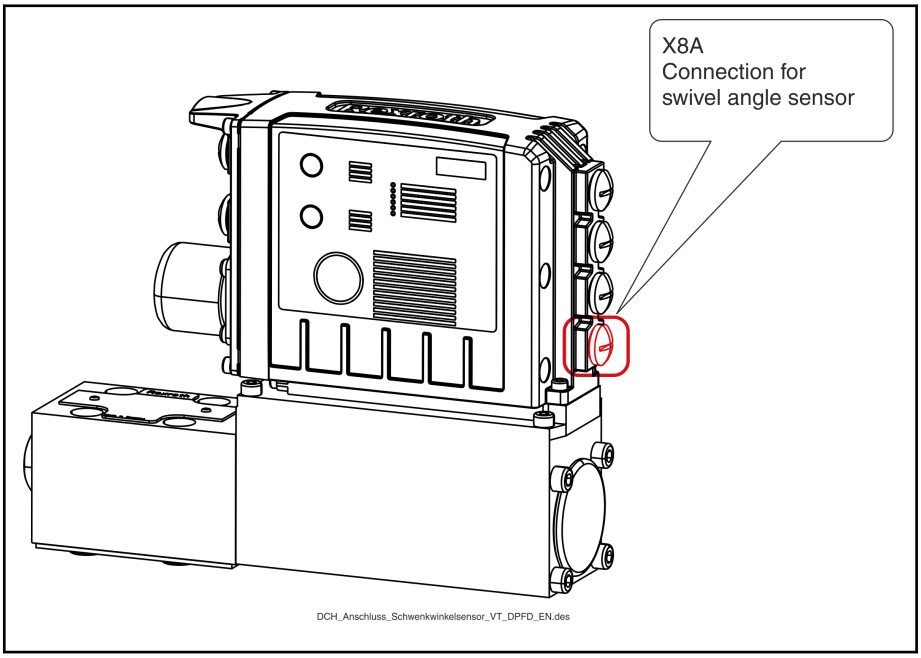


Fig. 5-37: Connection of swivel angle sensor on pilot valve VT-DFPD/HS5E

The swivel angle sensor is read via port X8A. This interface can process signals of max. ±11 Volt. Since the device can be operated in conjunction with different swivel angle sensors, the swivel angle sensor types, that is, their values, have to be configured.

Pilot valve for pump controller (VT-DFPF)

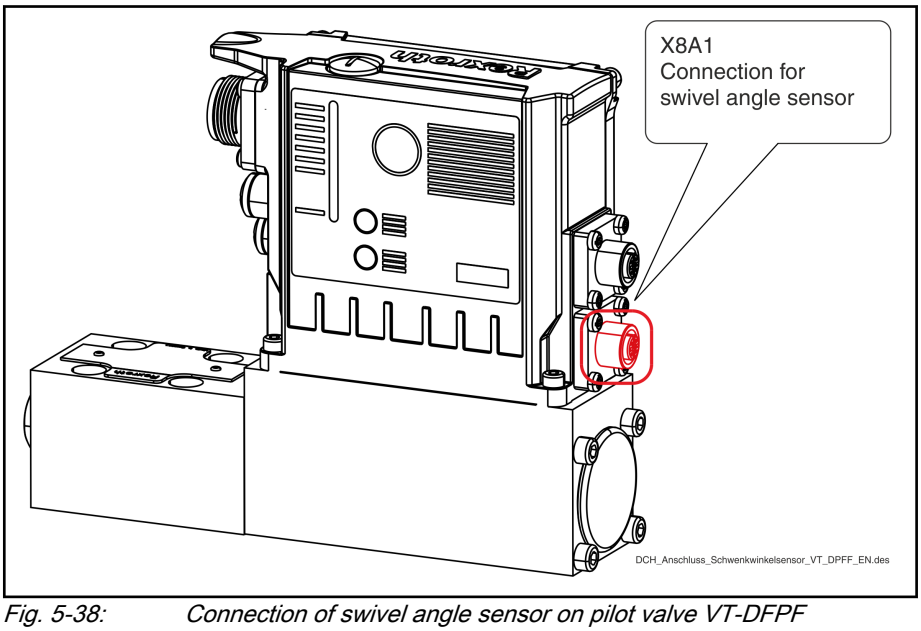


Fig. 5-38: Connection of swivel angle sensor on pilot valve VT-DFPF

With pilot valve VT-DFPF the swivel angle sensor is read at connection X8A1. With this pilot valve, too, the swivel angle sensor types, that is, their values, can be configured.

Control cabinet electronics for pump controller

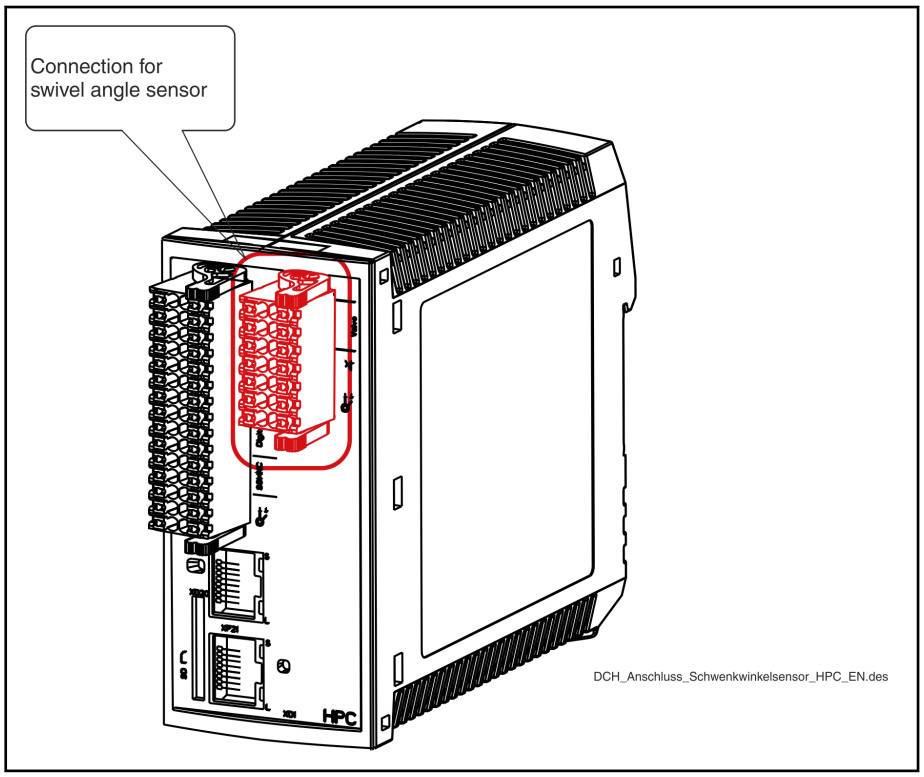


Fig. 5-39: Connection of swivel angle sensor to the control cabinet electronics

The swivel angle sensor is read via connection XG21.

Since the device can be operated in conjunction with different swivel angle sensors, the swivel angle sensor types, that is, their values, have to be configured.

Setting / selection of swivel angle sensor

To configure the swivel angle sensors, either known types can be selected from a list or, alternatively, the parameters can be set manually. By means of parameter "P-0-2948, Selection of swivel angle sensor type", the following sensor types can be selected.

Type (value P-0-2948)	Working voltage range	Level for wire break detection
VT-SWA (1)	2 V to 8 V	< 0.2 V or > 9.8 V
SWS (2)	0.5 V to 4.5 V	< 0.2 V or > 4.8 V
AWAX voltage (3)	2 to 10 V	< 0.2 V
AWAX current (4)	4 to 20 mA	< 2 mA
Manual (0)	Adjustable	Adjustable

Tab. 5-16: Selectable swivel angle sensors

The type that is to be adjusted manually can be freely configured via parameter P-0-2949.

The swivel angle sensors are defined by the following parameters:

- Configuration of swivel angle sensor (no monitoring, positive threshold only, negative threshold only, both thresholds, output of diagnostic message as error or warning)
- Lower working point (for -100 %) in Volt
- Upper working point (for +100 %) in Volt
- Lower threshold for wire break detection in Volt
- Upper threshold for wire break detection in Volt

With predefined sensor types (e.g. VT-SWA) the current values are shown in parameter P-0-2949.0.x. These values cannot be changed! Only if “manual sensor type” has been set can the individual sensor values be configured via parameter P-0-2949.0.x.

For inverting the actual swivel angle value signal, "P-0-2989, Configuration of pump controller" bit 0 and bit 2 are evaluated. Bit 0 indicates the drive motor’s direction of rotation, bit 2 the system/adjustment. The signal for the actual swivel angle value is then inverted according to the following table.

System/pump adjustment (P-0-2989, bit 2)	Direction of rotation (P-0-2989, bit 0)	Inversion of swivel angle actual value
HS5, HS5K, HS5P, HS5KP, HS5M, HS5E	Clockwise	No
	Counter-clockwise	Yes
SY(H)DFED, HS5V, HS5EV	Clockwise	No
	Counter-clockwise	No

Tab. 5-17: Actual swivel angle value

☞ The command “load basic parameters” deletes manual settings for the swivel angle sensor and restores the as-supplied condition.

The actual swivel angle value currently active is shown in parameter "S-0-0882, Swivel angle actual value". The actual swivel angle value can be smoothed via a low-pass filter. The time constant for this filter is set via parameter "P-0-2949.0.8, Filter time of swivel angle feedback value". Moreover, a derivative of the actual swivel angle value is generated. The derivative of the actual swivel angle value can be smoothed via a filter. The time constant for this filter is set via parameter "P-0-2961, Filter time of swivel angle feedback value derivative".

Actual pressure value acquisition

The actual swivel pressure value currently valid is shown in parameter "S-0-0809, Pressure feedback value". For the hydraulic system configuration "operation in the open circuit" and "closed circuit" various configurable actual pressure values are available. The “open” and “closed” circuit modes are configured by means of the “configuration of pump controller” (P-0-2989, bit 1):

Operation in the open circuit:

- Pressure feedback value 1, P-0-2940
- Pressure feedback value 2, P-0-2941

Operation in the closed circuit:

- Pressure feedback value A, S-0-0803 (pressure in port A of the pump)
- Pressure feedback value B, S-0-0804 (pressure in port B of the pump)

Pressure pulsation damping

Filtering the actual pressure values and their derivatives is required to keep faults arising from pressure pulsation of the pump to a minimum. In some cases, this pulsation can be aggravated due to unfavorable hose/tube lengths.

The actual pressure values are acquired via the analog inputs in the base clock cycle. The parameters "P-0-2960, Gate time derivation actual pressure value 1 or A" and "P-0-2979, Gate time derivation actual pressure value 2 or B" can be adjusted in 0.1-ms increments.

With the help of the time difference (gate time) that can be set by means of parameters, an optimum suppression of pressure pulsations can be achieved in the derivative of the actual pressure value:

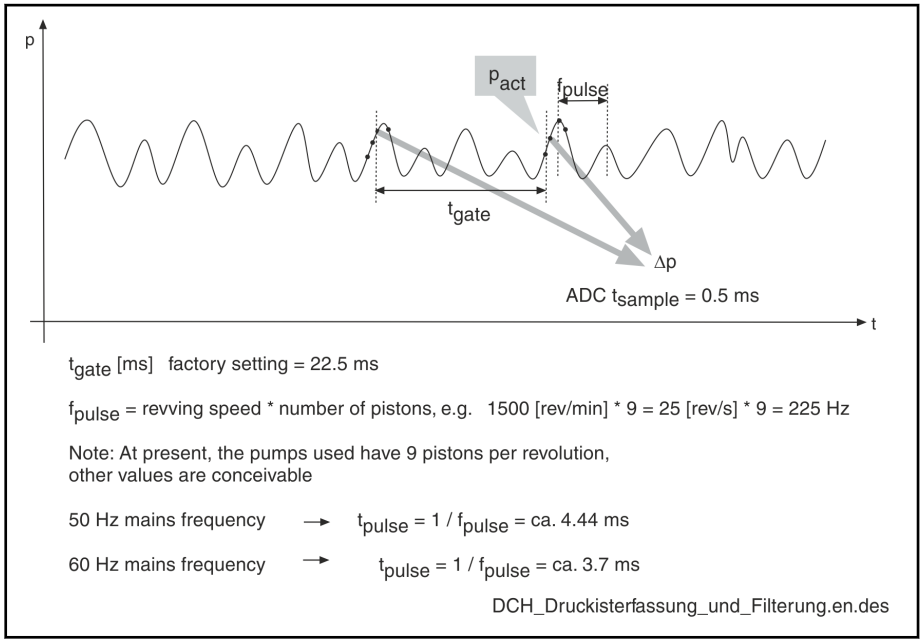


Fig. 5-40: Actual pressure value acquisition and filtering

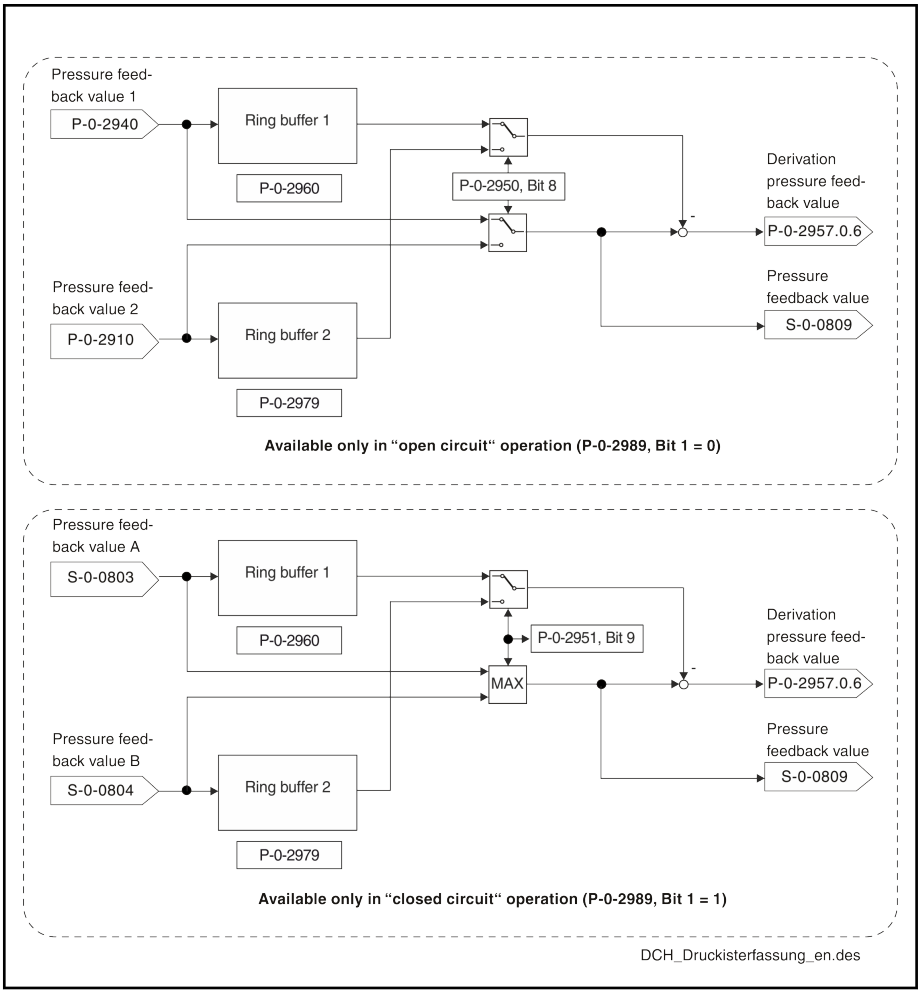


Fig. 5-41: Actual pressure value acquisition

Switching between two pressure sensors in the open circuit

Pressure control can optionally also be realized with 2 pressure sensors. Depending on the current controller strategy, the actual pressure for controlling is established by one of the two pressure sensors.

The two pressure sensors are arranged at different locations within the hydraulic system. One pressure sensor is, for example, installed near the pump, another sensor close to the actuator. The sensor that suits the current requirements is selected for pressure control.

The currently active actual pressure values are shown in parameters "P-0-2940, Pressure feedback value 1", and "P-0-2941, Pressure feedback value 2".

The selection of "pressure feedback value 1" or "pressure feedback value 2" is made with bit 8 of parameter "P-0-2950, Pump controller control word". The actual pressure value active for the controller is shown in parameter "S-0-0809, Pressure feedback value". The currently active pressure sensor is shown in parameter "P-0-2951 bit 3, Pump controller status word". The assignment “pressure feedback value 1” is already made in the basic configuration (as-supplied condition), but can be changed by the user. For operation in the open circuit, the assignment to "pressure feedback value 1" is obligatory. During commissioning the user has to check, whether the assignment has been correctly configured and a pressure sensor is connected to the relevant input.

Changing over to "pressure feedback value 2" can only take place while the controller is enabled. A precondition is that the assignment "pressure feedback value 2" has been configured. Otherwise, "pressure feedback value 1" remains selected (is displayed in the status word) and a warning (E2291) is generated.

Selection from two pressure sensors in the closed circuit

For the closed circuit, two measured pressure values are obligatory. The pressure in pump port B is displayed by pressure feedback value B (S-0-0804). The pressure in pump port A is shown by pressure feedback value A (S-0-0803). To determine the actual pressure value valid for the control, pressure feedback value A is compared to pressure feedback value B and the higher of both is used.

Pertinent parameters

- P-0-2940, Pressure feedback value 1
- P-0-2941, Pressure feedback value 2
- P-0-2948, Selection of swivel angle sensor type
- P-0-2949.0.1, Swivel angle sensor configuration
- P-0-2949.0.2, Swivel angle sensor, lower working point
- P-0-2949.0.3, Swivel angle sensor, upper working point
- P-0-2949.0.4, Swivel angle sensor wire rupture, lower threshold
- P-0-2949.0.5, Swivel angle sensor wire rupture, upper threshold
- P-0-2949.0.6, Swivel angle sensor wire rupture, timeout
- P-0-2949.0.7, Analog input of swivel angle feedback value
- P-0-2949.0.8, Filter time of swivel angle feedback value
- P-0-2951, Pump controller status word
- P-0-2960, Gate time derivation actual pressure value 1 or A
- P-0-2961, Filter time of swivel angle feedback value derivative
- P-0-2979, Gate time derivation actual pressure value 2 or B
- P-0-2989, Configuration of pump controller

Pertinent diagnostic messages

- E2280 Warning: Wire rupture of swivel angle sensor
- E2291 No assignment of actual pressure value 2
- F2280 Error wire rupture of swivel angle sensor

5.8 Calibration functions of pump

5.8.1 General information

To ensure the quality of pressure and swivel angle control, various calibration functions are implemented in the pump electronics:

1. Calibration of pressure sensor offset (sensor for pressure feedback value 1 or 2)
2. Calibration of pressure sensor A offset
3. Calibration of pressure sensor B offset
4. Pressure-related valve calibration (valve zero point)
5. Calibration of swivel angle offset (zero point)
6. Calibration of swivel angle factor (+100 %)
7. Leakage calibration
8. Calibration of swivel angle sensor of A10 slave pump
9. Calibration of swivel angle sensor of A4 slave pump

☞ It is recommended that the calibrations be carried out in the order given above during commissioning, when sensors are changed, and at regular intervals. Calibration functions 8 and 9 are required for the slave pump in master/slave systems. Generally, calibrations improve the precision of the system. Nevertheless, the system also works properly without any calibration. When the calibration is to be started, the parameters for the pump controller must have been configured and the optimization of controller parameters must have been completed.

With the help of parameter "P-0-2991, Calibration command control word" the calibration function is selected (bit 0-3 → selection of calibration function, bit 4-15 → reserved):

Number	Description / selection of calibration function
0	Calibration of pressure sensor offset (sensor for pressure feedback value 1 or 2)
1	Pressure-related valve calibration (valve zero point)
2	Calibration of swivel angle offset (zero point)
3	Calibration of swivel angle factor (+100 %)
4	Leakage calibration
5	Calibration of pressure sensor A offset
6	Calibration of pressure sensor B offset
7	Calibration of swivel angle sensor of A10 slave pump
8	Calibration of swivel angle sensor of A4 slave pump
15	Writing default values to the calibration values!

Tab. 5-18: Assignment P-0-2991

The selected calibration function is started with the drive control command C7900 via parameter "P-0-2991, Calibration command control word". The command can also be executed while the control is deactivated.

⚠ WARNING **Uncontrolled machine movements due to internal command values during calibration**

While calibrating, internal command values are used for the controller. The calibration function has no influence on the command values (S-parameters) pre-set by the machine control. However, these command values are not used while a calibration is running. Before the calibration function is started, the system must therefore be brought to a safe state for calibrating.

5.8.2 Abortion of calibration

A running calibration function is aborted in the case of:

- an error of class F2xxx or higher of the drive (cable break, voltage monitoring, etc.)
- an error that occurred during the calibration process (command value not reached, value outside tolerance, etc.)
- withdrawal of enable (with the exception of pressure offset calibration)

Generally, the following is valid when the calibration is aborted (e.g. by an error):

The calibration process is aborted and a command error is generated. The command itself remains active. The internal command values are valid ("P-0-2975, Pressure command value (without controller enable)", "P-0-2976, Swivel angle command value (without controller enable)"). Only when the calibration command is completed is the last operation mode activated. Then, the current command values are valid.

5.8.3 Calibration of pressure sensor offset

With this calibration, the offset value of the active pressure sensor (pressure feedback value 1 or 2, or A or B, respectively) is acquired and compensated. The active pressure sensor in "open circuit" operation (pressure feedback value 1 or 2) is selected via P-0-2950, Pump controller control word, bit 8. This calibration is used to calibrate the offset of the respective assignment.

Prerequisite:

- Pump drive motor OFF
- Pressure sensors must be “pressureless” (system unloaded)

The calibration is independent of the current drive status and can be carried out also without controller enable. The actual pressure value that is obtained is averaged over a given time and taken as new offset.

Calibration abortion:

Abortion criterion	Message	Note
Established offset > 10 bar	C7902	Original offset is maintained
No assignment available for actual pressure value.	C7915	-

Tab. 5-19: Abortion criterion for pressure sensor offset calibration

5.8.4 Pressure-related valve calibration (valve zero point)

This calibration serves to compensate for the pressure-related valve zero point drift.

Prerequisite:

- Pump drive motor ON
- All consumers disconnected from the pump (i.e. no oil flow and no oil consumption)
- Controller enable active (otherwise, command error C7901)

During the calibration process, the pump operates in pressure control with the pressure command values (pressure levels) preset in P-0-2981. The pressure ratings (maximum of 8 calibration pressure ratings in P-0-2981) are approached over a firmly set ramp (100 bar/s).

The valve command values established for every pressure rating are summed up over a given time (the time of P-0-2947.0.12) and stored as valve offset value in "P-0-2982, Valve correction pressure offset".

☞ The calibration should be carried out with the parallel structure, since in the cascade structure the valve zero point drifts are compensated for by the integrator.

Calibration abortion:

Abortion criterion	Message	Note
Calibration value > +-20 %	C7903	Original calibration values are maintained
Pressure control difference > +-5 bar	C7904	Original calibration values are maintained

Tab. 5-20: Abortion criteria for pressure-related valve calibration (valve zero point)

5.8.5 Calibration of swivel angle offset (zero point)

This calibration is used to calibrate the offset of the swivel angle sensor.

Prerequisite:

- Pump drive motor ON
- All consumers disconnected from the pump (i.e. no oil flow and no oil consumption)
- Controller enable active (otherwise, command error C7901)

During the calibration process, the pump operates in the closed-loop pressure control mode with a reference pressure that corresponds to parameter "P-0-2947.0.16, Reference pressure for pump controller calibration". After successful calibration, the established swivel angle zero point (correction value) can be found in parameter "P-0-2994, Established calibration swivel angle zero point"!

Calibration abortion:

Abortion criterion	Message	Note
Calibration value > +20 %	C7905	Original offset is maintained
(Actual pressure value < 12 bar) or (actual pressure value > 28 bar)	C7906	Original offset is maintained

Tab. 5-21: Abortion criteria for calibration of swivel angle offset (zero point)

☞ In rare applications it may happen that the pump is operated exclusively in swivel angle control and that no pressure sensor is installed. In order to be able to calibrate the swivel angle sensor in these cases, the calibration function for the swivel angle sensor of the A4 or A10 slave pump may be used.

5.8.6 Calibration of swivel angle factor (+100 %)

This calibration function is used to calibrate the factor of the swivel angle sensor.

Prerequisite:

- Pump drive motor ON
- Direct full flow through an actuator (e.g. open unloading valve to the tank)
- Controller enable active (otherwise, command error C7901)

During the calibration process the valve of the pump is activated with a fixed valve command value. During this, the actual pressure value is monitored.

The factor for the calibration value is established on the basis of the current swivel angle. If the established factor is outside the allowed range, message C7908 is generated. After successful calibration, the established swivel angle

factor (correction value) can be found in parameter "P-0-2995, Established calibration swivel angle factor"!

Calibration abortion:

Abortion criterion	Message	Note
Actual pressure value > 80 bar	C7907	Original offset is maintained
Swivel angle factor outside 0.5 - 2	C7908	Original offset is maintained

Tab. 5-22: Abortion criteria for calibration of swivel angle factor (+100 %)

☞ In rare applications it may happen that the pump is operated exclusively in swivel angle control and that no pressure sensor is installed. In order to be able to calibrate the swivel angle sensor in these cases, the calibration function for the swivel angle sensor of the A4 or A10 slave pump may be used.

5.8.7 Leakage calibration

The swivel angle controller offers the possibility of compensating for pump leakage. To this end, an offset value that corresponds to the leakage is added to the swivel angle command value.

Prerequisite:

- Pump drive motor ON
- All consumers disconnected from the pump (i.e. no oil flow and no oil consumption)
- Controller enable active (otherwise, command error C7901)

During the calibration process, the pump operates in pressure control with the pressure command value preset in "P-0-2996, Pressure command value for leakage calibration". When the calibration is carried out, the reference pressure (P-0-2947.0.16) is approached first, then pressure level 2 (P-0-2996). The actual swivel angle value is averaged over a defined time and saved for both pressure levels. On the basis of these values the leakage offset value is calculated.

Calibration abortion:

Abortion criterion	Message	Note
Leakage offset value > +-30 %	C7909	The original calibration is maintained
Pressure control difference > +-10 bar	C7910	The original calibration is maintained
With 2nd pressure rating: Deviation of actual pressure value +-10 bar	C7911	The original calibration is maintained

Tab. 5-23: Abortion criteria for leakage calibration

5.8.8 Calibration of swivel angle sensor of A10 slave pump and calibration of swivel angle sensor of A4 slave pump

This function is used to calibrate the swivel angle sensor (offset & factor) of the slave pump in a master/slave system.

☞ This calibration function can also be used for single pumps to which no pressure sensor is connected and which are therefore merely operated in swivel angle control. In this case this calibration can be used as an alternative to the calibration of the swivel angle offset (zero point) and calibration of the swivel angle factor (+100 %).

Prerequisite:

- Pump drive motor ON
- Direct full flow through an actuator (e.g. open unloading valve to the tank)
- Controller enable active (otherwise, command error C7901)

⚠ WARNING **Hazard due to missing pressure monitoring function with maximum flow!**

During calibrating the pump changes over to maximum displacement. While doing so, the pressure is not monitored. For this reason, make sure beforehand that the complete flow can be displaced and, at the same time, the pressure remains within the permissible pressure range.

During the calibration process the valve of the pump is activated with a fixed valve command value.

During this calibration the offset value and the factor for the swivel angle sensor are established. If the value for the swivel angle offset is outside the valid range, message C7916 is generated.

Calibration abortion:

Abortion criterion	Message	Note
Calibration value of swivel angle offset > +/- 20 %	C7916	The original offset and factor are maintained

Tab. 5-24: Abortion criteria for the calibration of the swivel angle sensor

5.8.9 Commissioning, parameters, diagnostic and status messages

After the basic parameters were loaded, the following calibration default values are valid:

Calibration function	Default value
Pressure sensor offset	0
Valve offset values	0
Swivel angle sensor offset	0
Swivel angle sensor factor	1
Leakage compensation calibration value	9 % (see P-0-2961)

Tab. 5-25:

Pertinent parameters

- P-0-2942, Calibration history
- P-0-2947.0.1, Max. allowed pressure sensor offset calibration value
- P-0-2947.0.2, Max. allowed valve offset calibration value (amount)

- P-0-2947.0.3, Max. allowed pressure ctrl. diff. for valve offset calibr.
- P-0-2947.0.4, Max. swivel angle sensor zero point corrective value
- P-0-2947.0.5, Max. allowed pressure ctrl. diff. for SWA offset calibration
- P-0-2947.0.6, Valve comm. value for swivel angle factor calibration
- P-0-2947.0.7, Min. allowed swivel angle sensor factor
- P-0-2947.0.8, Max. allowed swivel angle sensor factor
- P-0-2947.0.9, Max. allowed act. pressure value for SWA factor calibration
- P-0-2947.0.10, Max. allowed leakage offset
- P-0-2947.0.11, Max. allowed pressure differential for leakage calibration
- P-0-2947.0.12, Calibration time
- P-0-2947.0.13, Min. time for control error detection
- P-0-2947.0.14, Threshold value controller deviation detection
- P-0-2947.0.15, Valve error detection time
- P-0-2947.0.16, Reference pressure for pump controller calibration
- P-0-2947.0.17, Default swivel angle factor - slave pump calibration
- P-0-2990, C79xx Calibration command parameter
- P-0-2991, Calibration command control word
- P-0-2994, Established calibration swivel angle zero point
- P-0-2995, Established calibration swivel angle factor
- P-0-2996, Pressure command value for leakage calibration

Pertinent diagnostic messages

- C7900, Start selected calibration command
- C7901, No drive enable
- C7902, Pressure sensor offset value too high
- C7903, Calibration value too high for valve calibration
- C7904, Pressure ctrl differential too high during valve calibration
- C7905, Swivel angle zero point too great
- C7906, Pressure feedback value invalid during calibration
- C7907, Pressure feedback value too high during calibration
- C7908, Swivel angle factor invalid
- C7909, Leakage too high for calibration
- C7910, Pressure differential too high during leakage calibration
- C7911, Pressure level not reached during leakage calibration
- C7912, Error message present during calibration
- C7913, Error during calibration, external command active
- C7914, Calibration control word contains invalid bit combination
- C7915, No assignment of actual pressure value
- C7916, Swivel angle zero point of slave pump too large

6 Operation modes

6.1 General information on the operation modes

6.1.1 Supported operation modes

The selection of operation modes defines, which command values will be processed in which way and how the controller structure of the drive controller looks like. The operation mode does not determine how the command values are transmitted from the master to the drive.

One of the eight operation modes that are defined in parameters is always active if the conditions below are fulfilled:

- Control section is ready for operation
- Controller enable signal sees a positive edge
- Drive follows command value input
- "Drive Halt" function has not been activated
- No drive control command active
- No error reaction is carried out

An overview of the operation modes supported per device is given in chapter "Overview of devices".

☞ The operation modes supported by the firmware depend on the hardware and firmware and are contained in parameter "S-0-0292, List of supported operation modes".

6.1.2 Operation mode handling

Operation mode selection

Up to 8 different operation modes can be configured in the drive (depending on "S-0-0292, List of supported operation modes"). Assignment and configuration are made using the following parameters:

- S-0-0032, Primary operation mode
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

☞ If the value "0" was entered in one of these parameters, the error message "F6007 Switching to non-initialized operation mode" is generated when this operation mode is activated.

Activation of operation mode

The operation mode is activated and controlled using the entries in the drive control words, which depend on the master communication type:

- S-0-0134, Master control word
- P-0-4077, Field bus: Control word
- P-0-4068, Field bus: Control word IO

- P-0-4028, Device control word
- P-0-0120, Control word easy startup

8 additional internal operation modes (internally firmly configured) are available for the provision of commands to the axis by the integrated control MLD as well as for use by the easy startup mode. It is possible to switch between these operation modes during operation.

The effective specification is shown in bits 8, 9, 11, and 12 of parameter "P-0-0116, Device control: Control word".

The following is valid for parameter P-0-0116:

- Bits 8 and 9 → selection of primary operation mode and secondary operation modes 1 to 3
- Bit 11 → selection of secondary operation modes 4 to 7 (Sercos only)



The secondary operation modes 4 to 7 can only be utilized over Sercos interface. For this reason, bit 11 is only effective in conjunction with parameter S-0-0134 (master control word with Sercos) in the control word of the device control (P-0-0116)!

The figure below illustrates the interrelation between the control word of the respective master communication and the device control word/device status word with regard to the operation mode selection.

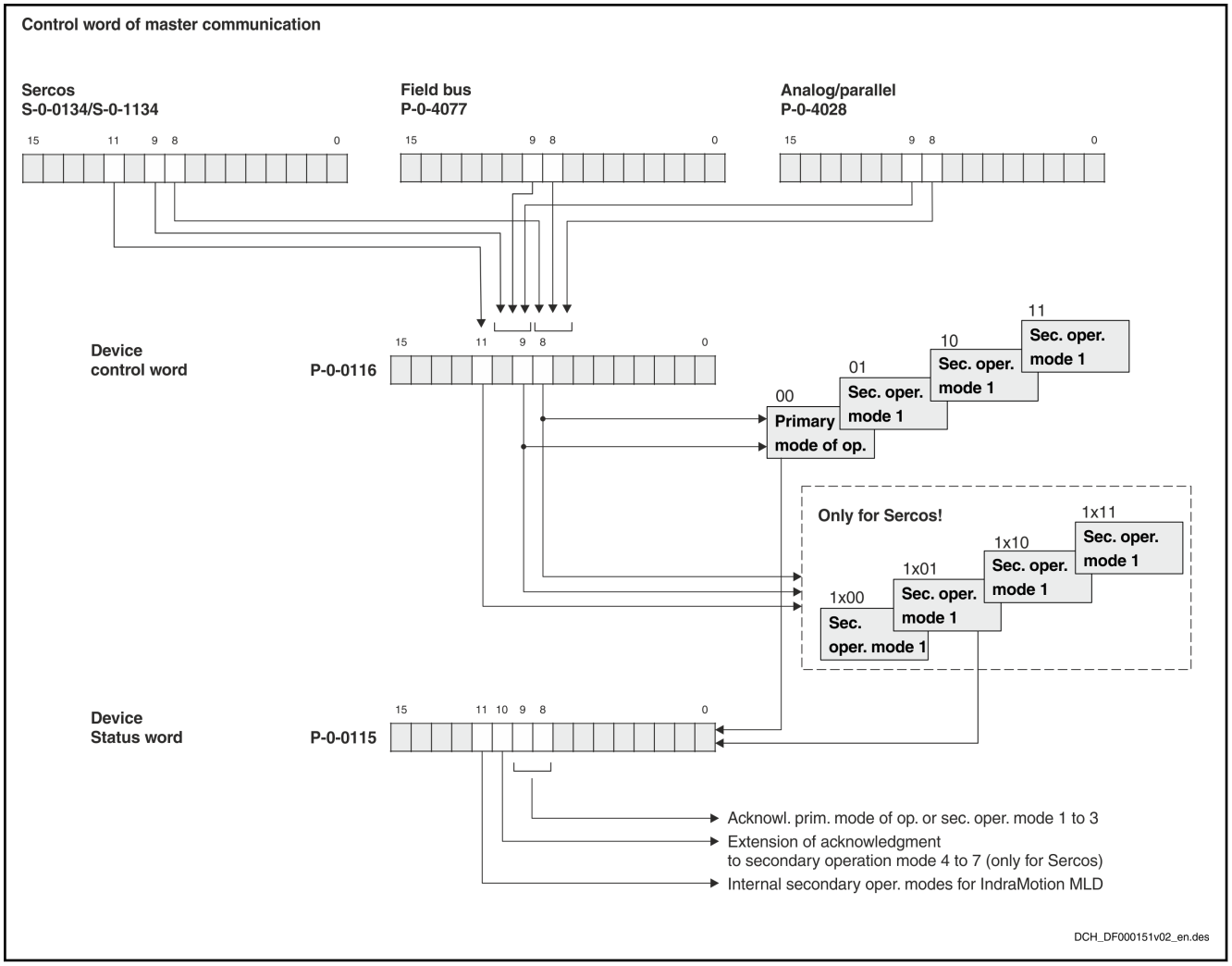


Fig. 6-1: Operation mode selection via control word

The control bits (8 and 9) in parameter P-0-0116 are also contained in the control words that are dependent on master communication (cf. S-0-0134, P-0-4077, P-0-4068 and P-0-4028) and can consequently also be handled in these control words.

An operation mode determined via the operation mode selection is active when:

- the drive (control section and power section) is ready for operation

- and -

- the controller enable signal sees a positive edge.

Acknowledging the active operation mode

In conjunction with the activation of an operation mode, the following feedback is given:

- Parameter "S-0-0390, Diagnostic message number" shows the associated diagnostic message number of the active operation mode (e.g., "A0101" in the "(open/closed-loop) velocity control" mode).
- Parameter "S-0-0095, Diagnostic message" shows the active mode of operation in text form (e.g., "A0101 (Open/closed-loop) velocity control").

- In parameter "P-0-0115, Device control: Status word", bit 3 ("drive follows external command values") is used to acknowledge whether or not the drive is operating in the preset operation mode.
- In parameter "P-0-0115, Device control: Status word", bits 8, 9, and 10 ("acknowledgment of operation mode") are used to indicate the operation mode currently active.

☞ The status bits (3, 8, 9, and 10) in parameter P-0-0115 are also contained in the status words (S-0-0135, P-0-4078) that are dependent on master communication and can consequently also be read out from there. Bit 10 is, however, only provided in conjunction with Sercos interface!

Changing the operation mode

When the controller enable of the drive is activated and after the initialization routines were run, the drive changes over to the operation mode selected via bit 8 and 9 of the specific control word of the relevant master communication (S-0-0134, P-0-4077, P-0-4068, P-0-4028 or P-0-0116).

☞ The change of operation mode is accomplished within a position controller clock cycle. Before the command values of the activated operation mode become effective, a further position controller cycle is run, because the operation mode has to be initialized first.

Special cases

Under the following **exceptional circumstances**, the desired operation mode is not carried out in spite of the operation mode having been correctly selected:

- **Drive error** is present
  → The associated error reaction is run.
- **Fatal warning** was triggered
  → The associated reaction is run.
- Execution of a "**drive command**" (e.g. homing, set absolute position, ...)
  → The started command is being executed.
- **Drive Halt**
  → This drive function is being executed.

Drive-controlled change of operation mode

In order to achieve a quick and smooth change of operation mode in running operation, it is possible to make a "drive-controlled change of operation mode". Drive-internally this procedure ensures that, when the operation mode is changed, the transition is carried out in a synchronized, i.e. jerk-free way, even if the command value changes abruptly.

Command value acceptance and acknowledgment

Immediate command value acceptance

The specified command value is accepted directly when the relevant command value parameter (e.g., S-0-0036, S-0-0080, S-0-0258, …) is written in the following operation modes:

- Direct valve control
- (Open/closed-loop) flow control
- Closed-loop pressure control
- Closed-loop swivel angle control
- Torque/force control
- (Open/closed-loop) velocity control

- Closed-loop position control with cyclic command value provision
- Drive-internal interpolation

Command value acceptance after master request

In the **positioning modes** (drive-controlled positioning, positioning block mode), however, the command value (target position, velocity, positioning block, ...) is only accepted, when the master explicitly requests this by a "command value acceptance".

The command value acceptance is carried out in different ways, according to the positioning mode or profile type:

- "Drive-controlled positioning" mode

  Acceptance of the given command value (position, velocity) by toggling bit 0 of parameter "S-0-0346, Positioning control word"

  → **Toggle mechanism**

- "Positioning block mode"

  The positioning block selected via "P-0-4026, Positioning block selection" is accepted via a positive edge of bit 0 of parameter "P-0-4060, Positioning block control word", if the parallel interface is used as master communication or, in the case of field buses, the I/O mode.

  → **Edge control**



When the positioning block mode is used with field buses in the freely configurable operation mode (P-0-4084 = 0xFFFE) or with Sercos interface, the toggle mechanism is applied as well **contrarily to the above rule**.

Command value acknowledgment

The explicit acknowledgment of the command value acceptance only takes place for the positioning modes (drive-controlled positioning, positioning block mode).

It is possible to check in the master whether and when the preset command value was accepted in the drive (command value acceptance handshake).

The command value is acknowledged in different ways depending on the positioning mode:

- "Drive-controlled positioning" mode

  The drive acknowledges the command value acceptance by toggling bit 0 of parameter "S-0-0419, Positioning command acknowledge".

- "Positioning block mode"

  The drive acknowledges the command value acceptance by displaying the effective positioning block in parameter "P-0-4051, Positioning block acknowledgment".



In the positioning block mode, too, the acceptance of a new positioning block results in toggling of bit 0 of parameter S-0-0419, because here, the positioning command value is processed in an identical way as in the operation mode "drive-controlled positioning".

6.1.3 Starting value upon change of operation mode

General information

As of firmware release HDx20V16, for a change of operation mode (e.g. from velocity to position) a selection can be made via bit 8 in "P-0-0556, Config

word of axis controller", whether the starting value after the transition is to be the actual value or the command value:

- Bit 8 = 0: Starting value is actual value
- Bit 8 = 1: Starting value is command value

In firmware releases before HDx20V16 this setting option was not provided, and in the case of a change of operation mode, the new mode always started on the basis of the actual values. As of firmware version HDx20V16, the command values are active (bit 8 = 1) as starting values by default after basic parameters are loaded.

Actual values as starting values

In order to prevent or minimize a velocity step-change when switching operation modes, the generator starts with actual values (position, velocity) at present. This was realized with the objective of keeping the (valve) control variable constant, thus preventing a step-change in the control variable. To this end, the position command value is calculated from the current control variable so as to ensure that no step-change occurs in the control variable at the moment of switching over. The current actual velocity is taken as new command velocity.

For changing to a position operation mode, the following procedure is valid:

- The integrator in the velocity controller is always cleared
- The current value in the state feedback is taken into account when calculating the command value or the control variable
- Feedforward control is subtracted from the actuating signal. This results in the actuating signal of the position controller.
- Position fine positioning active:

  If the previous operation mode was no position mode, the fine positioning integrator receives the remaining actuating signal at standstill and the Kv component is set to zero.

  Position fine positioning inactive:

  If the previous operation mode was no position mode, the remaining actuating signal is completely included in the Kv component.
- If, however, the previous operation mode was a position mode, the fine positioning integrator remains unchanged. The Kv component is calculated from the actuating signal minus the fine positioning I-component.
- On the basis of the calculated Kv component and the current actual position value the new position command value is determined, at which the position generator starts.

Force command values are generally not calculated for alternating control. Force command values (S-0-0550 Positive / S-0-0551 Negative) are applied directly as command values for alternating control. The table below shows, which actual values are used as starting values with the various changes of operation modes.

Old operation mode	New operation mode	Starting value is actual value
Direct valve control	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{act}$ Control variable is maintained
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{act}$ $S_{comm} = S_{act}$ + control variable
Force	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{act}$ Control variable is maintained
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{act}$ $S_{comm} = S_{act}$ + control variable
Velocity	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{act}$
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{act}$ $S_{comm} = S_{act}$ + control variable
Position (including alternating control)	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{act}$ Control variable is maintained
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{act}$ $S_{comm} = S_{act}$ + control variable

v	Velocity
S	Position
F	Force
F_{comm}	Force command value P-0-0069
F_{act}	Force feedback value S-0-0552
Valve control variable	(P-0-2873.0.16)
v_{com}	Command velocity
v_{act}	S-0-0535
$S_{comm} = S_{act}$ + control variable	The new position command is generated from the actual position value plus the current control variable. The control variable virtually corresponds to v_{act} (actual velocity)!
S_{act}	Actual position value
Control variable is maintained	At the moment of switching over, the current control variable is maintained since the new

	command value is the old actual value (e.g. no change in velocity -> v = const.)

Tab. 6-1: Actual values as starting values

Starting value is command value

In contrast to the principle of using actual values as starting values, with command values as starting values, the existing command values are applied without any modification (see table below). This helps to avoid minor inaccuracies in the new position command value or the command velocity that result from the encoder resolution or rounding errors and can occur when using actual values as starting values.

On the other hand, jumps (-> instabilities) in the control variable have to be accepted when, upon changing of the operation mode, the new operation starts with unchanged command values. These jumps can occur in conjunction with changeovers from one position operation mode to another position operation mode.

Old operation mode	New operation mode	Starting value is command value
Direct valve control	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{act}$
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{comm}$ $S_{comm} = S_{act}$ + control variable
Force	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{comm}$
	Velocity	$v_{comm} = v_{act}$
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{comm}$ $S_{comm} = S_{act}$ + control variable
Velocity	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{comm}$
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{comm}$ $S_{comm} = S_{act}$ + control variable
Position (including alternating control)	Direct valve control	Valve control variable
	Force	$F_{comm} = F_{act}$
	Velocity	$v_{comm} = v_{comm}$
	Position (including alternating control) Drive Halt (AH)	$v_{comm} = v_{comm}$ $S_{comm} = S_{comm}$ (Step-change in control variable possible)

Tab. 6-2: Command values as starting values

Change from velocity operation mode to position operation mode

If, with a command value strategy selected (transition and start with command values), a velocity operation mode is to be switched to a position operation mode, then the position command value is started at a value with which the valve control value is maintained (as with starting with actual values). In other words: The new position value is calculated taking account of feedforward control, Kv component and, if applicable, I-component so that the previous command velocity is maintained.

Pertinent parameters

- P-0-0556, Config word of axis controller

6.2 Direct valve control

6.2.1 Brief description

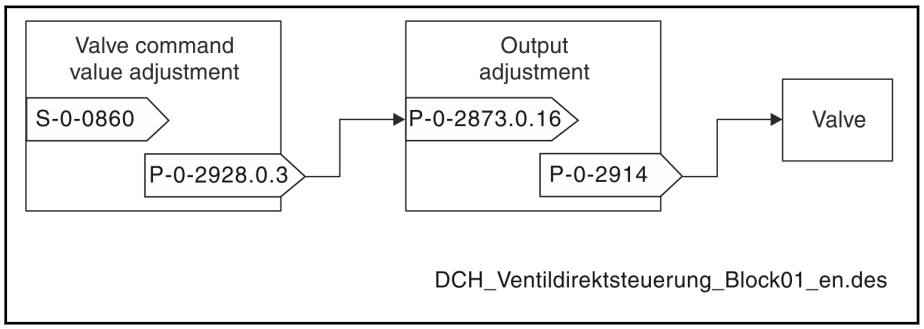


Fig. 6-2: Block diagram "direct valve control"

In the "direct valve control" mode, a valve command value is preset for the drive. If required, this value can be directed via a ramp.

Features

- Output of the sum of the command values preset in parameters "S-0-0860, Spool command value" and "S-0-0861, Spool command value additive"
- Optional bypassing of output adjustment using "P-0-2928.0.1 Valve command value control word bit 1"
- To avoid step-like changes, the command value can be led via a simple ramp or a 4-quadrant ramp, which can be changed over by "P-0-2928.0.1 Valve command value control word", bit 0.

6.2.2 Command value adjustment for direct valve control

Block diagram

The graphic below illustrates command value adjustment in the "direct valve control" mode as a block diagram.

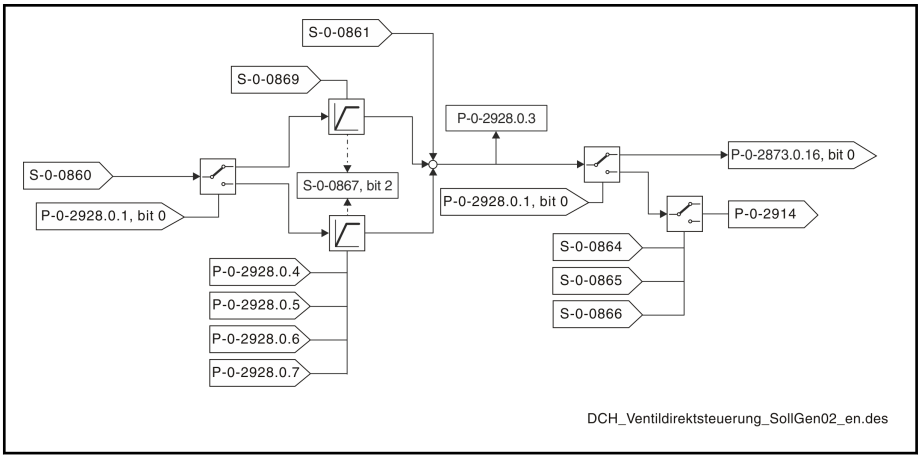


Fig. 6-3: Command value adjustment for direct valve control

Command value ramp

The command value provided by "S-0-0860, Spool command value" is fed via a ramp to prevent step-like changes. The ramp can either be a simple ramp or a 4-quadrant ramp. Switching between these two options is possible by means of parameter "P-0-2928.0.1, Valve command value control word" bit 0.

The simple ramp is determined by "S-0-0869, Spool ramp time".

The 4-quadrant ramp is determined by

"P-0-2928.0.4 Valve command value ramp time positive, acceleration"

"P-0-2928.0.5 Valve command value ramp time positive, deceleration"

"P-0-2928.0.6 Valve command value ramp time negative, acceleration"

"P-0-2928.0.7 Valve command value ramp time negative, deceleration".

Additive valve command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0861, Spool command value additive". If required, this value can also be cyclically configured.

Output variable

The output variable of command value adjustment for direct valve control is "P-0-2928.0.3, Output of valve command value generator".

The output variable can now optionally be output via output adjustment or directly to the valve. This can be set in "P-0-2928.0.1, Valve command value control word" bit 1.

6.2.3 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "direct valve control" mode is indicated by the following diagnostic message:

"A0158, Direct valve control"

6.2.4 Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-2928.0.1, Valve command value control word
- P-0-2928.0.3, Output of valve command value generator
- P-0-2928.0.4, Valve command value ramp time positive, acceleration
- P-0-2928.0.5, Valve command value ramp time positive, deceleration
- P-0-2928.0.6, Valve command value ramp time negative, acceleration
- P-0-2928.0.7, Valve command value ramp time negative, deceleration
- S-0-0860, Spool command value
- S-0-0861, Spool command value additive

- S-0-0867, Spool status word
- S-0-0869, Spool ramp time

6.3 Closed-loop torque/force control / direct valve control

6.3.1 Brief description

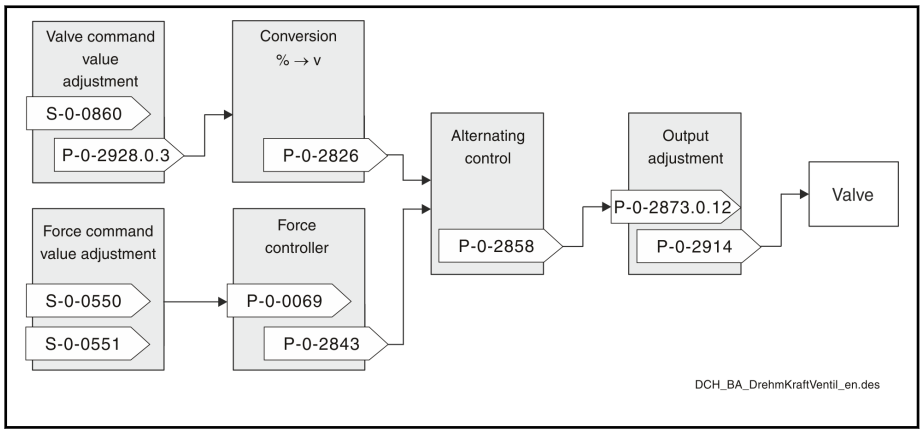


Fig. 6-4: Overview of operation mode of closed-loop torque/force control / direct valve control

In the "closed-loop torque/force control / direct valve control" mode, a valve command value and a positive/negative torque/force command value are provided for the drive. If required, these command values can be directed via a ramp generator. In this operation mode, alternating control can be activated. The alternating control ensures changing over to closed-loop force control as soon as the set changeover condition is fulfilled.

Features

- Command value generators for valve and torque/force
- Alternating control can be used
- Use of output adjustment

6.3.2 Valve command value adjustment

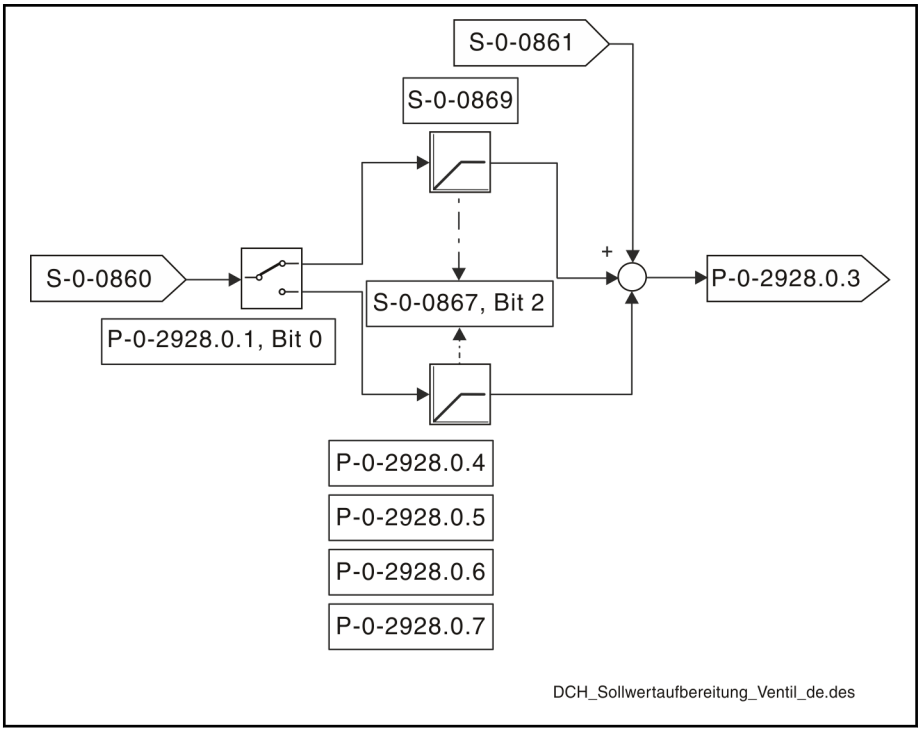


Fig. 6-5: Valve command value adjustment

Command value ramp

The command value preset in "S-0-0860, Spool command value" can be fed via a ramp to prevent step-like changes. This can either be a simple ramp or the 4-quadrant ramp. Switching between these two options is possible using parameter "P-0-2928.0.1, Valve command value control word" bit 0.

The simple ramp is determined by "S-0-0869, Spool ramp time".

The 4-quadrant ramp is determined by

"P-0-2928.0.4 Valve command value ramp time positive, acceleration"

"P-0-2928.0.5 Valve command value ramp time positive, deceleration"

"P-0-2928.0.6 Valve command value ramp time negative, acceleration"

"P-0-2928.0.7 Valve command value ramp time negative, deceleration".

Additive valve command value

In addition, it is possible to feed forward an unfiltered additive command value via "S-0-0861, Spool command value additive". If required, this value can also be cyclically configured.

Output variable

The output variable of command value adjustment for direct valve control is "P-0-2928.0.3, Output of valve command value generator". This value is converted with the help of valve standard velocity into a velocity.

6.3.3 Force command value adjustment

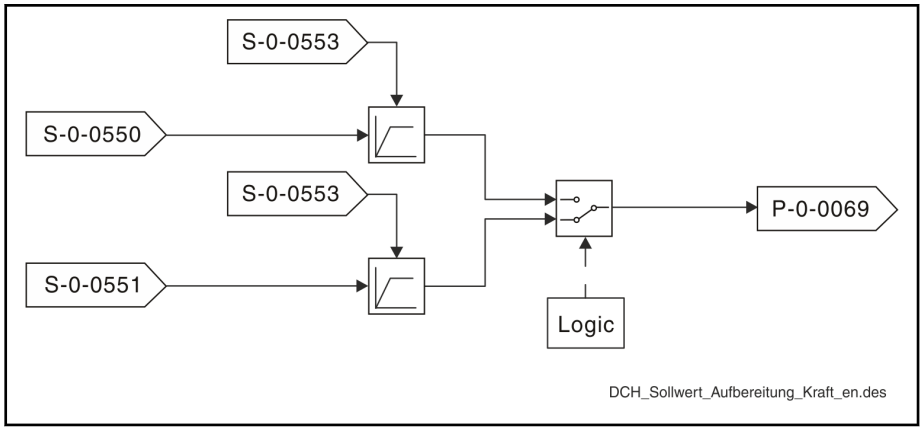


Fig. 6-6: Force command value adjustment

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter "Alternating control".

Output variable

The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.3.4 Diagnostic messages

Diagnostic status message

Active operation mode

The activated "closed-loop torque/force control" mode is indicated by the following diagnostic message:

- A0173, Torque/Force control/Direct valve control

6.3.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0824, Status "Torque/force command value attained"
- S-0-0860, Spool command value
- S-0-0861, Spool command value additive
- S-0-0867, Spool status word
- S-0-0869, Spool ramp time
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0069, Torque/force command value of controller
- P-0-2843, Output of force controller
- P-0-2855, Alternating control, status word
- P-0-2858, Output of alternating control
- P-0-2914, Effective valve command value
- P-0-2928.0.1, Valve command value control word
- P-0-2928.0.3, Output of valve command value generator
- P-0-2928.0.4, Valve command value ramp time positive, acceleration

- P-0-2928.0.5, Valve command value ramp time positive, deceleration
- P-0-2928.0.6, Valve command value ramp time negative, acceleration
- P-0-2928.0.7, Valve command value ramp time negative, deceleration
- P-0-2928.0.8, Valve command value emergency ramp

Pertinent diagnostic messages

- A0173, Torque/Force control/Direct valve control

6.4 Closed-loop pressure control / direct valve control

6.4.1 Brief description

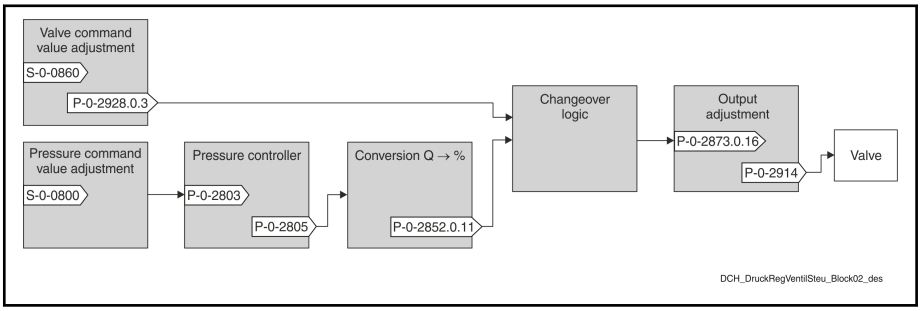


Fig. 6-7: Overview of operation mode of closed-loop pressure control / direct valve control

In the operation mode "closed-loop pressure control / direct valve control" a pressure command value and a valve command value are fed to the drive. If required, these command values can be filtered. Switching between closed-loop pressure control and direct valve control is accomplished using a changeover logic.

Features

- Command value generators for "direct valve control" and "closed-loop pressure control"
- The complete pressure controller can be utilized
- Switching between valve control and closed-loop pressure control with the help of the "changeover logic"
- Use of output adjustment

6.4.2 Valve command value adjustment

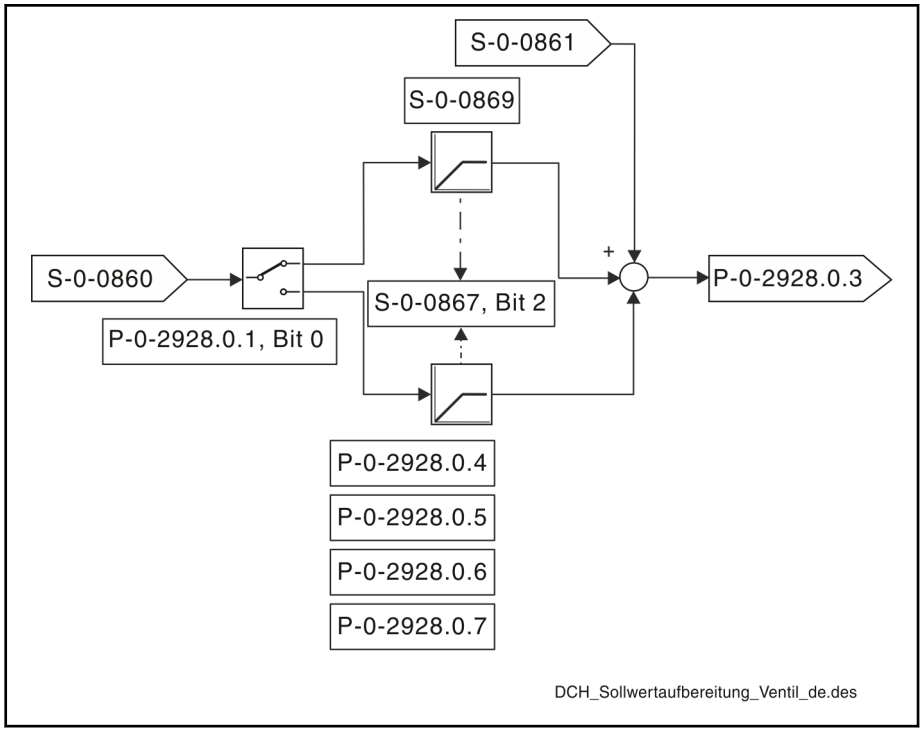


Fig. 6-8: Valve command value adjustment

Command value ramp

The command value provided by "S-0-0860, Spool command value" is fed via a ramp to prevent step-like changes. This can either be a simple ramp or a 4-quadrant ramp. Switching between these two options is possible by means of parameter "P-0-2928.0.1, Valve command value control word", bit 0.

The simple ramp is determined by "S-0-0869, Spool ramp time".

The 4-quadrant ramp is determined by

"P-0-2928.0.4, Valve command value ramp time positive, acceleration", "P-0-2928.0.5, Valve command value ramp time positive, deceleration",

"P-0-2928.0.6, Valve command value ramp time negative, acceleration" and

"P-0-2928.0.7, Valve command value ramp time negative, deceleration".

Additive valve command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0861, Spool command value additive". If required, this value can also be cyclically configured.

Output variable

The output variable of command value adjustment for direct valve control is "P-0-2928.0.3, Output of valve command value generator". The output variable is fed to the changeover logic.

6.4.3 Pressure command value adjustment

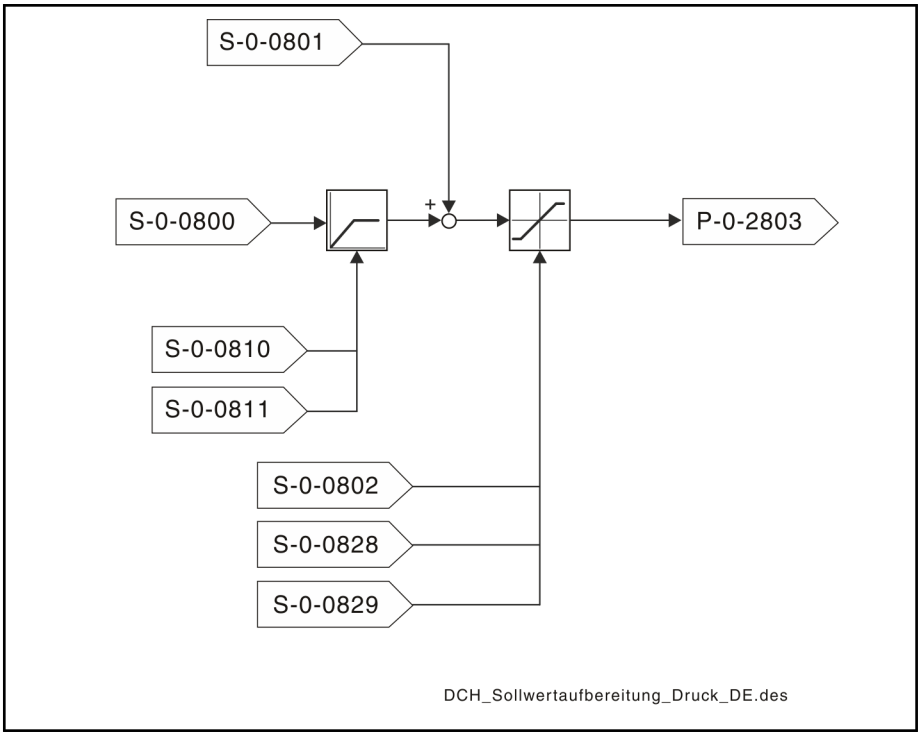


Fig. 6-9: Pressure command value adjustment

Command value ramp

The command value provided by "S-0-0800, Pressure command value" is fed via a ramp to prevent step-like changes. The ramp is defined by "S-0-0810, Pressure ramp time" and "S-0-0811, Pressure ramp reference".

Additive pressure command value

Moreover, it is possible to feed forward an additive command value via "S-0-0801, Pressure command value additive". If required, this value can also be cyclically configured.

Limitation

The output of the command value generator can be limited by means of "S-0-0802, Bipolar pressure limit value".

Output variable

The output variable of command value adjustment is "P-0-2803, Pressure command value of controller". It is connected upstream of the pressure controller, which is described in more detail under "Pressure controller".

Changeover logic

The behavior of the changeover logic is described in more detail in the chapter "Drive control".

The output of the changeover logic is parameter "P-0-2873.0.16, Output adjustment command value", which is provided via output adjustment to the valve "P-0-2914, Effective valve command value".

6.4.4 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated operation mode "closed-loop pressure control / direct valve control (p/Q)" is indicated by the following diagnostic message:

- "A0174, Pressure control/Direct valve control (p/Q)"

Monitoring functions

Monitoring functions specific to the operation mode:

- "E2065, Pressure command value > limit value"

6.4.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0860, Spool command value
- S-0-0861, Spool command value additive
- S-0-0867, Spool status word
- S-0-0869, Spool ramp time
- P-0-2928.0.1, Valve command value control word
- P-0-2928.0.3, Output of valve command value generator
- P-0-2928.0.4, Valve command value ramp time positive, acceleration
- P-0-2928.0.5, Valve command value ramp time positive, deceleration
- P-0-2928.0.6, Valve command value ramp time negative, acceleration
- P-0-2928.0.7, Valve command value ramp time negative, deceleration
- S-0-0800, Pressure command value
- S-0-0801, Pressure command value additive
- S-0-0802, Bipolar pressure limit value
- S-0-0810, Pressure ramp time
- S-0-0811, Pressure ramp reference
- S-0-0813, System pressure
- S-0-0814, Tank pressure
- S-0-0828, Positive pressure limit value
- S-0-0829, Negative pressure limit value
- S-0-0830, Pressure status word
- P-0-2803, Pressure command value of controller
- P-0-2805, Output of pressure controller
- P-0-2852.0.11, Correction value: Changeover logic p/Q pressure controller
- P-0-2873.0.16, Output adjustment command value
- P-0-2914, Effective valve command value

Pertinent diagnostic messages

- A0174, Pressure control/Direct valve control (p/Q)
- E2065, Pressure command value > limit value

6.5 (Open/closed-loop) flow control

6.5.1 Brief description

Functional packages Valve (IFB), Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL):

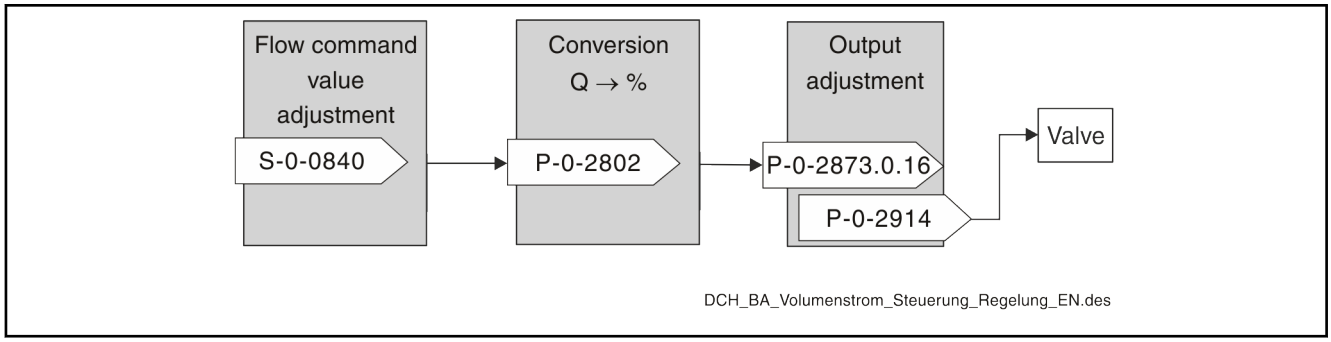


Fig. 6-10: Overview of operation mode of (open/closed-loop) flow control for IFB, AXR OL and AXR CL

Functional package p/Q

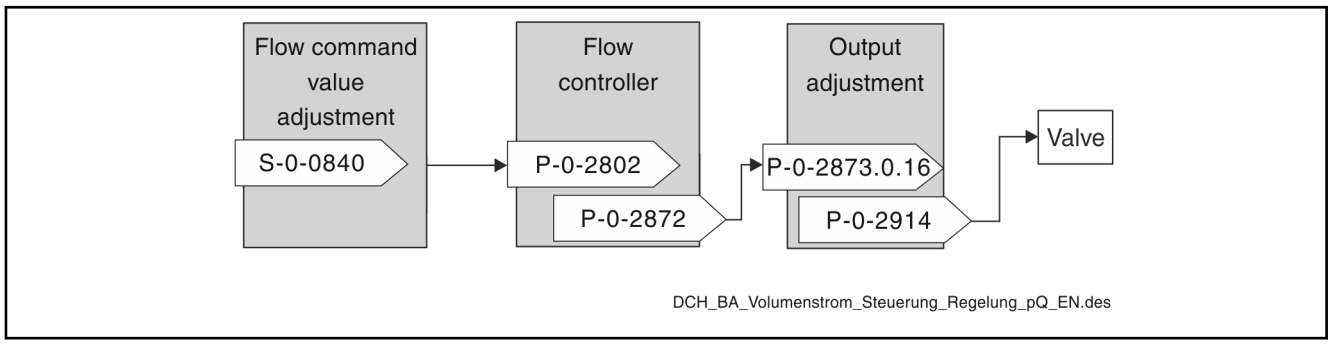


Fig. 6-11: Overview of operation mode of closed-loop torque/force control / (open/closed-loop) flow control for p/Q

In the “(open/closed-loop) flow control" mode, a flow command value is preset for the drive. If required, this command value can be directed via a ramp generator. The flow can be open- or closed-loop-controlled depending on the functional package used. With functional package p/Q the flow control loop is closed in the drive by determining the actual flow value (measurement of pressure drop across a control land and stored normalized flow characteristic curve). With all other functional packages, the flow is only open-loop-controlled, with the flow command value being converted into a corresponding valve control variable with the help of internal parameters.

Features

- Command value generator for flow
- Limitation of the preset command value to a limit value that can be parameterized
- Use of output adjustment

Determination of the actual flow value

- Functional package Valve (IFB), Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL):

  The actual flow value is determined on the basis of the actual valve position value, the valve size and the related system pressure.

☞ In case that the function of characteristic curve compensation and overlap compensation are active at the same time in the output adjustment, the actual flow value can no longer be correctly calculated and is therefore always set to zero.

- Functional package p/Q:

The actual flow value is calculated from the measurement of the pressure drop across a control land (Δp), the nominal pressure (p_N) and the stored normalized flow characteristic curve (Q_N).

$$Q_{act}(\Delta p, valve_{act}) = \sqrt{\frac{\Delta p}{p_N}} * Q_N(valve_{act})$$

Fig. 6-12: Determination of the actual flow value

With open-loop flow control, the real actual flow value may significantly differ from the command value depending on the operating conditions.

6.5.2 Flow command value adjustment

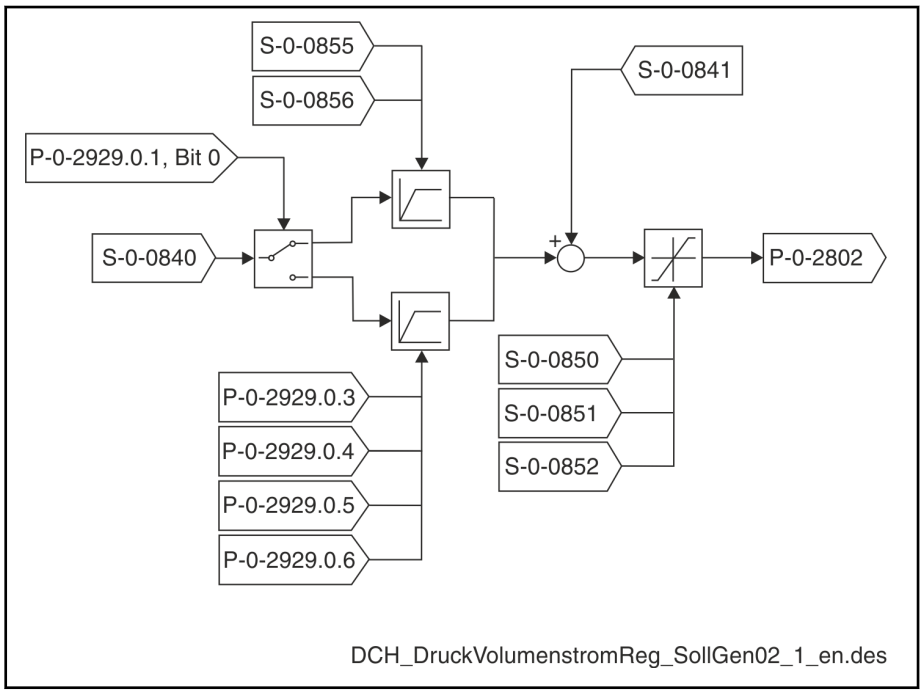


Fig. 6-13: Flow command value adjustment

Command value ramp

The command value provided by "S-0-0840 Flow command value" is fed via a ramp to prevent step-like changes. This can either be a simple ramp or a 4-quadrant ramp. Switching between these two options is possible by means of parameter "P-0-2929.0.1, Flow control word", bit 0.

The simple ramp is determined by "S-0-0855, Flow ramp reference" and "S-0-0856, Flow ramp time".

The 4-quadrant ramp is defined by "P-0-2929.0.3, Flow ramp time positive, acceleration", "P-0-2929.0.4, Flow ramp time positive, deceleration", "P-0-2929.0.5, Flow ramp time negative, acceleration" and "P-0-2929.0.6, Flow ramp time negative, deceleration".

Additive flow command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0841, Flow command value additive". If required, this value can also be cyclically configured.

Command value limitation

The effective flow command value is limited to the value specified in "S-0-0850, Bipolar flow limit value" or in parameters "S-0-0851, Positive flow limit value" or "S-0-0852, Negative flow limit value".

Output variable The output variable of command value adjustment for flow control is "P-0-2802, Flow command value internal".

6.5.3 Diagnostic messages and monitoring functions

Diagnostic status messages The activated "(open/closed-loop) flow control" mode is indicated by the following diagnostic message:

"A0171, Flow (open-/closed-loop control)"

Monitoring functions Monitoring functions specific to the operation mode:

"E2066, Flow command value > limit value"

6.5.4 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0840, Flow command value
- S-0-0841, Flow command value additive
- S-0-0842, Flow feedback value
- S-0-0850, Bipolar flow limit value
- S-0-0851, Positive flow limit value
- S-0-0852, Negative flow limit value
- S-0-0855, Flow ramp reference
- S-0-0856, Flow ramp time
- P-0-2802, Flow command value internal
- P-0-2873.0.16, Output adjustment command value
- P-0-2914, Effective valve command value
- P-0-2929.0.1, Flow control word
- P-0-2929.0.3, Flow ramp time positive, acceleration
- P-0-2929.0.4, Flow ramp time positive, deceleration
- P-0-2929.0.5, Flow ramp time negative, acceleration
- P-0-2929.0.6, Flow ramp time negative, deceleration

Pertinent diagnostic messages

- A0171, Flow (open-/closed-loop control)
- E2066, Flow command value > limit value

6.6 Closed-loop torque/force control / (open/closed-loop) flow control

6.6.1 Functional package

Functional package Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL):

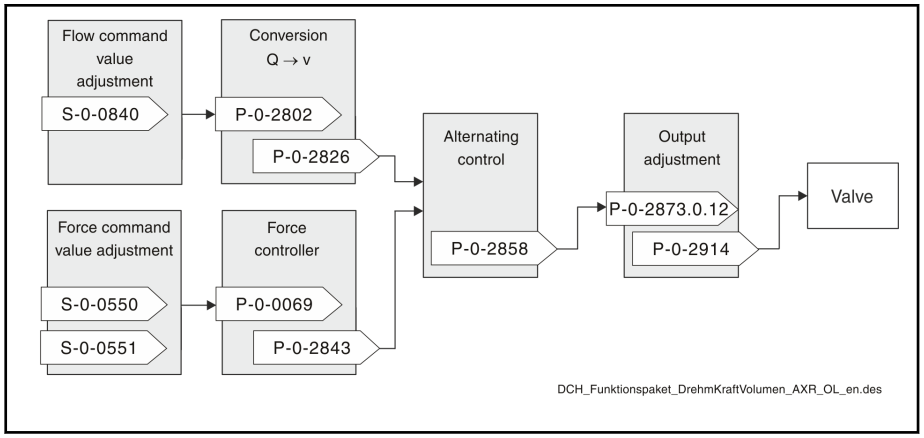


Fig. 6-14: Overview of operation mode of closed-loop torque/force control / (open/closed-loop) flow control for AXR OL and AXR CL

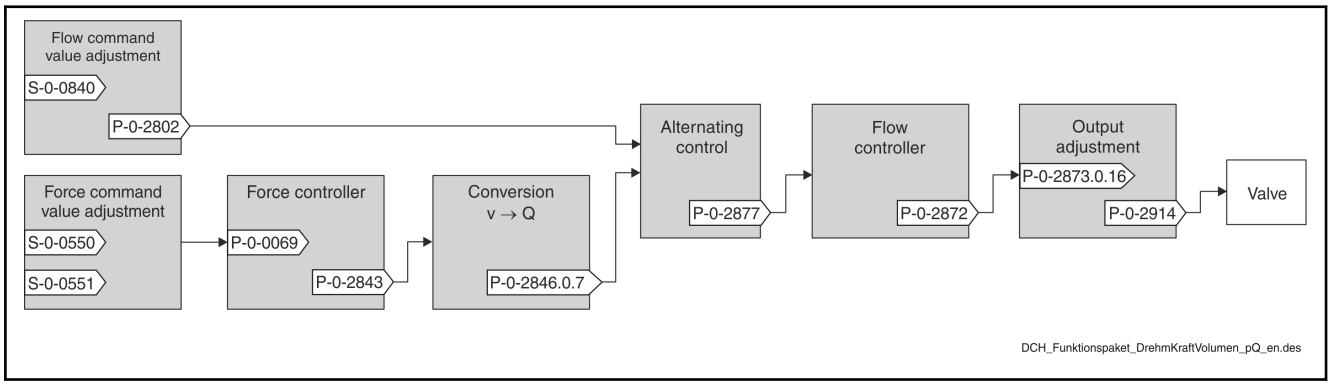


Fig. 6-15: Overview of operation mode of closed-loop torque/force control / (open/closed-loop) flow control for p/Q

In the "closed-loop torque/force control / (open/closed-loop) flow control" mode, a flow command value and a positive/negative torque/force command value are provided for the drive. If required, these command values can be directed via a ramp generator. In this operation mode, alternating control can be activated. The alternating control ensures changing over to closed-loop force control as soon as the set changeover condition if fulfilled.

In the functional packages Axis Controller OL and CL, only open-loop flow control takes place, with the flow command value being converted into a corresponding valve control value with the help of internal parameters. In contrast to this, in functional package p/Q the flow is closed-loop controlled.

Features

- Command value generators for flow and torque/force
- Limitation of the preset flow command value to limit values that can be parameterized
- Alternating control can be used
- Utilization of output adjustment

Establishment of actual flow value

- Functional package Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL):

  The actual flow value is determined on the basis of the actual valve position value, the valve size and the related system pressure.

☞ In case that the functions of characteristic curve compensation and overlap compensation are active at the same time in output adjustment, the actual flow value can no longer be correctly calculated and is therefore always set to zero.

- Functional package p/Q:

  The actual flow value is calculated from the measurement of the pressure drop across a control land (Δp), the nominal pressure (p_N) and the stored normalized flow characteristic curve (Q_N).

$$Q_{act}(\Delta p, valve_{act}) = \sqrt{\frac{\Delta p}{p_N}} * Q_N(valve_{act})$$

Fig. 6-16: Formula

☞ With open-loop flow control, the real actual flow value may significantly differ from the command value depending on the operating conditions.

6.6.2 Flow command value adjustment

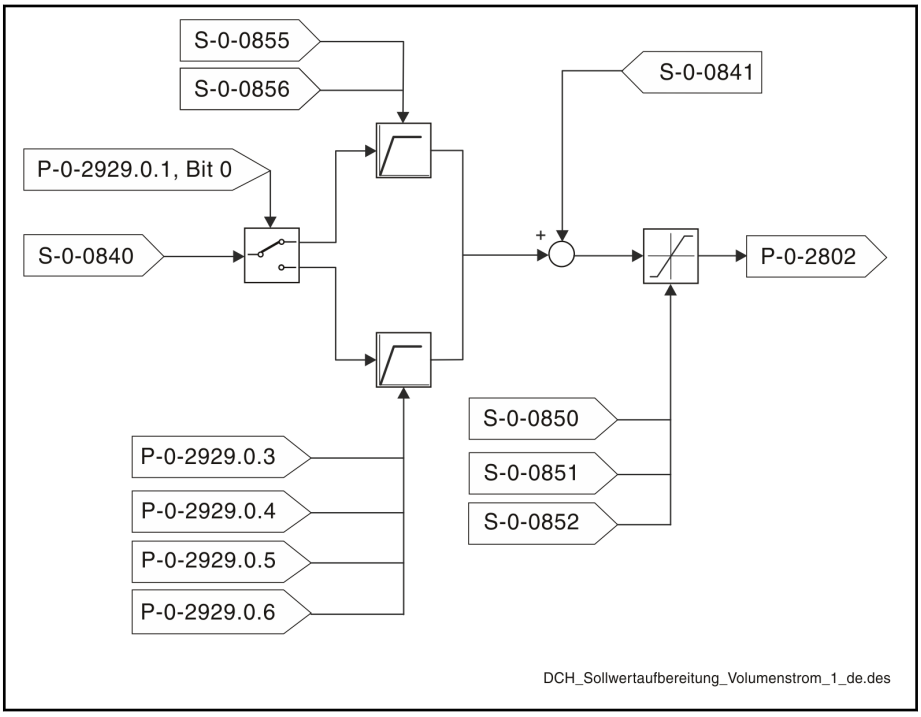


Fig. 6-17: Flow command value adjustment

Command value ramp

The command value provided by "S-0-0840, Flow command value" is fed via a ramp to prevent step-like changes. This can either be a simple ramp or a 4-quadrant ramp. Switching between these two options is possible by means of parameter "P-0-2929.0.1, Flow control word", bit 0.

The simple ramp is determined via

- "S-0-0855, Flow ramp reference" und
- "S-0-0856, Flow ramp time".

The 4-quadrant ramp is determined by

- "P-0-2929.0.3, Flow ramp time positive, acceleration"
- "P-0-2929.0.4, Flow ramp time positive, deceleration"
- "P-0-2929.0.5, Flow ramp time negative, acceleration"
- "P-0-2929.0.6, Flow ramp time negative, deceleration".

Additive flow command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0841, Flow command value additive". If required, this value can also be cyclically configured.

Command value limitation

The effective flow command value is limited to the value specified in parameter "S-0-0850, Bipolar flow limit value" or in parameters "S-0-0851, Positive flow limit value" or "S-0-0852, Negative flow limit value".

Output variable

The output variable of command value adjustment for flow control is "P-0-2802, Flow command value internal".

6.6.3 Force command value adjustment

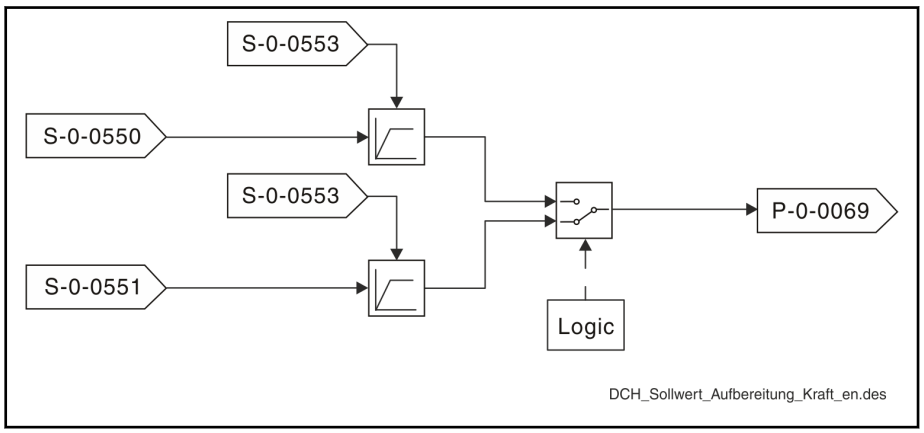


Fig. 6-18: Force command value adjustment

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter "Alternating control".

Output variable

The output variable of command value adjustment is "P-0-0069, Torque/force command value of controller".

6.6.4 Diagnostic messages and monitoring functions

Diagnostic status message

Active operation mode

The activated "closed-loop torque/force control / (open/closed-loop) flow control" mode is indicated by the following diagnostic message:

- A0176, Torque/Force control/Flow (open-/closed-loop)

Monitoring functions

Monitoring functions specific to the operation mode:

- E2066, Flow command value > limit value

6.6.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0824, Status "Torque/force command value attained"

- S-0-0840, Flow command value
- S-0-0841, Flow command value additive
- S-0-0842, Flow feedback value
- S-0-0850, Bipolar flow limit value
- S-0-0851, Positive flow limit value
- S-0-0852, Negative flow limit value
- S-0-0855, Flow ramp reference
- S-0-0856, Flow ramp time
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0069, Torque/force command value of controller
- P-0-2843, Output of force controller
- P-0-2802, Flow command value internal
- P-0-2855, Alternating control, status word
- P-0-2858, Output of alternating control
- P-0-2872, Output of valve characteristic curve
- P-0-2914, Effective valve command value
- P-0-2929.0.1, Flow control word
- P-0-2929.0.3, Flow ramp time positive, acceleration
- P-0-2929.0.4, Flow ramp time positive, deceleration
- P-0-2929.0.5, Flow ramp time negative, acceleration
- P-0-2929.0.6, Flow ramp time negative, deceleration

Pertinent diagnostic messages

- A0176, Torque/Force control/Flow (open-/closed-loop)
- E2066, Flow command value > limit value

6.7 Closed-loop pressure control

6.7.1 Brief description

Functional package Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL)

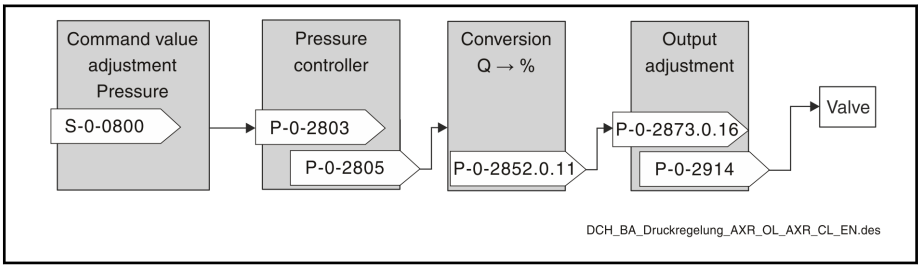


Fig. 6-19: Overview of operation mode of closed-loop pressure control for AXR OL and AXR CL

Functional package p/Q

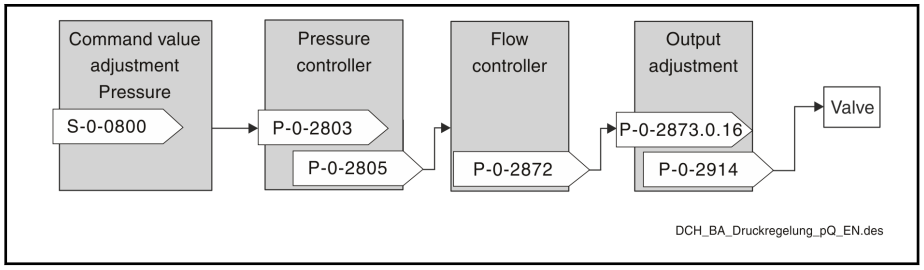


Fig. 6-20: Overview of operation mode of closed-loop pressure control for p/Q

In the operation mode "closed-loop pressure control" a pressure command value is fed to the drive. If required, these command values can be filtered.

Features

- Command value generator for "pressure control"
- The complete pressure controller can be utilized
- Utilization of output adjustment

6.7.2 Pressure command value adjustment

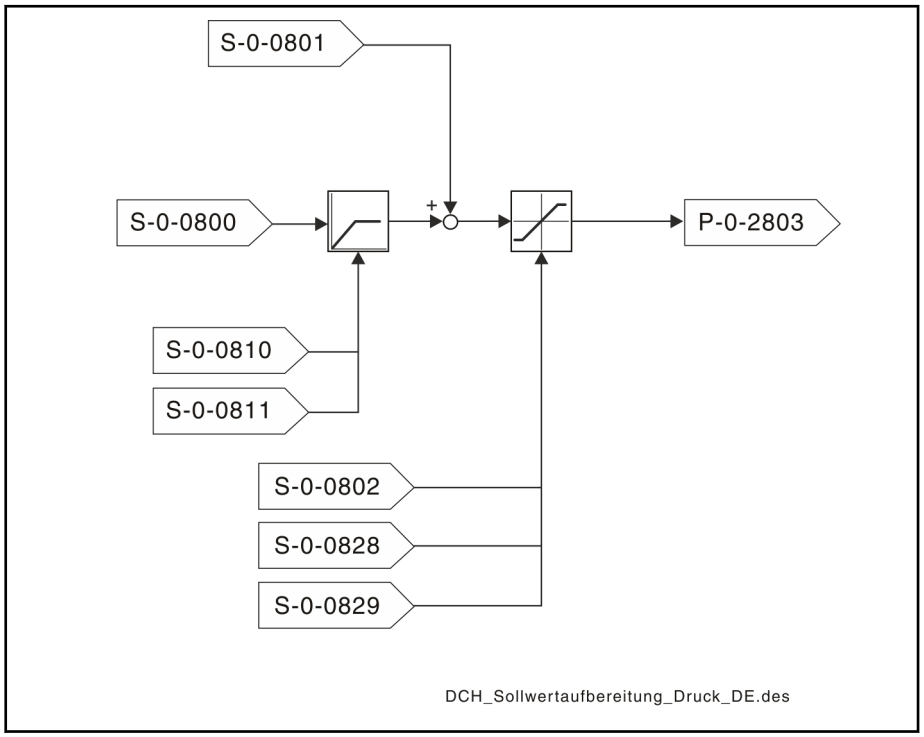


Fig. 6-21: Pressure command value adjustment

Command value ramp

The command value preset in "S-0-0800, Pressure command value" is fed via a ramp to prevent step-like changes. The ramp is defined by "S-0-0810, Pressure ramp time" and "S-0-0811, Pressure ramp reference".

Additive pressure command value

In addition, it is possible to feed forward an additive command value via "S-0-0801, Pressure command value additive". If required, this value can also be cyclically configured.

Limitation

The output of the command value generator can be limited by means of "S-0-0802, Bipolar pressure limit value".

Output variable

The output variable of command value adjustment is defined in "P-0-2803, Pressure command value of controller".

6.7.3 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "pressure control" is indicated by the following diagnostic message depending on the characteristic:

- A0170, Pressure mode

Monitoring functions

Monitoring functions specific to the operation mode:

- E2065, Pressure command value > limit value

6.7.4 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0800, Pressure command value
- S-0-0801, Pressure command value additive
- S-0-0802, Bipolar pressure limit value
- S-0-0810, Pressure ramp time
- S-0-0811, Pressure ramp reference
- S-0-0813, System pressure
- S-0-0814, Tank pressure
- S-0-0828, Positive pressure limit value
- S-0-0829, Negative pressure limit value
- S-0-0830, Pressure status word
- P-0-2803, Pressure command value of controller
- P-0-2805, Output of pressure controller
- P-0-2852.0.11, Correction value: Changeover logic p/Q pressure controller
- P-0-2873.0.16, Output adjustment command value

Pertinent diagnostic messages

- A0170, Pressure mode
- E2065, Pressure command value > limit value

6.8 Closed-loop pressure control / (open/closed-loop) flow control

6.8.1 Brief description

Functional package Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL)

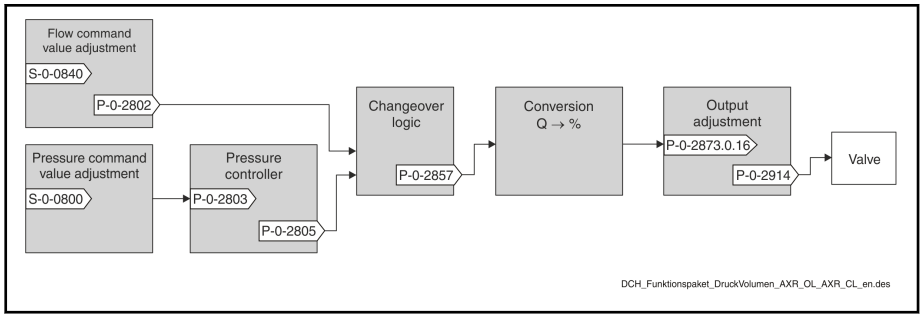


Fig. 6-22: Overview of operation mode of closed-loop pressure control / (open/closed-loop) flow control for AXR OL and AXR CL

Functional package p/Q

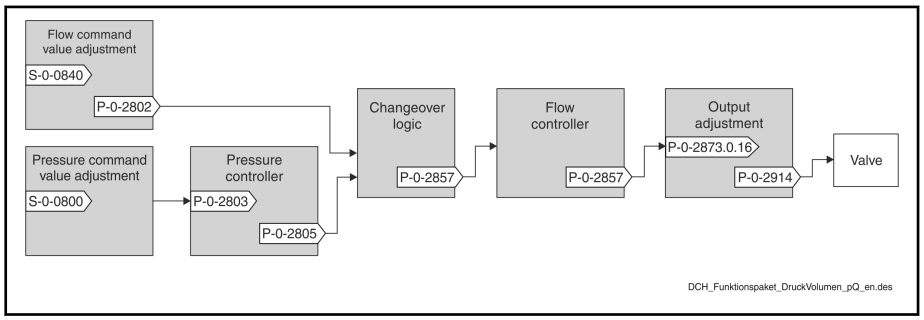


Fig. 6-23: Overview of operation mode of closed-loop pressure control / (open/closed-loop) flow control for p/Q

Functional package pump control (DFE)

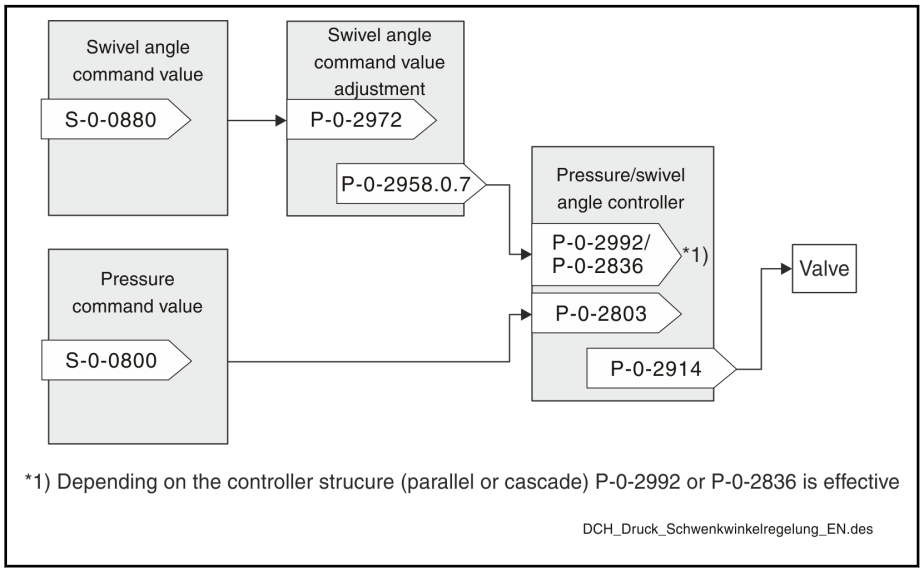


Fig. 6-24: Overview of operation mode of closed-loop pressure control / (open/closed-loop) flow control for DFE

In the operation mode "closed-loop pressure control / (open/closed-loop) flow control" a pressure command value and a flow command value are fed to the drive. If required, these command values can be directed via a ramp generator.

The swivel angle command value is adjusted in swivel angle command value processing before it is passed to the actual swivel angle controller.

Switching between pressure control and flow control is accomplished using a changeover logic.

Features

- Command value generator for flow and pressure
- Limitation of given command values to individual limit values that can be parameterized
- Switching between (open/closed-loop) flow control and closed-loop pressure control with the help of the "changeover logic"
- Utilization of output adjustment

The command values are processed differently depending on the device type. The flow can be open or closed-loop-controlled depending on the functional package. The pressure can always be closed-loop-controlled.

Establishment of actual flow value

- Functional package Axis Controller Open Loop (AXR OL) and Axis Controller Closed Loop (AXR CL):

  The actual flow value is determined on the basis of the actual valve position value, the valve size and the related system pressure.

☞ In case that the function of characteristic curve compensation and overlap compensation are active at the same time in output adjustment, the actual flow value can no longer be correctly calculated and is therefore always set to zero.

- Functional package p/Q:

  The actual flow value is calculated from the measurement of the pressure drop across a control land (Δp), the nominal pressure (p_N) and the stored normalized flow characteristic curve (Q_N).

$$Q_{act}(\Delta p, valve_{act}) = \sqrt{\frac{\Delta p}{p_N}} * Q_N(valve_{act})$$

Fig. 6-25: Determination of the actual flow value

- Functional package pump control (DFE)

  The actual flow value is calculated from the actual swivel angle value ($swivel_{act}$), the displacement of the pump (V_{pump}) and the current drive speed (n_{drive}).

  $Q_{act} = swivel_{act} * V_{pump} * n_{drive}$

☞ With open-loop flow control, the real actual flow value may significantly differ from the command value depending on the operating conditions.

6.8.2 Flow command value adjustment

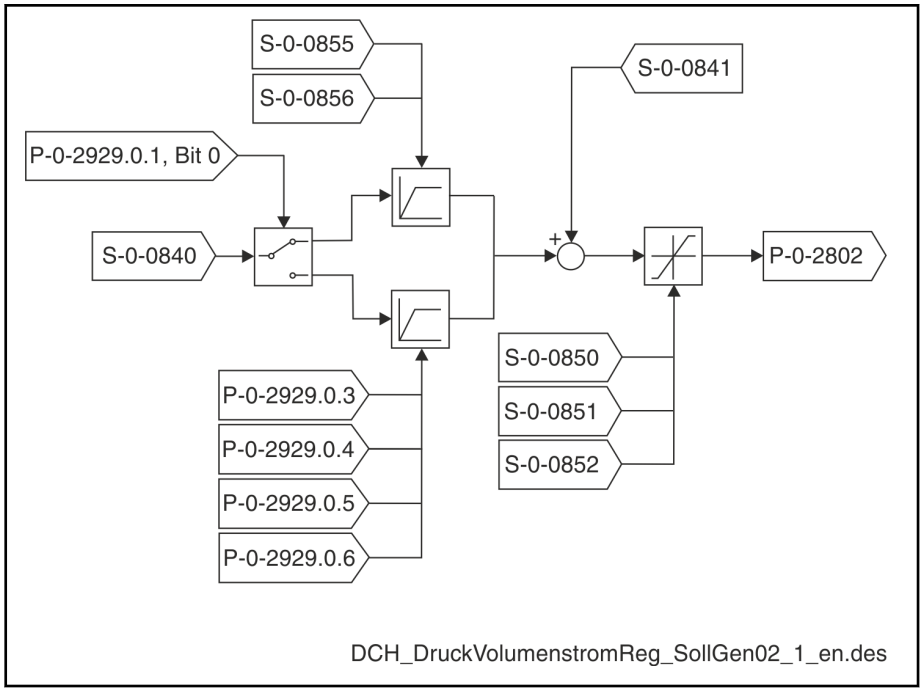


Fig. 6-26: Flow command value adjustment

Command value ramp

The command value provided by "S-0-0840, Flow command value" is fed via a ramp to prevent step-like changes. This can either be a simple ramp or a 4-quadrant ramp. Switching between these two options is possible by means of parameter "P-0-2929.0.1, Flow control word", bit 0.

The simple ramp is determined via

"S-0-0855, Flow ramp reference" and

"S-0-0856, Flow ramp time".

The 4-quadrant ramp is determined by

"P-0-2929.0.3, Flow ramp time positive, acceleration",

"P-0-2929.0.4, Flow ramp time positive, deceleration",

"P-0-2929.0.5, Flow ramp time negative, acceleration" and

"P-0-2929.0.6, Flow ramp time negative, deceleration".

Additive flow command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0841, Flow command value additive". If required, this value can also be cyclically configured.

Command value limitation

The effective flow command value is limited to the value specified in "S-0-0850, Bipolar flow limit value" or in parameters "S-0-0851, Positive flow limit value" or "S-0-0852, Negative flow limit value".

Output variable

The output variable of command value adjustment for flow control is "P-0-2802, Flow command value internal".

6.8.3 Pressure command value adjustment

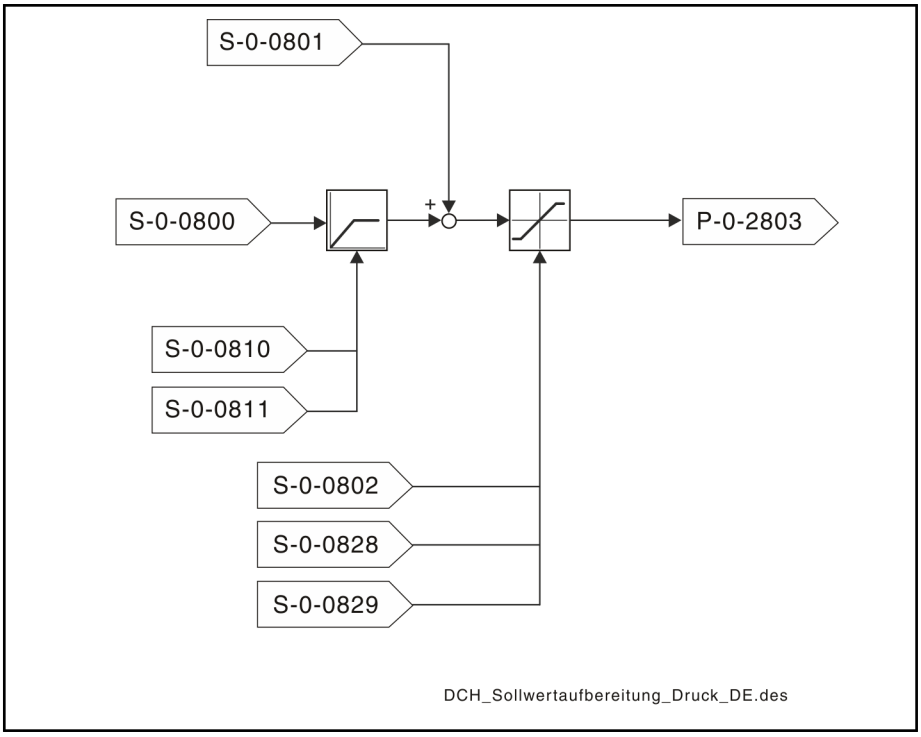


Fig. 6-27: Pressure command value adjustment

Command value ramp

The command value provided by "S-0-0800, Pressure command value" is filtered. The ramp is defined by "S-0-0810, Pressure ramp time" and "S-0-0811, Pressure ramp reference".

Additive pressure command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0801, Pressure command value additive". If required, this value can also be cyclically configured.

Command value limitation

The effective pressure command value is limited to the value specified in "pressure limit value, bipolar" or in parameters "S-0-0828, Positive pressure limit value", or "S-0-0829, Negative pressure limit value".

Output variable

The output variable of command value adjustment is "P-0-2803, Pressure command value of controller". It is connected upstream of the pressure controller, which is described in more detail in chapter "Drive control".

6.8.4 Swivel angle command value processing

Swivel angle command value processing is described in chapter "Pressure/ swivel angle controller (pump controller)".

6.8.5 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "closed-loop pressure control / (open/closed-loop) flow control" mode is indicated by the following diagnostic message:

- "A0172, Pressure control/Flow (open-/closed-loop) control"

Monitoring functions

Monitoring functions specific to the operation mode:

- "E2065, Pressure command value > limit value"

- "E2066, Flow command value > limit value"

6.8.6 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0800, Pressure command value
- S-0-0801, Pressure command value additive
- S-0-0802, Bipolar pressure limit value
- S-0-0810, Pressure ramp time
- S-0-0811, Pressure ramp reference
- S-0-0828, Positive pressure limit value
- S-0-0829, Negative pressure limit value
- S-0-0830, Pressure status word
- S-0-0840, Flow command value
- S-0-0841, Flow command value additive
- S-0-0842, Flow feedback value
- S-0-0850, Bipolar flow limit value
- S-0-0851, Positive flow limit value
- S-0-0852, Negative flow limit value
- S-0-0855, Flow ramp reference
- S-0-0856, Flow ramp time
- P-0-2802, Flow command value internal
- P-0-2803, Pressure command value of controller
- P-0-2805, Output of pressure controller
- P-0-2857, Output of changeover logic p/Q
- P-0-2872, Output of valve characteristic curve
- P-0-2873.0.16, Output adjustment command value
- P-0-2914, Effective valve command value
- P-0-2929.0.1, Flow control word
- P-0-2929.0.3, Flow ramp time positive, acceleration
- P-0-2929.0.4, Flow ramp time positive, deceleration
- P-0-2929.0.5, Flow ramp time negative, acceleration
- P-0-2929.0.6, Flow ramp time negative, deceleration
- P-0-2943, Pump displacement volume
- P-0-2986, Output adjustment of pump command value
- P-0-2993, Current drive speed

Pertinent diagnostic messages

- A0172, Pressure control/Flow (open-/closed-loop) control
- E2065, Pressure command value > limit value
- E2066, Flow command value > limit value

6.9 Torque/force control

6.9.1 Brief description

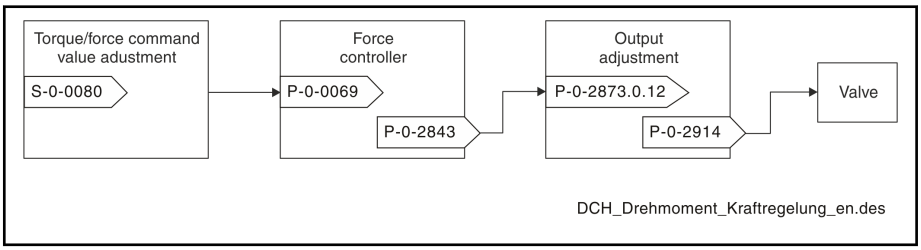


Fig. 6-28: "Torque/force control" block diagram

In the "closed-loop torque/force control" mode, an additive torque/force command value is provided for the drive. If required, this command value can be interpolated with the help of a ramp. In conjunction with linear drives (cylinders), we speak of force control, with rotary drives (hydraulic motor), we speak of torque control. For sensing the actual force, pressure cells are required. In the drive, the measured pressure is converted into a force on the basis of the cylinder dimensions entered. Direct force sensing can also be realized with a force transducer.



This operation mode only supports a torque/force command value provision with a value range of 2 bytes. The parameters "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" are not supported by this operation mode.

Features

- Command value generator for torque/force

6.9.2 Torque/force command value adjustment

Principle of command value adjustment

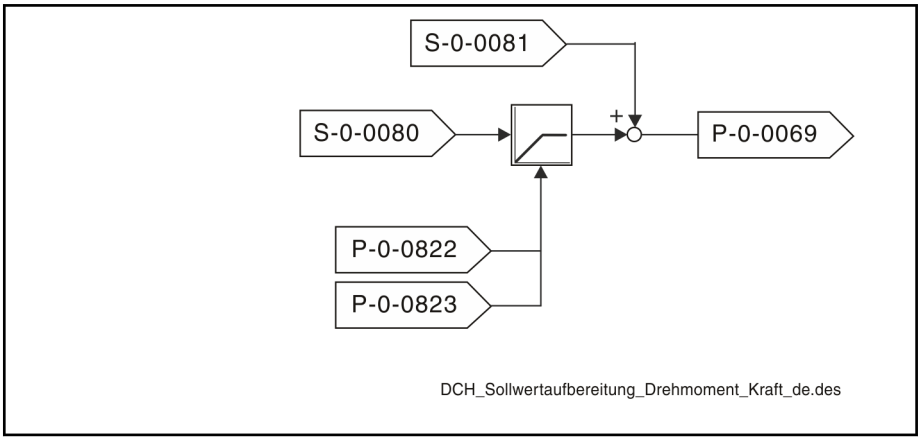


Fig. 6-29: Command value adjustment in torque/force control

Command value ramp

The command value provided by "S-0-0080, Torque/force command value (2 bytes)" is fed via a ramp to prevent step-like changes. The ramp can be modified by setting "S-0-0822, Torque/force ramp (2 bytes)" and "S-0-0823, Torque/force ramp time".

Additive force command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0081, Additive torque/force command value (2 bytes)". If required, this value can also be cyclically configured.

Output variable The output variable of command value adjustment for closed-loop torque/force control is "P-0-0069, Torque/force command value of controller (2 Byte)".

☞ The output variable is entered additionally in parameter "P-0-0049, Torque/force command value of controller (2 Byte)". This parameter can, however, only display values of up to max. 2 bytes.

6.9.3 Diagnostic messages and monitoring functions

Diagnostic status message

The activated "torque/force control" mode is displayed by the following diagnostic message:

- A0100, Torque/Force control

Monitoring functions

- F8079, Velocity limit value exceeded

  The value of parameter "S-0-0040, Velocity feedback value of encoder 1" is monitored as soon as it is outside the "S-0-0124, Standstill window". If it exceeds the 1.125-fold of the value parameterized in "S-0-0091, Bipolar velocity limit value" the error message "F8079, Velocity limit value exceeded" is generated.

6.9.4 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0040, Velocity feedback value of encoder 1
- S-0-0080, Torque/force command value (2 bytes)
- S-0-0081, Additive torque/force command value (2 bytes)
- S-0-0084, Torque/force feedback value (2 bytes)
- S-0-0091, Bipolar velocity limit value
- S-0-0124, Standstill window
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0822, Torque/force ramp (2 bytes)
- S-0-0823, Torque/force ramp time
- S-0-0824, Status "Torque/force command value attained"
- P-0-0049, Torque/force command value of controller (2 Byte)
- P-0-0069, Torque/force command value of controller
- P-0-2843, Output of force controller
- P-0-2873.0.12, Input of output adjustment
- P-0-2914, Effective valve command value

Pertinent diagnostic messages

- A0100, Torque/Force control
- F8079, Velocity limit value exceeded

6.10 (Open/closed-loop) velocity control

6.10.1 Brief description

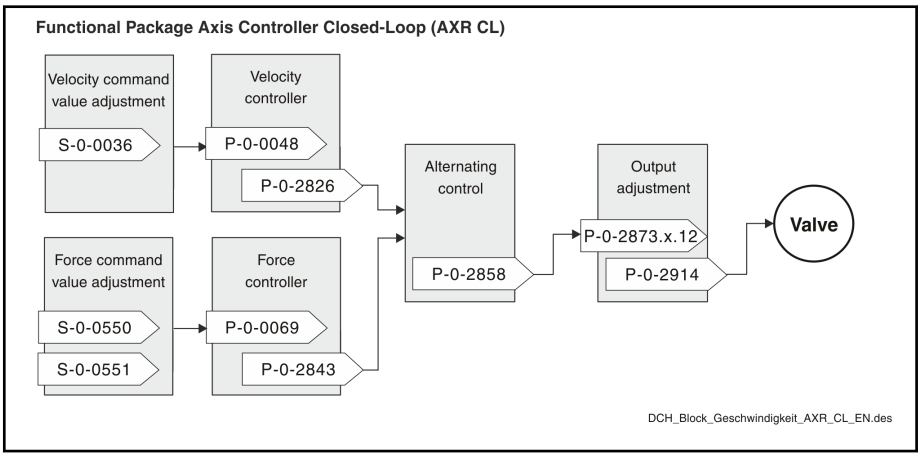


Fig. 6-30: Overview of operation mode of (open/closed-loop) velocity control for AXR CL

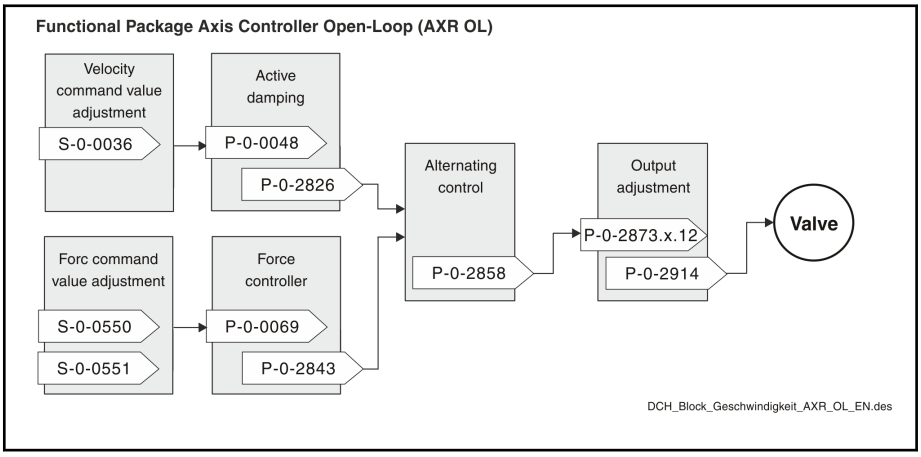


Fig. 6-31: Overview of operation mode of (open/closed-loop) velocity control for AXR OL

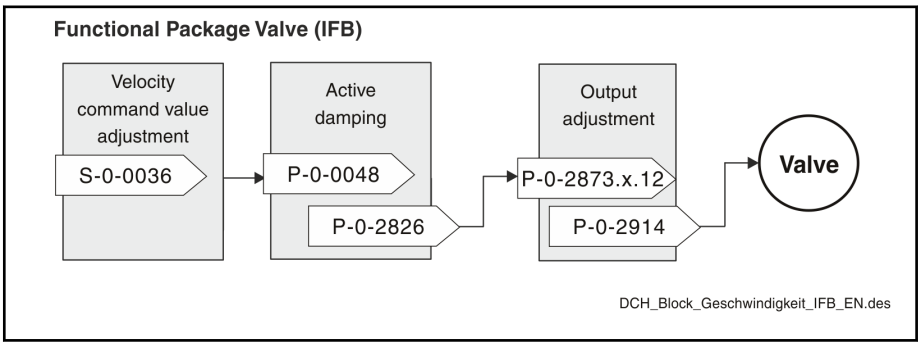


Fig. 6-32: Overview of operation mode of (open/closed-loop) velocity control for IFB

In the "(open/closed-loop) velocity control" mode a velocity command value is provided for the drive. The velocity command value is limited by ramps and filters.

☞ Closed-loop velocity control is only possible with functional package Axis Controller Closed Loop (AXC CL); otherwise, the velocity is open-loop controlled.

Features

- Command value ramps can be generated by a drive-internal command value generator
- With functional package Axis Controller Open Loop and Closed Loop, switching between open or closed-loop velocity control and closed-loop force control with the help of "alternating control"
- Ramp generator with separately adjustable, two-stage acceleration and deceleration limits of the preset velocity command value. Switching from ramp 1 to ramp 2 is done with selectable velocity and run-up stop that can be parameterized
- Monitoring of command velocity and actual velocity for exceeding parameter "S-0-0091, Bipolar velocity limit value"
- Moreover, the drive-related limit value "S-0-0113, Maximum velocity of the drive" is also monitored
- Smoothing of preset command value by means of average value filter (jerk limitation by means of moving average)

6.10.2 Velocity command value adjustment

Overview

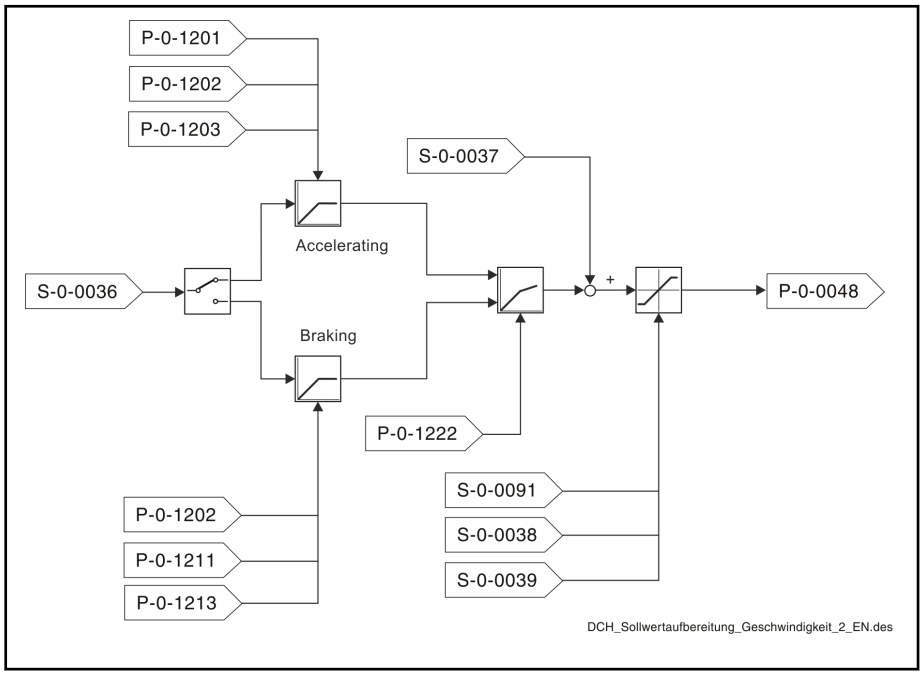


Fig. 6-33: Command value adjustment in closed-loop velocity control

Command value ramp

The command value provided by parameter "S-0-0036, Velocity command value" can be limited in steps via 2 ramps in terms of increase (acceleration) and deceleration.

- Acceleration process

  → In the first step, the increase in the command value is limited via "P-0-1201, Ramp 1 pitch" (acceleration ramp 1). If the command velocity exceeds the threshold entered in parameter "P-0-1202, Final speed ramp 1", the increase of the command value is limited by the value of "P-0-1203, Ramp 2 pitch" (acceleration ramp 2).

- Deceleration or braking process

→ For decelerating, "P-0-1211, Deceleration ramp 1" and "P-0-1213, Deceleration ramp 2" are used by analogy.



This allows parameterizing different ramps for the acceleration and the braking process.

Jerk limitation

The output of the ramp generator can be jerk-limited additionally by means of "P-0-1222, Velocity command filter" through a low-pass filter of first order.

Additive velocity command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0037, Additive velocity command value". If required, this value can also be cyclically configured.

Command value limitation

The effective velocity command value is limited to the value specified in parameter "S-0-0091, Bipolar velocity limit value" or in parameters "S-0-0038, Positive velocity limit value" or "S-0-0039, Negative velocity limit value".

6.10.3 Force command value adjustment

Overview

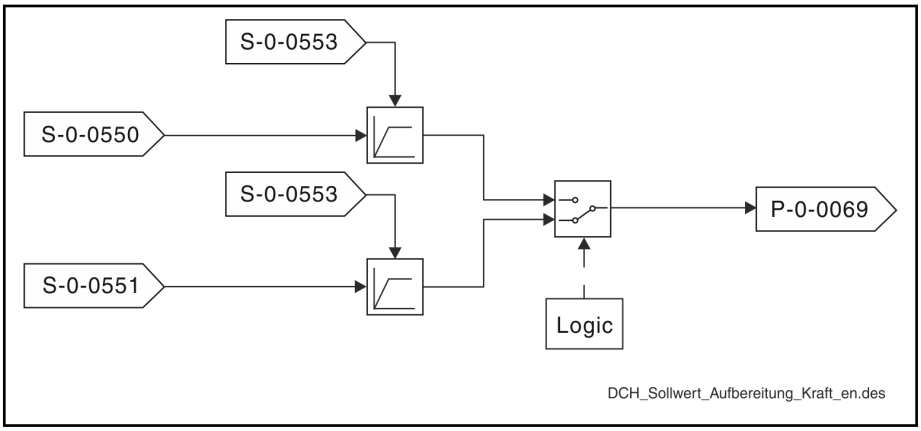


Fig. 6-34: Command value adjustment for closed-loop force control

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter "Alternating control".

Output variable

The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.10.4 Diagnostic messages and monitoring functions

Diagnostic status message

Active operation mode

The activated "(open/closed-loop) velocity control" mode is displayed by the following diagnostic message:

- A0101, (Open/Closed-loop) velocity control

Monitoring functions

Monitoring functions specific to the operation mode:

- E2063, Velocity command value > limit value
  The velocity command value exceeded the velocity limit value
- F8079, Velocity limit value exceeded
  The actual velocity value exceeded the velocity limit value

6.10.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0091, Bipolar velocity limit value
- S-0-0113, Maximum velocity of the drive
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0048, Velocity command value of controller
- P-0-0069, Torque/force command value of controller
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2
- P-0-1222, Velocity command filter

Pertinent diagnostic messages

- A0101, (Open/Closed-loop) velocity control
- E2063, Velocity command value > limit value
- F8079, Velocity limit value exceeded

6.11 Closed-loop position control with cyclic command value provision

6.11.1 Brief description

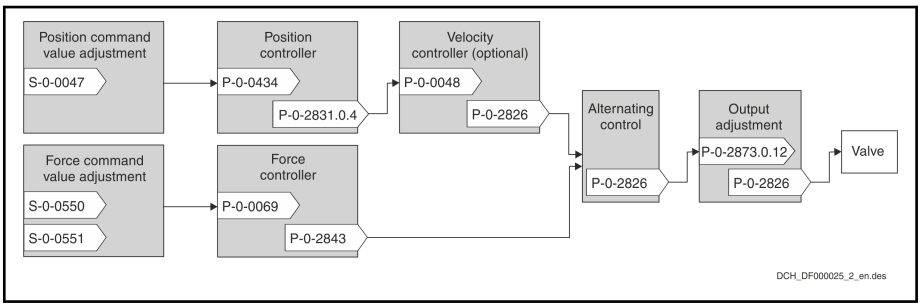


Fig. 6-35: "Position control with cyclic command value input" block diagram

In the "closed-loop position control" mode, a cyclic position command value is made available to the drive within the NC cycle. This command value is fine-interpolated in the drive and, if necessary, jerk-limited via filters before being transmitted to the actual position controller.

Features

- Closed-loop position control on the basis of the command value preset in parameter "S-0-0047, Position command value"
- NC-controlled or drive-controlled position control with internal, dynamic synchronization when operation modes are changed over
- Time base for cyclic command value provision defined by "S-0-0001, NC cycle time (TNcyc)"
- Switching between closed-loop position control and closed-loop force control with the help of "alternating control"
- Monitoring of the position command value difference for exceeding parameter "S-0-0091, Bipolar velocity limit value"
- Position command values of the control unit smoothed by means of adjustable average value filter; calculation from acceleration limit value and jerk limit value; indication in parameter "P-0-0042, Current position command average value filter order"
- Fine interpolation of position command value of the control unit to position controller cycle; can be changed over via "P-0-0187, Position command processing mode"
- Adjustable position command value delay in position controller clock cycles ("P-0-0456, Position command value delay"); maximum of 32 cycles.



The condition for this operation mode is clock-synchronized communication between the control unit and the drive, as it is the case with Sercos interface, for example.

6.11.2 Command value adjustment in position control

Block diagram

The graphic below illustrates command value adjustment in the "closed-loop position control" mode as a block circuit diagram.

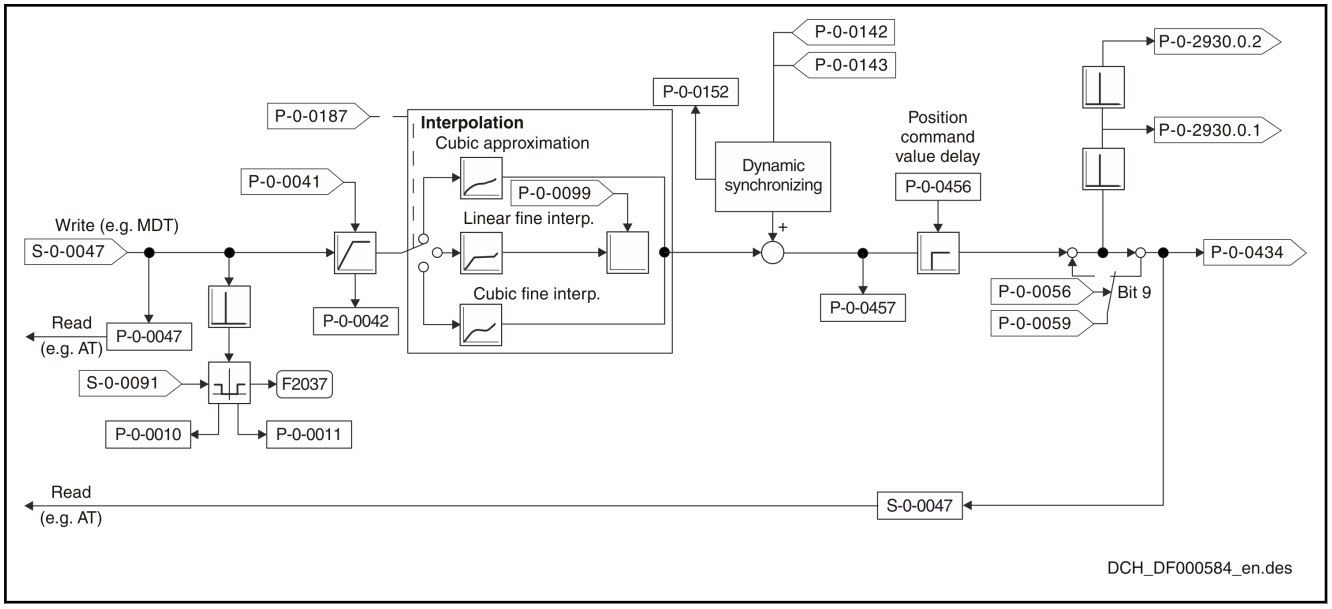


Fig. 6-36: Command value adjustment in position control

NC- or drive-controlled position control

We distinguish the following characteristics of the operation mode "position control with cyclic command value provision":

- **NC-controlled position control** (cf. diagnostic messages A0102 to A0105)

  The drive generally follows the position command values which are cyclically provided by the master within the NC clock cycle.

- **Drive-controlled position control** (cf. diagnostic messages A0154 to A0157)

  In the case of a changeover of operation mode to cyclic closed-loop position control, the drive realizes the corresponding synchronization process, i.e. it generates, internally by means of the internal synchronization parameters (P-0-0142, P-0-0143, P-0-0154, P-0-0151), a smooth transition of the internal position command value from the current actual position to the new command value characteristic given by the NC. After the synchronization process has been completed, the drive follows the position command values provided by the master in the NC clock cycle.

☞ The command value cyclically transmitted by the control unit is shown in parameter "P-0-0047, Position command value of control".

The internal position command value at the position controller is indicated in parameter "P-0-0434, Position command value of controller". If required, it can also be read out via parameter "S-0-0047, Position command value".

Command value filtering (jerk limitation)

The position command values provided by the control unit can be smoothed via an adjustable average value filter (parameter "P-0-0041, Position command average value filter time constant", moving average for a maximum of 64 values). The resulting filtering degree is indicated by "P-0-0042, Current position command average value filter order". This filter can be used for jerk limitation.

In the case of drive-controlled position control, a step-change in the position command value is implemented by a change of the position command average value filter with synchronization movement in closed-loop control.

☞ The PT1 filter for jerk limitation that can be parameterized via "P-0-0099, Position command smoothing time constant" only takes effect with linear fine interpolation.

Fine interpolation of the position command value

The position command value cyclically transmitted in the NC cycle by the control unit can be fine-interpolated in the drive, if necessary.

Via "P-0-0187, Position command processing mode" it is possible to switch between:

- linear fine interpolator,
- cubic approximator (default setting) or
- cubic fine interpolator (according to contour)

☞ It is recommended that the cubic fine interpolator (according to contour) be used, because it provides a clearly higher quality of velocity and acceleration feedforward control, particularly with lag-less position control.

Position command value delay

Downstream of the fine interpolator, the position command value can be delayed by a maximum of 32 position controller cycles, before it is fed to the position controller. This allows a master axis to be controlled synchronously with the controlled slave axis. The number of position controller cycles is set using "P-0-0456, Position command value delay". The undelayed "P-0-0457, Position command value generator" is entered in a ring buffer, the delayed position command value is then taken over to "P-0-0434, Position command value of controller".

Drive-controlled change of operation mode

During drive-controlled change of operation mode, the drive internally makes sure that when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly.

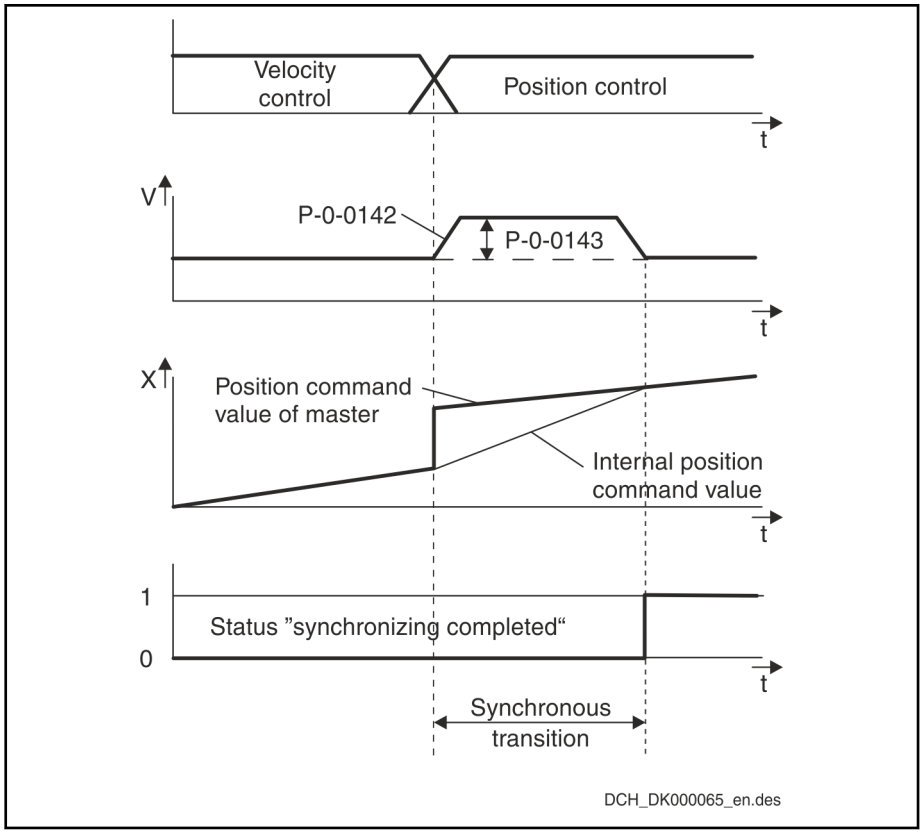


Fig. 6-37: Time diagram "Drive-controlled change of operation mode"

6.11.3 Force command value adjustment

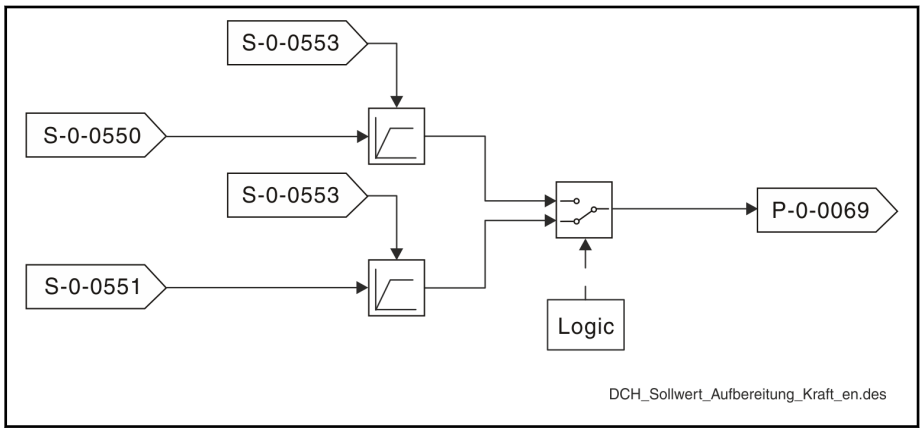


Fig. 6-38: Command value adjustment for closed-loop force control

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter "Alternating control".

Output variable

The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.11.4 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "cyclic position control" mode is indicated by the following diagnostic message:

- A0102, Position mode, encoder 1
- A0104, Position mode lagless, encoder 1
- A0165, Position control with control word of axis controller
- A0154, Position mode drive controlled, encoder 1
- A0156, Position mode lagless, encoder 1 drive controlled
- A0160, Pos. ctrl drive-controlled with ctrl word of axis controller

Monitoring functions

Monitoring functions specific to the operation mode:

- F2037, Excessive position command difference

  In every NC cycle new position command values are transmitted to the drive. The difference between the current and the last position command value is determined and checked for plausibility. For this, the velocity required for reaching the preset position command value (S-0-0047) is calculated and compared with "S-0-0091, Bipolar velocity limit value". The NC cycle time (TNcyc in S-0-0001) is used as the time base for converting the position command value differences into a velocity. If the command velocity corresponding to the preset position command value exceeds the value in S-0-0091, the error message "F2037 Excessive position command difference" is generated. In addition, the two command values involved are written to the following parameters:

  – P-0-0010, Excessive position command value
  – P-0-0011, Last valid position command value

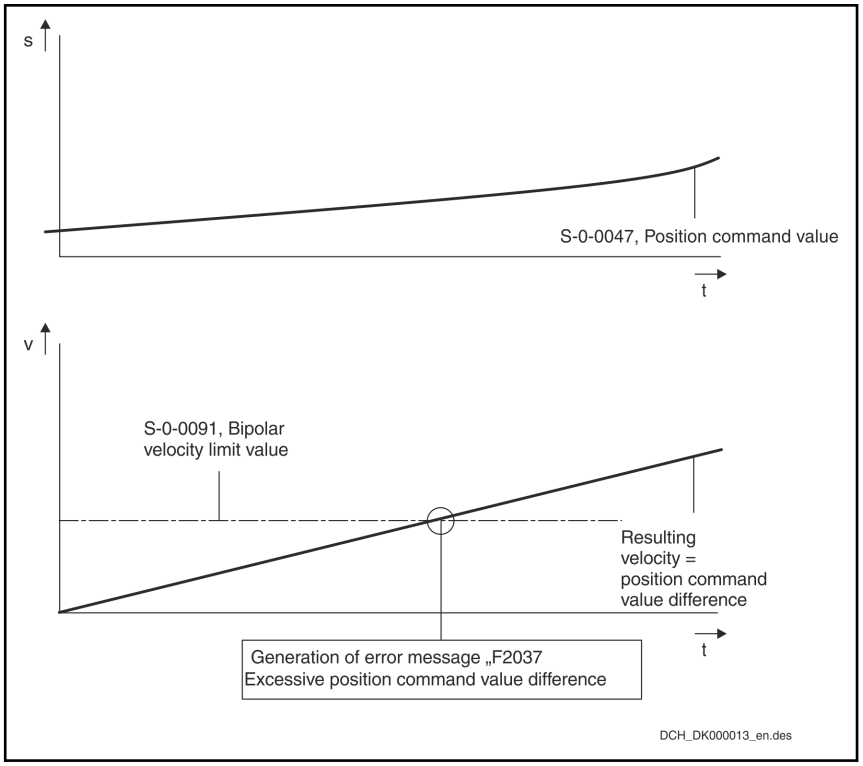


Fig. 6-39: Error monitoring "F2037, Excessive position command difference"

☞ The value entered in parameter "S-0-0091, Bipolar velocity limit value" should be approximately 5 to 10 % higher than the intended maximum velocity of the axis.

☞ Responding of the monitoring function can have the following causes:

- Incorrect command value provision by the control unit
- Command value transmission error

6.11.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-0041, Position command average value filter time constant
- P-0-0042, Current position command average value filter order
- P-0-0099, Position command smoothing time constant
- P-0-0142, Synchronization acceleration
- P-0-0143, Synchronization velocity
- P-0-0151, Synchronization window for modulo format
- P-0-0152, Synchronization completed
- P-0-0154, Synchronization direction
- P-0-0187, Position command processing mode
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0458, Delay of add. command values

- P-0-0010, Excessive position command value
- P-0-0011, Last valid position command value
- P-0-0047, Position command value of control
- P-0-0100, Position command value extension
- S-0-0047, Position command value
- P-0-0059, Additive position command value, controller
- P-0-0069, Torque/force command value of controller
- P-0-0098, Max. deviation
- P-0-0432, Correction value: position controller quadrant correction
- P-0-0434, Synchronization acceleration
- P-0-0435, Control word of position controller
- P-0-0556, Config word of axis controller
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- P-0-0091, Bipolar velocity limit value
- P-0-0550, Torque/force command value, positive
- P-0-0551, Torque/force command value, negative
- P-0-0553, Torque/force command value ramp

Pertinent diagnostic messages

- A0102, Position mode, encoder 1
- A0103, Position mode, encoder 2
- A0104, Position mode lagless, encoder 1
- A0154, Position mode drive controlled, encoder 1
- A0156, Position mode lagless, encoder 1 drive controlled
- A0160, Pos. ctrl drive-controlled with ctrl word of axis controller
- A0161, Drive-controlled posit. with ctrl word of axis controller
- F2037, Excessive position command difference

6.12 Drive-controlled positioning

6.12.1 Brief description

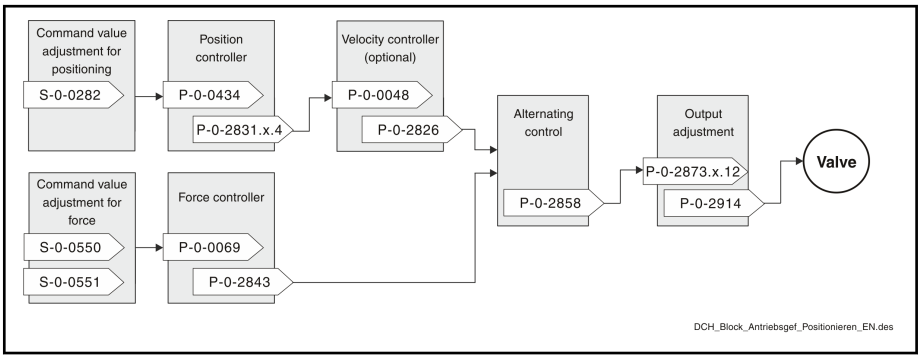


Fig. 6-40: "Drive-controlled positioning" block diagram

The two operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-inter-

nal interpolation" mode is the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-controlled positioning" mode, a positioning command value is preset for the drive. The drive can continue processing this value internally in absolute (position target) or relative (travel distance) form. In the internal interpolator, a position command value characteristic is generated as the input variable for the position controller from the preset positioning data (effective target position, velocity, acceleration and jerk). In contrast to "drive-internal interpolation", with "drive-controlled positioning" the acceptance of the command values can be controlled via the positioning control word (S-0-0346). It is possible to parameterize different types of position processing (see features).

Features

- Processing of an absolute target position or a relative travel distance
- Drive-internal generation of a position command value profile to reach the positioning command value (S-0-0282) while maintaining the adjustable positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359); can be set separately
- Switching between closed-loop position control and closed-loop force control with the help of "alternating control"
- The command value is generated within the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position controller cycle is accomplished by means of cubic fine interpolation.
- Acceptance of the positioning command value via toggle bit (S-0-0346, bit 0)
- Jerk limitation of the generated position command value with parameter "S-0-0193, Positioning jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time by means of "P-0-0641, Interpolation cmd value average value filter time constant"
- "Adjustable P-0-0456, Position command value delay"; maximum of 32 cycles.
- Evaluation of the positioning velocity with parameter "S-0-0108, Feedrate override"
- Monitoring of positioning velocity for exceeding the value in parameter "S-0-0091, Bipolar velocity limit value"
- Monitoring of target position for compliance with position limit values (see "S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value")
- Acceleration and deceleration ramps can be set separately ("S-0-0260, Positioning acceleration" or "S-0-0359, Positioning deceleration")
- Position limit values taken into account when accepting target position, positioning velocity and positioning acceleration
- Jog mode ("infinite travel" positive/negative; S-0-0346, bits 1 and 2)
- Residual path processing can be activated
- "On-the-fly acceptance" of the new target position or intermediate stop



In this operation mode, it is possible to separately parameterize the acceleration and deceleration processes in order to achieve optimum adjustment to the respective application-specific requirements.

6.12.2 Command value adjustment with drive-controlled positioning

Overview

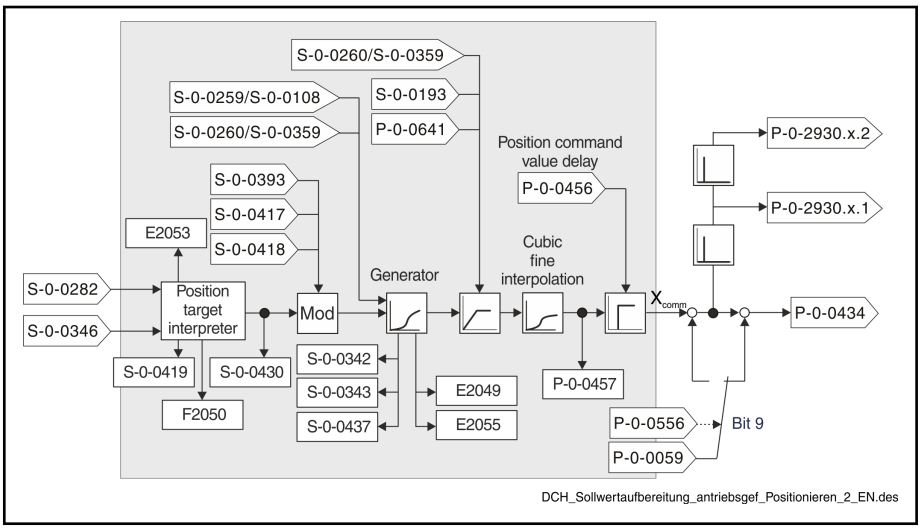


Fig. 6-41: Command value adjustment with drive-controlled positioning

Position target interpreter

Accepting and acknowledging the command value

The acceptance and internal processing of "S-0-0282, Positioning command value" to a value entered in parameter "S-0-0430, Effective target position" is controlled via "S-0-0346, Positioning control word".

Upon every edge of bit 0 (toggle bit) of S-0-0346, the content of "S-0-0282, Positioning command value", is, depending on bit 3 of S-0-0346,

- **copied** to parameter S-0-0430 (when bit 3 = 0 → absolute **target position**)

- or -

- **added** to the value of parameter S-0-0430 (when bit 3 = 1 → **travel distance**).

☞ If a positioning process is interrupted by switching bits 1 and 2 of S-0-0346 from status "00" to"01", "10" or "11", a repeated edge reversal has to take place in bit 0 in order to start a new positioning process! A residual path possibly present is cleared, i.e. the status of bit 4 of S-0-0346 is automatically interpreted as "1" during the next positioning process.

Via "S-0-0419, Positioning command acknowledge" (bit 0), the drive acknowledges that it has accepted the positioning command value. This allows realizing a data handshake for monitoring the command value acceptance between master and drive.

☞ The active target position is displayed in parameter "S-0-0430, Effective target position".

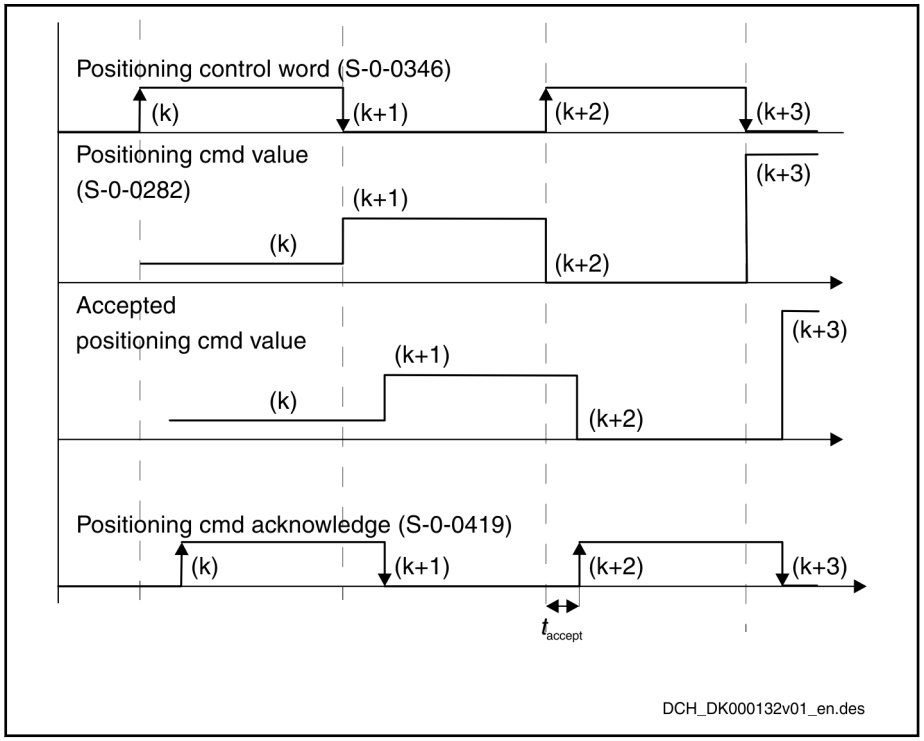


Fig. 6-42: Positioning command value acceptance and acknowledgment

Time t_{accept}, see fig. 6-42 " Positioning command value acceptance and acknowledgment" on page 335, defines the time that passes between the change in state of the acceptance bit by the control unit and the reception of acknowledgment in the master. The time is made up of the effective transmission time of the command values and actual values and thus depends on the configuration of the interface to the master (e.g. Sercos/field bus timing parameters).



If the "drive-controlled positioning" mode is not yet active, the acceptance of the new positioning command value is not acknowledged. If bit 0 of S-0-0346 is unequal to bit 0 of S-0-0419 while this operation mode is being activated, the positioning command value from S-0-0282 is immediately accepted and the drive moves to this command value.

The acceptance is acknowledged when the new positioning command value is taken over from the intermediate buffer to parameter "S-0-0430, Effective target position" and thus to the position command value generator.

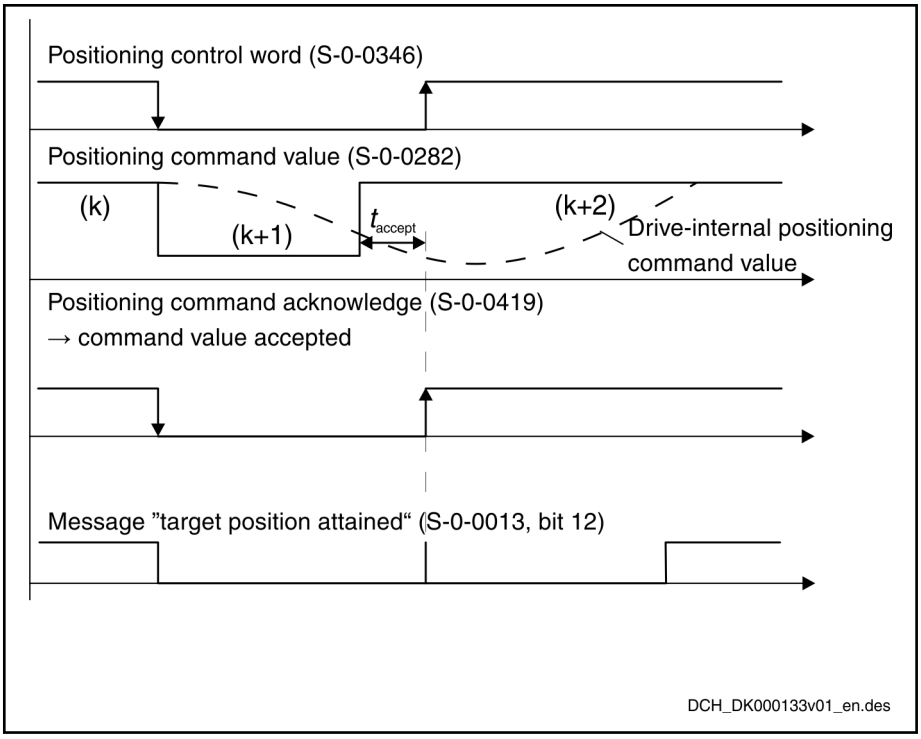


Fig. 6-43: Acknowledgment of positioning command value acceptance in mode "complete move to positioning command value (k+2)"

With the help of parameter "S-0-0346, Positioning control word", the behavior of block acceptance can be configured apart from the control of the operation mode.

Positioning generator

The drive generates the position command value profile necessary to move to the target position while adhering to "S-0-0259, Positioning velocity", "S-0-0260, Positioning acceleration", "S-0-0359, Positioning deceleration", "S-0-0193, Positioning jerk" as well as "S-0-0108, Feedrate override".

6.12.3 Force command value adjustment

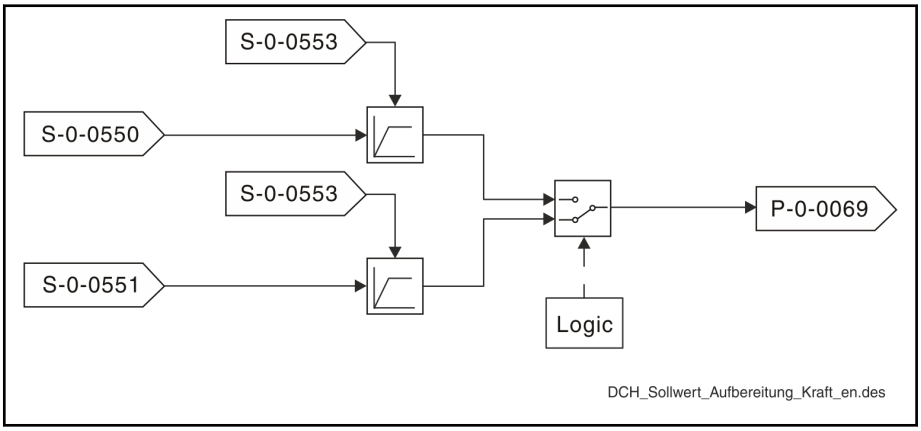


Fig. 6-44: Command value adjustment for closed-loop force control

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0550, Torque/force command value, positive".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter Alternating control.

Output variable

The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.12.4 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "drive-controlled positioning" mode is displayed by one of the following diagnostic messages:

- A0150, Drive-controlled positioning, encoder 1
- A0151, Drive-controlled positioning, encoder 1, lagless
- A0161, Drive-controlled posit. with ctrl word of axis controller

Monitoring functions

Monitoring functions specific to the operation mode:

- E2049, Positioning velocity >= limit value
- E2053 or F2057, Target position out of travel range
- E2055, Feedrate override S-0-0108 = 0
- F2050, Overflow of target position preset memory

If, in the "complete move to positioning command value" mode, one tries to preset a new positioning command value by toggling parameter "S-0-0346, Positioning control word", although the preceding positioning command value (k+1) was not accepted (because the drive had not yet approached the preceding positioning command value (k)), the error message "F2050, Overflow of target position preset memory" is generated.

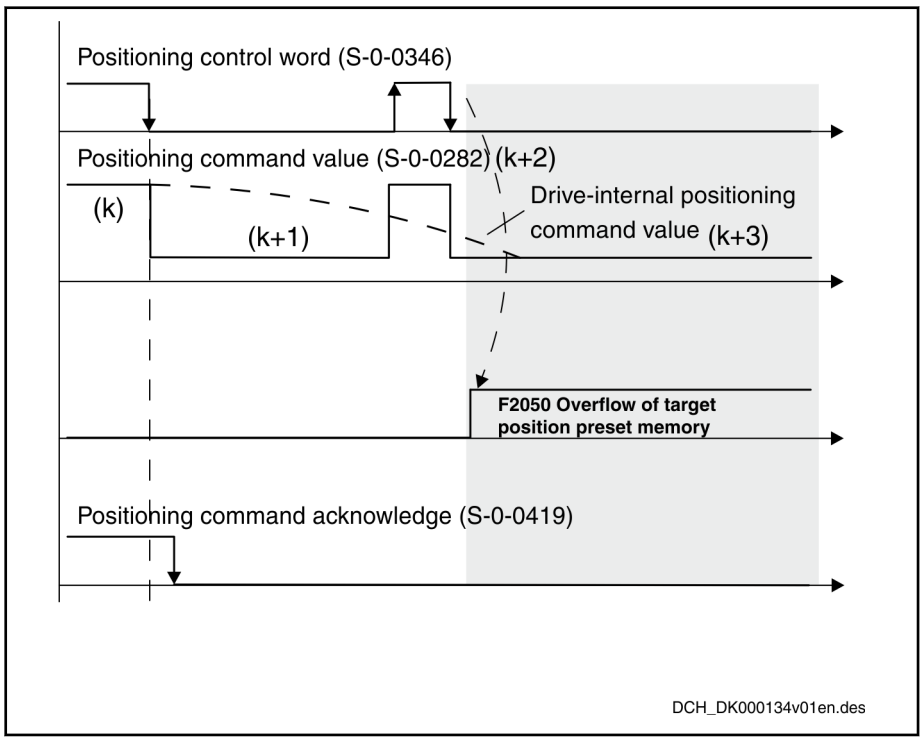


Fig. 6-45: Acknowledgment with error "overflow of target position preset memory"

6.12.5 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0193, Positioning jerk
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0282, Positioning command value
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0346, Positioning control word
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0059, Additive position command value, controller
- P-0-0069, Torque/force command value of controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-2930.0.1, Feedforward control setpoint velocity
- P-0-2930.0.2, Feedforward control setpoint acceleration

Pertinent diagnostic messages

- A0150, Drive-controlled positioning, encoder 1
- A0151, Drive-controlled positioning, encoder 1, lagless
- A0161, Drive-controlled posit. with ctrl word of axis controller
- E2049, Positioning velocity >= limit value
- E2053, Target position out of travel range
- E2055, Feedrate override S-0-0108 = 0
- F2050, Overflow of target position preset memory
- F2057, Target position out of travel range

6.13 Drive-internal interpolation

6.13.1 Brief description

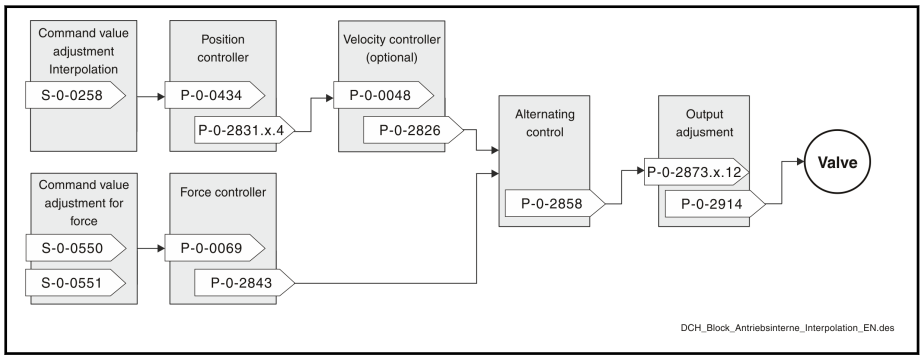


Fig. 6-46: Block diagram of drive-internal interpolation

The two operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-internal interpolation" mode forms the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-internal interpolation" mode, a target position is directly preset for the drive. In the internal positioning generator, a position command value characteristic is generated (interpolated) as input value for the position controller from the preset value for the target position taking account of preset positioning data (velocity, acceleration and jerk). New command values (target position, velocity, acceleration and jerk) are accepted directly in the positioning generator. This means that, for example, the velocity can be changed during the positioning process. A new target position is directly accepted as well without the previous target position having to have been reached first.

Features

- Drive-internal generation of a position command value profile to travel to a preset target position (S-0-0258) while maintaining the adjustable positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359); can be set separately
- Switching between closed-loop position control and closed-loop force control with the help of "alternating control"
- The command value is generated within the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position controller cycle is accomplished by means of cubic fine interpolation.
- Jerk limitation of generated position command value with parameter "S-0-0193, Positioning jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time by means of interpolation cmd value average value filter time constant "P-0-0641, Interpolation cmd value average value filter time constant"
- Adjustable "P-0-0456, Position command value delay" in position controller cycles; maximum of 32 cycles
- Evaluation of the positioning velocity with "S-0-0108, Feedrate override"
- Monitoring of positioning velocity for exceeding the value in parameter "S-0-0091, Bipolar velocity limit value"
- Monitoring of the target position for compliance with the position limit values
- Acceleration and deceleration ramps, can be set separately



In this operation mode, it is possible to separately parameterize the acceleration and deceleration processes. This allows optimum adjustment to the respective application-specific requirements.

6.13.2 Command value adjustment with drive-internal interpolation

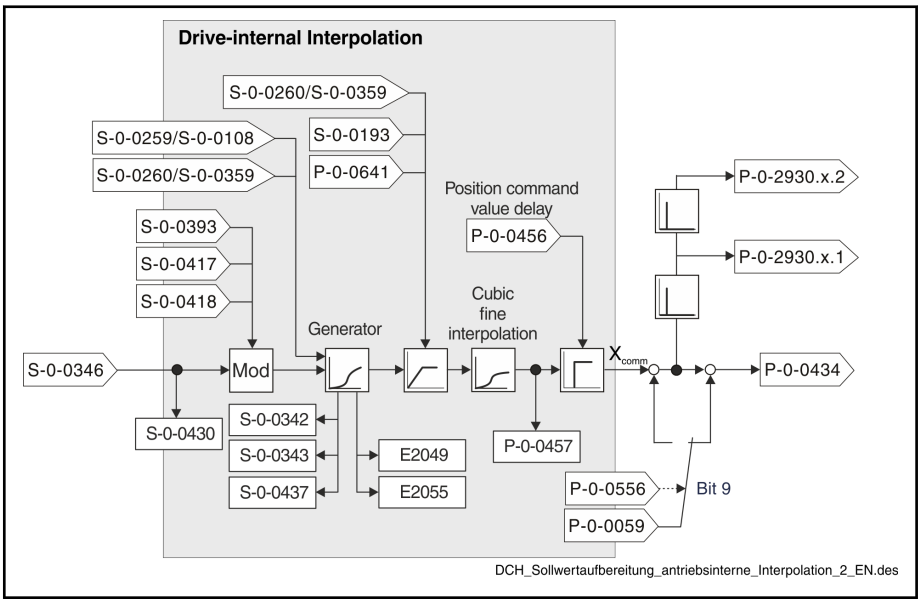


Fig. 6-47: Command value adjustment with "drive-internal interpolation"

The target position can be cyclically preset via parameter "S-0-0258, Target position". The drive generates the position command value profile necessary to move to the target position while adhering to "S-0-0259, Positioning velocity", "S-0-0260, Positioning acceleration", "S-0-0359, Positioning deceleration", "S-0-0193, Positioning jerk" as well as "S-0-0108, Feedrate override". The target position preset by the control master is shown in parameter "S-0-0430, Effective target position".

6.13.3 Force command value adjustment

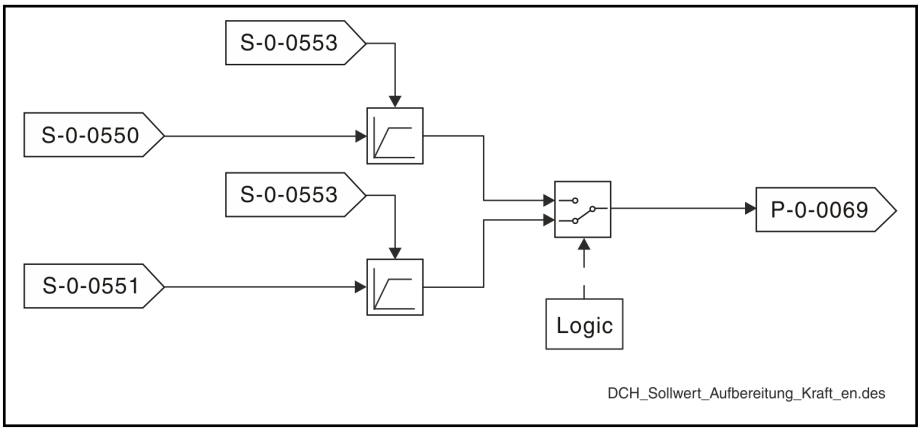


Fig. 6-48: Command value adjustment for closed-loop force control

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in the chapter “Alternating control”.

Output variable The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.13.4 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "drive-internal interpolation" mode is indicated by one of the following diagnostic messages:

- A0106, Drive-internal interpolation, encoder 1
- A0108, Drive controlled interpolation, lagless, encoder 1 or
- A0166, Drive-internal interpolat. with ctrl word of axis controller

Monitoring functions

Monitoring functions specific to the operation mode:

- E2049, Positioning velocity >= limit value
- E2055, Feedrate override S-0-0108 = 0

6.13.5 Pertinent parameters/diagnostic messages

Pertinent parameters

- S-0-0108, Feedrate override
- S-0-0193, Positioning jerk
- S-0-0258, Target position
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0059, Additive position command value, controller
- P-0-0069, Torque/force command value of controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-2930.0.1, Feedforward control setpoint velocity
- P-0-2930.0.2, Feedforward control setpoint acceleration

Pertinent diagnostic messages

- A0106, Drive-internal interpolation, encoder 1
- A0108, Drive controlled interpolation, lagless, encoder 1
- A0166, Drive-internal interpolat. with ctrl word of axis controller
- E2049, Positioning velocity >= limit value
- E2055, Feedrate override S-0-0108 = 0

6.14 Positioning block mode

6.14.1 Brief description

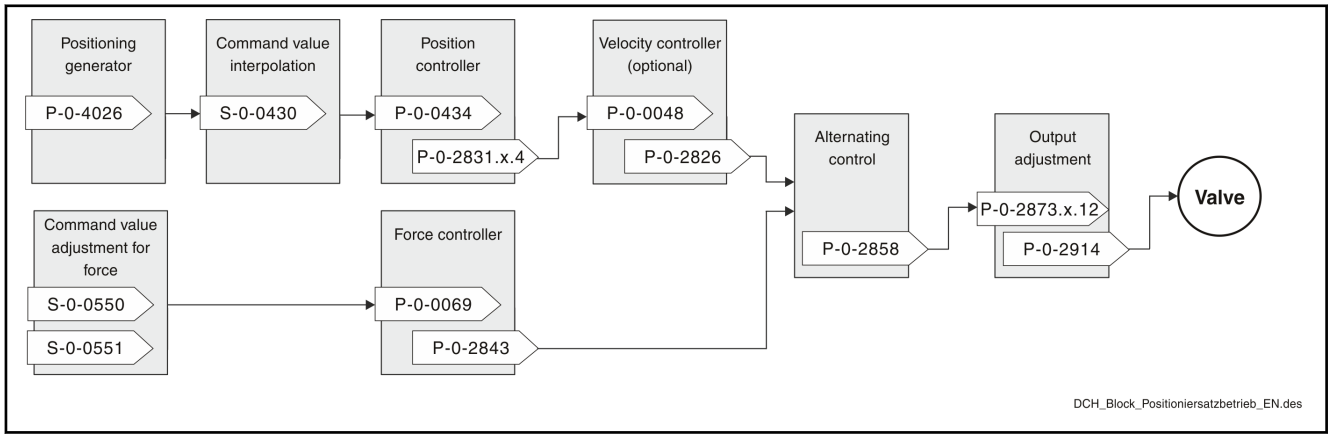


Fig. 6-49: Positioning block mode block diagram

In the “positioning block mode” operation mode, it is possible to run up to 64 programmed positioning blocks. The drive moves to the target position in position control, while maintaining velocity, acceleration, deceleration and jerk limits as defined in the respective positioning block. This operation mode is ideal for programming simple cyclic programming sequences without a higher-level control using IndraWorks. The positioning block mode can, however, also be used for dislocating positioning processes from the control and merely having commanding of the control word (S-0-0346) carried out by the control.

Features

- Parameterization of up to 64 positioning blocks; each with target position/travel distance, velocity, acceleration, deceleration, and jerk
- The command value is generated within the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position controller cycle is accomplished by means of cubic fine interpolation.
- Jerk limitation of the generated position command value via "S-0-0193, Positioning jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time by means of "P-0-0641, Interpolation cmd value average value filter time constant"
- Adjustable "P-0-0456, Position command value delay"; maximum of 32 cycles
- Defined block acceptance by toggling bit 0 in "S-0-0346, Positioning control word" with reaction time $t_{R_strobe} = t_{position}$

  Note: An exception to this is the I/O mode with field bus drives. In this case, acceptance takes place by a positive edge of bit 0 in "P-0-4060, Positioning block control word".

→ Block selection and acknowledgment via separate parameters (handshake principle)

- Positioning modes that can be freely parameterized:
  - Relative positioning
  - Absolute positioning
  - Infinite travel (positive or negative)
- Single-block or sequential block mode with different conditions for advancing:
  - Block advance with switch cams
  - Block advance at defined position value
  - Block transition with "old" or "new" positioning velocity
- In the as-supplied condition, the positioning velocity is limited to 100 for safety reasons
- Positioning block transition with freely definable delay time (P-0-4018)
- Positioning taking account of command value mode (shortest distance, positive direction, ...)
- Residual path processing can be activated (→ no loss of incremental dimension)
- "Slow travel" mode can be activated (velocity limitation to "S-0-0259, Positioning velocity"
- Adjustable velocity override

Fields of application

Sequential block processing allows executing several positioning blocks in direct succession without having to give a new start signal each time. Typical fields of application are:

- There is no or only a very simple higher-level control unit available and the activation is only realized via digital I/Os or a field bus control word (I/O mode with field bus interface).
- Quick reaction times or block advances are required. The required motion profiles can be represented in the drive by the maximum possible 64 positioning blocks.
- Positioning processes are required which cover long distances at high speeds (rapid traverse) and then position at the end position at low speed without any intermediate stops; for example:
  - Taking up or putting down of items to be handled in handling robots
  - Execution of joining processes in assembly facilities

A sequential block chain consists of a start block and one or several sequential blocks. The start block is selected and activated in the usual way. The transition to the sequential block can take place in various ways.

Sequential block operation is possible with both, absolute and relative positioning blocks with residual path storage. The last block of a sequential block chain is not defined as sequential block, which marks the end of the sequential block chain.

6.14.2 Command value adjustment with positioning block mode

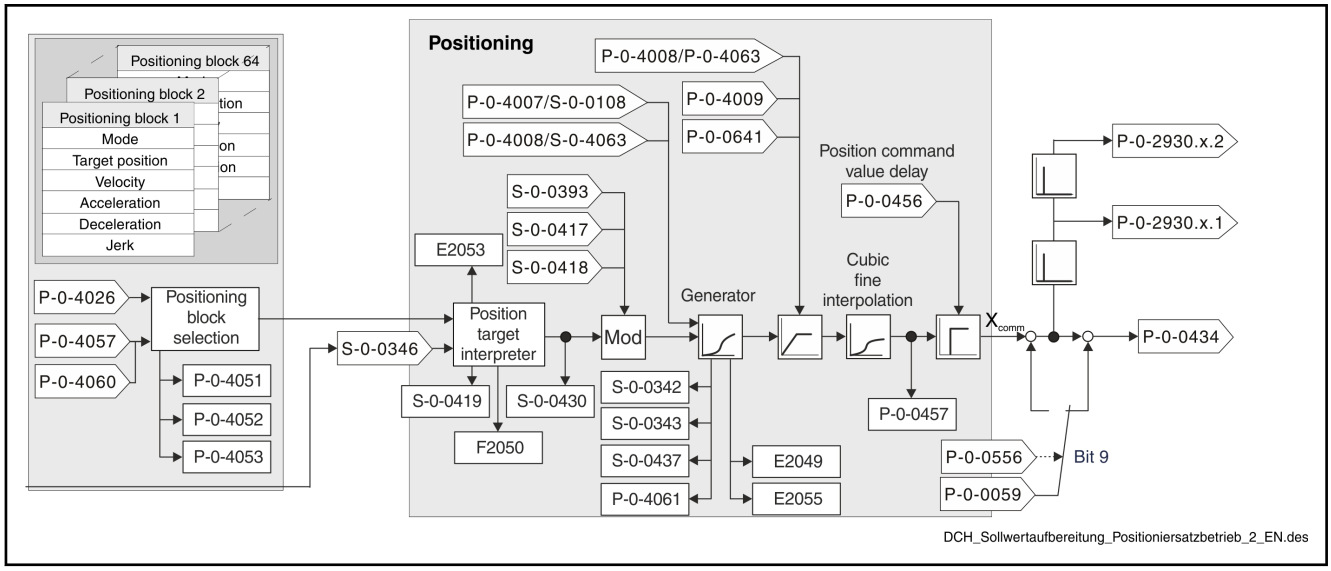


Fig. 6-50: Command value adjustment with positioning block mode

6.14.3 Single-block processing

Description of basic function

General information

Positioning block elements

A positioning block is defined by:

- P-0-4006, Positioning block target position
- P-0-4007, Positioning block velocity
- P-0-4008, Positioning block acceleration
- P-0-4009, Positioning block jerk
- P-0-4018, Positioning block delay time
- P-0-4019, Positioning block mode
- P-0-4063, Positioning block deceleration

Each parameter contains 64 elements, with elements of the same number describing the travel profile of the respective positioning block with this number.

The drive reaches the relevant positioning block velocity after an acceleration phase at the corresponding "P-0-4008, Positioning block acceleration".

Effective positioning velocity

The effective velocity during a positioning process is calculated as follows:

v_{max} = P-0-4007 * S-0-0108 / 100 %

where:

v_{max}: Velocity

P-0-4007: Positioning block velocity

S-0-0108: Feedrate override

Effective acceleration and deceleration

The maximum deceleration is specified by parameter "P-0-4063, Positioning block deceleration".

NOTICE **The specified target is never reached or overrun when the acceleration or deceleration value equals zero, because the drive can no longer brake!**

⇒ Set acceleration value > 0!

☞ A further limitation is achieved with the value of parameter "S-0-0138, Bipolar acceleration limit value", because this limit value takes effect in all operation modes with position control.

Jerk limitation by jerk filter

In the "positioning block mode" mode the position command value can be filtered at the output of the positioning generator. We distinguish between two cases for setting of the filter order.

Case 1: Filter order calculated from A / R

The filter order of the (moving) average filter available to do this (cf. P-0-0042) is calculated on the basis of the preset positioning block acceleration or the positioning block jerk.

This means that the parameterized acceleration or deceleration only becomes effective after t = P-0-0042 × T_{NCYC}.

☞ T_{NCYC} is the generator cycle time (S-0-0001).

Internally determining the value of P-0-0042 for positioning block mode

P-0-0042 = P-0-4008 / P-0-4009 or P-0-0042 = P-0-4063 / P-0-4009

where:

P-0-0042: Current position command average value filter order

P-0-4008: Current position command average value filter order

P-0-4063: Positioning block deceleration

P-0-4009: Positioning block jerk

☞ With a value equal to zero in parameter P-0-4009, the smoothing filter is switched off, i.e. the desired acceleration or deceleration is immediately reached.

Case 2: Constant filter order

The filter order can also be set to a constant value. This can be carried out via parameter "P-0-0641, Interpolation cmd value average value filter time constant". The filter order is calculated from the time constant referred to the generator cycle time T_{NCYC}. With an order > 0, the function of constant filter order is active and the calculation A / R is not effective. In this context, a new filter order may only take effect upon initialization of the operation mode, as well as upon block change. The current filter order is continued to be shown in P-0-0042.

Position command value delay

Downstream of the fine interpolator, the position command value can be delayed before it is fed to the position controller. This allows a master axis to be controlled synchronously with the controlled slave axis. The number of position controller cycles is set using "P-0-0456, Position command value delay". The undelayed position command value generator (P-0-0457) is entered in a ring buffer, the delayed position command value is then taken over to the position command value controller (P-0-0434).

Positioning block control word

With parameter "P-0-4060, Positioning block control word" (bit 1), the positioning velocity can be limited to the value defined in parameter "S-0-0259, Positioning velocity".

Position feedback

When a positioning block has been completed, bit 4 (end position reached) is set in parameter "P-0-4061, Positioning block status word".

→ |S-0-0430 - S-0-0051| < S-0-0057 && no sequential block

Interrupting a positioning block

The positioning block mode can be interrupted by:

- Withdrawing the controller enable
- Activating "Drive Halt"
- Changing the operation mode
- Jogging
- Positioning stop or operational stop (S-0-0346, bit 1 and bit 2 = 1)
- A drive error occurring

Positioning block modes

Parameter "P-0-4019, Positioning block mode" is used to define the way in which the target position is processed in parameter "P-0-4006, Positioning block target position". There are the following options:

- Absolute positioning
- Relative positioning
- Relative positioning with residual path storage
- Infinite travel in positive/negative direction
- Sequential block processing

Command value mode (S-0-0393)

The parameter "S-0-0393, Command value mode" controls the drive behavior in case "modulo format" was set as processing format of the position data.

The following modes have to be distinguished:

- Shortest distance
- Positive direction
- Negative direction

The following limiting conditions have to be taken into account:

- If the amount of the current actual velocity is greater than the velocity threshold for positioning in modulo format (S-0-0417), the drive is always operated in the direction last active.
- If the target position is within the target position window in the modulo format (S-0-0418), positioning is always carried out according to the "shortest distance" principle.

NOTICE

If the velocity threshold for positioning in modulo format was parameterized with very small values that are within the noise level of the actual velocity value, this can cause unpredictable behavior.

Activating positioning blocks

Command value acceptance

Depending on the master communication, a positioning block is started by:

- Toggling of bit 0 in parameter "S-0-0346, Positioning control word"

- or -

- With field bus interface in IO mode, positive edge of bit 0 in parameter "P-0-4060, Positioning block control word"

The positioning command value is thereby copied (absolute target position) or added (relative position target, travel distance) to the effective target position (S-0-0430).

☞ The block acceptance is confirmed by updating "P-0-4051, Positioning block acknowledgment" and "S-0-0419, Positioning command acknowledge". In addition, with a positive edge of bit 0 of parameter P-0-4060, bit 0 of parameter S-0-0346 is also toggled internally.

Depending on the master communication and profile type, the block acceptance requires different configurations in the cyclic command value channel:

- **Sercos interface**
  - "S-0-0346, Positioning control word" has to be configured in the cyclic data channel (MDT)
- **Field bus interface**
  - In the freely configurable mode (profile type P-0-4084 = 0xFFFE), bit 0 of P-0-4077 is mapped to bit 0 of S-0-0346.
  - In the "I/O mode positioning" (profile type P-0-4084 = 0xFF82), bit 3 of P-0-4068 is mapped to bit 0 of "P-0-4060, Positioning block control word".

    As an alternative, starting in the I/O mode is also possible by setting the start signal (P-0-4068, bit 1).

See also "Command value acceptance and acknowledgment".

☞ If bit 0 is different in S-0-0346 and in S-0-0419 when the operation mode is activated, the selected positioning block is immediately accepted and executed.

Block selection

In the positioning block mode, the block is always selected via the content of parameter "P-0-4026, Positioning block selection".

Depending on the master communication, parameter P-0-4026 can be written in different ways:

Configuration of P-0-4026	Master communication	
	Sercos interface	Field bus interface
Via cyclic data channel	■	■
Via digital inputs	■	■
Via serial interface	■	■
Via field bus control word	--	■

Tab. 6-3: Possibilities of writing parameter P-0-4026 depending on master communication

☞ The assignment of P-0-4026 to digital inputs requires, among other things, the parameters "S-0-0144, Signal status word" and "S-0-0145, Signal control word".

Absolute positioning

Parameter setting "P-0-4019, Positioning block mode" = 0b0000 0000 0000 0000

Function In an absolute positioning block, the target position is a fixed (absolute) position within the machine coordinate system.

For absolute positioning the drive must have been homed.

Example:

Absolute positioning with target position = 700 (current position = 200)

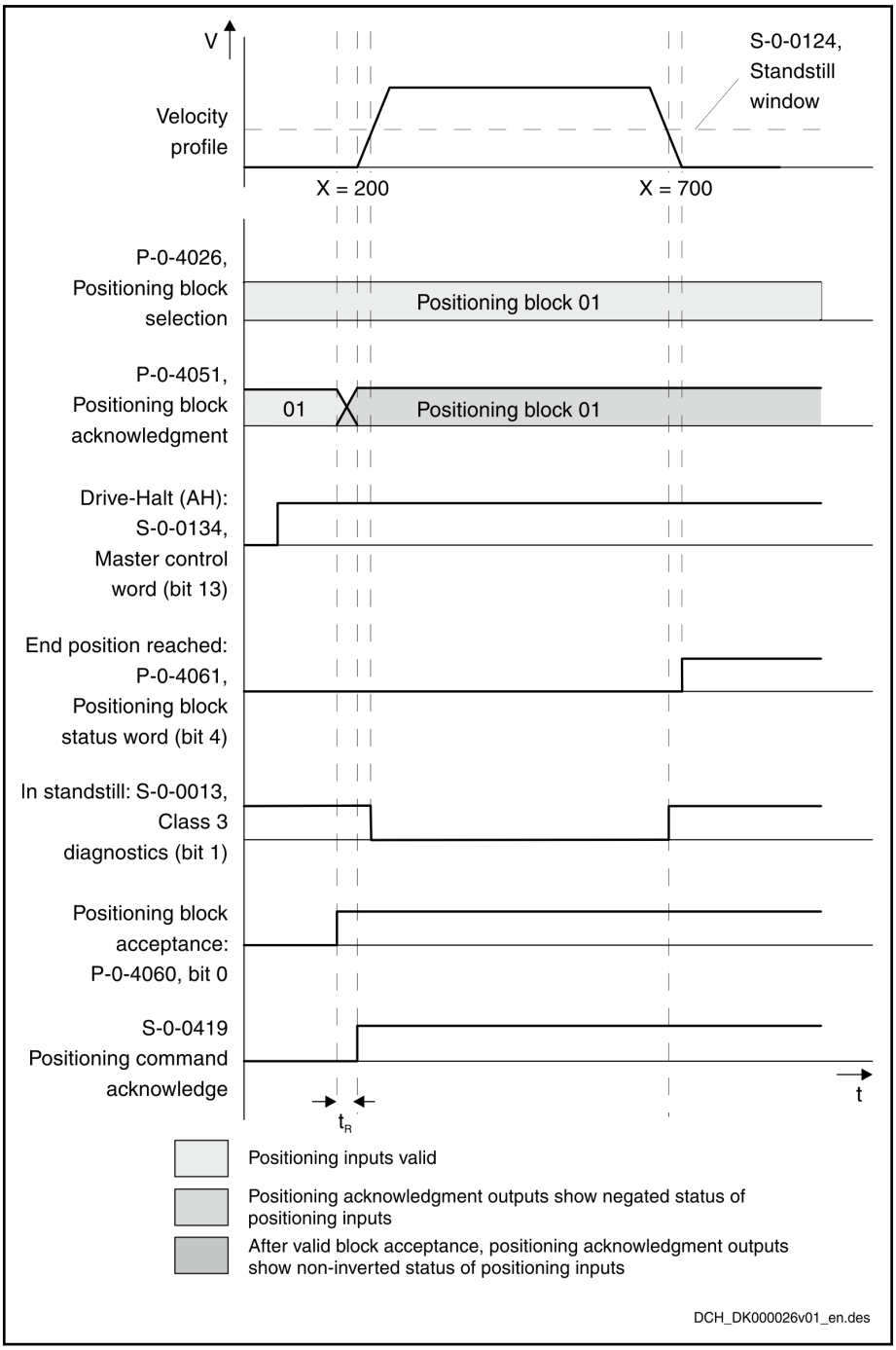


Fig. 6-51: Absolute positioning block

☞ Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Relative positioning without residual path storage

Parameter setting "P-0-4019, Positioning block mode" = 0b0000 0000 0000 0010

Dedicated position In the case of relative positioning blocks without residual path storage, the target position contained in the positioning block is added to the current position.

Relative positioning blocks are also executed, if the drive has not been homed.

Incremental dimension reference By sequencing relative positioning blocks it is possible to position with incremental dimension. If a relative positioning block without residual path storage is interrupted, the incremental dimension reference gets lost.

When the positioning block is completed (i.e. the drive reaches the target position and the message "end position reached" is active), positioning is possible without losing the incremental dimension reference.

☞ If infinite positioning in either a forward or backward direction is achieved by sequencing relative positioning blocks (conveyor belt), the position data must be scaled in modulo format (modulo value = length of conveyor belt or modulo value = 2 × maximum travel distance).

Example:

Relative positioning without residual path storage with travel distance = 700 (current position = 200; target position = 900)

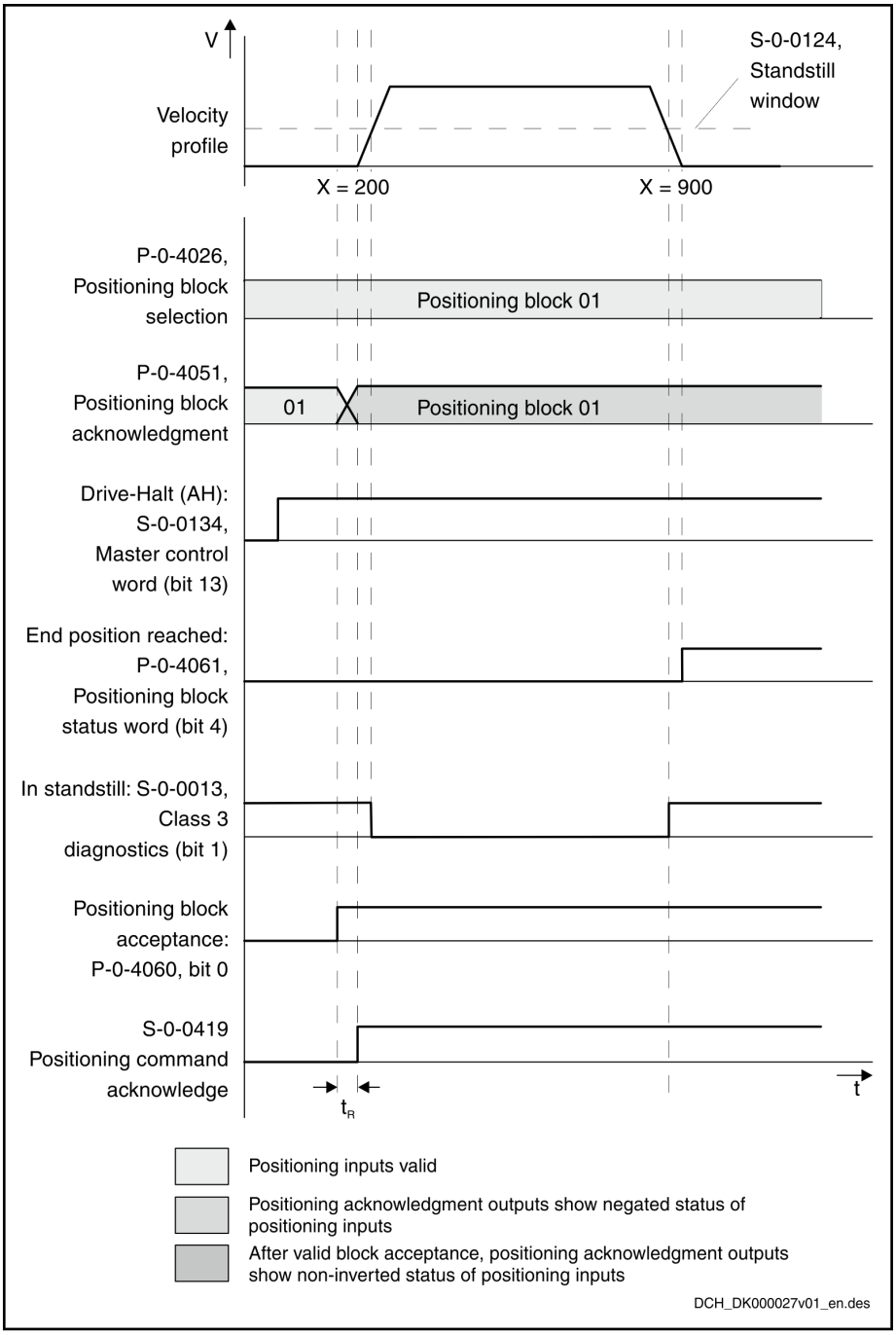


Fig. 6-52: Relative positioning block without residual path storage

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Example:

Relative positioning without residual path storage with target position = 700 (current position = 200); interrupting and restarting a relative positioning block without residual path storage

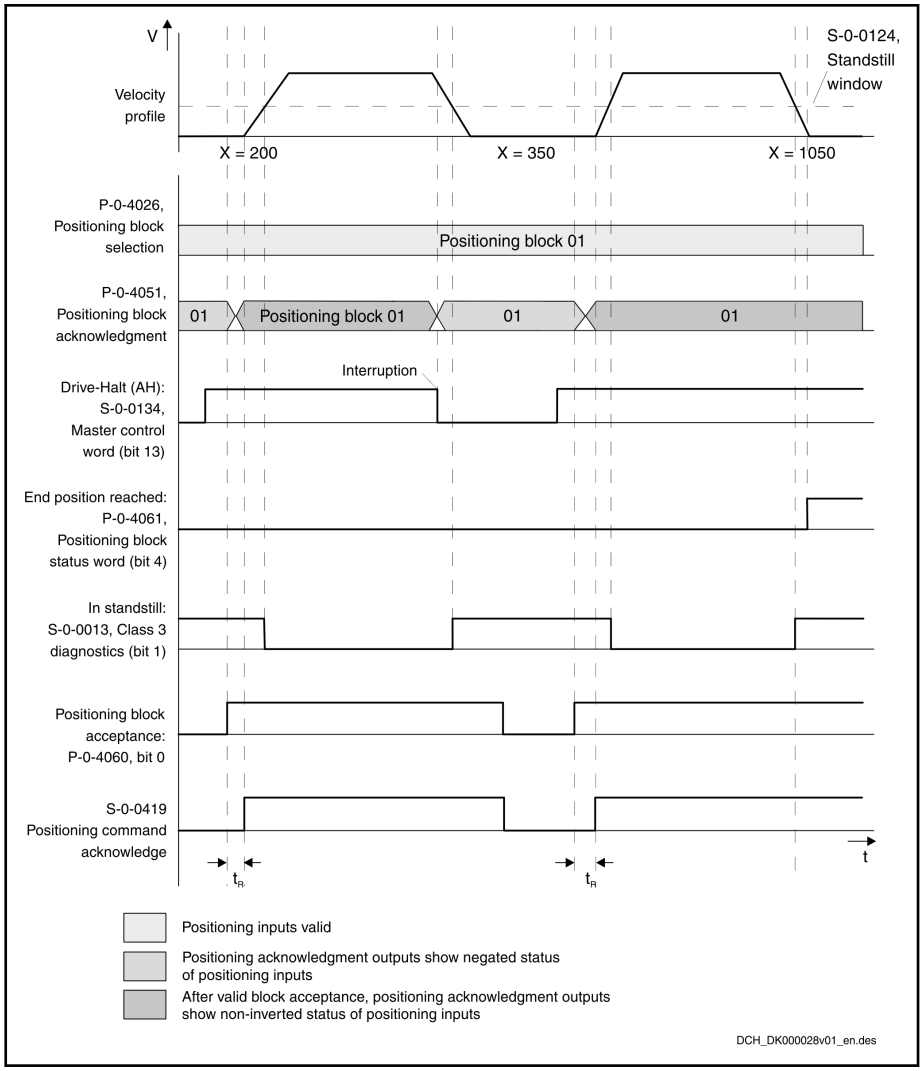


Fig. 6-53: Interrupting a relative positioning block without residual path storage

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Relative positioning with residual path storage

Basic function

Parameter setting

"P-0-4019, Positioning block mode" = 0b0000 0001 0000 0010

Residual path

If positioning blocks are interrupted, a distance still to be traveled up to the target position remains. This remaining distance is the residual path.

In a relative positioning block with residual path storage, the target position is a relative distance that relates to the target position at which the message "end position reached" was last active.

Relative positioning blocks with residual path storage are also executed, if the drive has not been homed.

Incremental dimension reference

By sequencing relative positioning blocks it is possible to position with incremental dimension. If a relative positioning block with residual path storage is interrupted, the incremental dimension reference is retained.

☞ If another positioning block is started while such a positioning block is being executed, the residual path is rejected. If this new block is also a relative positioning block with residual path storage, the target position is related to the current actual position as a relative distance.

Example:

- Relative positioning with residual path storage with travel distance = 700 (plus residual path = 20 of positioning block n-1)
- Without interruption
- Current position = 180; new target position = 900

Dedicated position The last valid target position is used as dedicated position (in the example, position = 200 of positioning block n-1).

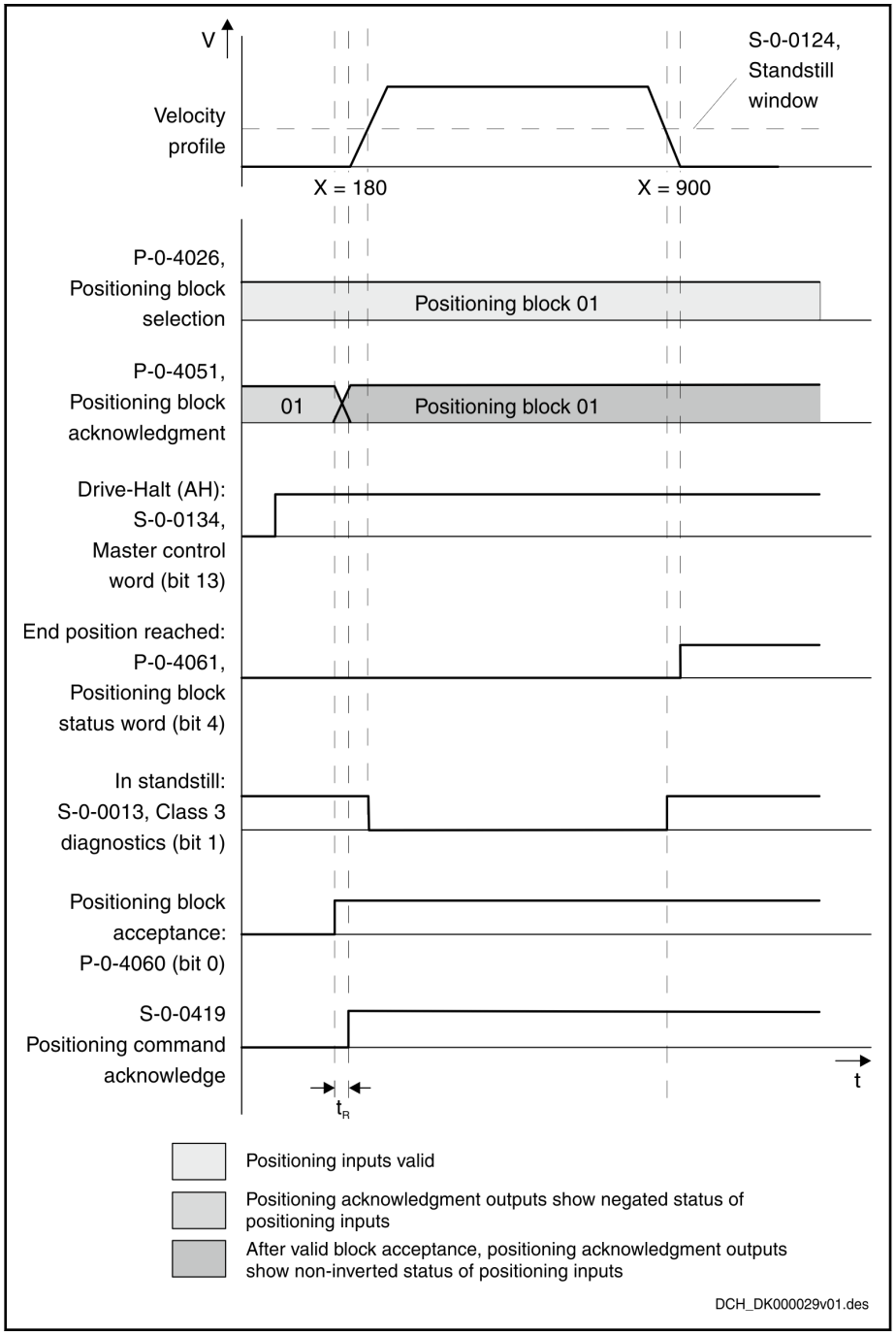


Fig. 6-54: Relative positioning block with residual path storage

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Relative positioning block with residual path storage after activating drive enable

Example:

Interrupted relative positioning block with residual path storage after activation of drive enable with travel distance = 400 (current position = 200; target position = 800).

Dedicated Position

The position command value at the last "end position reached" (position = 200) message is used as the dedicated position.

The incremental dimension reference is ensured.

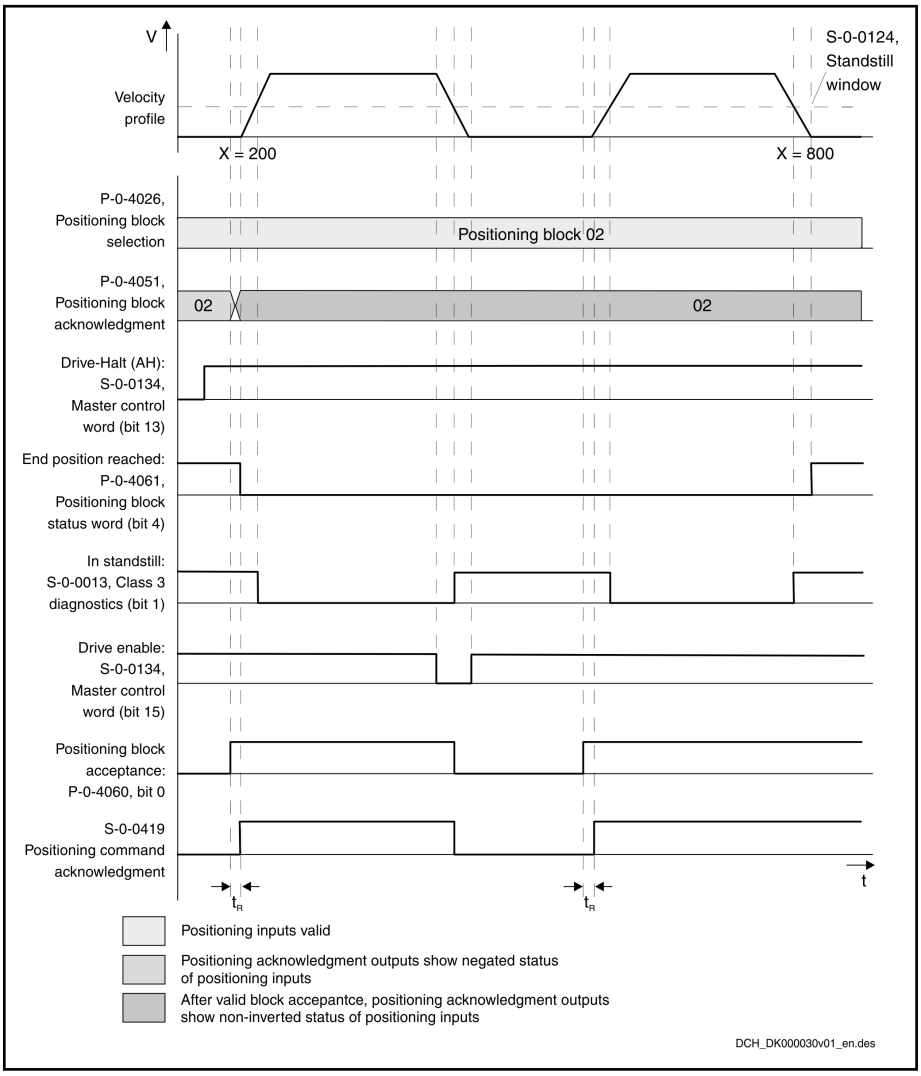


Fig. 6-55: Relative positioning block with residual path storage after activating drive enable

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

6.14.4 Sequential block processing

Basic function

For sequential block processing, the same basic rules apply as for single-block processing. In addition to mere positioning block functions with defined positioning blocks and block acceptance, there also is a defined block transition to be parameterized.

Selecting and activating a sequential block

A positioning block with sequential block is selected and activated in the usual way, with only the first block of the sequential block chain being selected. The sequential block is the block with the next higher block number. A sequential block itself can also have a sequential block so that after a start block up to 63 sequential blocks can be set.

☞ The potential sequential block of the last valid block is block 0.

Advancing conditions in sequential block mode

There are two basically different modes for block advancing, which can be subdivided as follows:

- Position-dependent block advance
  - Block transition with old positioning velocity
  - Block transition with new positioning velocity
- Block transition with intermediate stop and defined delay time (see P-0-4018)
- Switching signal-dependent block advance

Position-dependent block advance

General information

With position-dependent block advance, switching to the sequential block is carried out at the target position of the start block.

There are three different types of block transition:

- Block transition with old positioning velocity (mode 1)
- Block transition with new positioning velocity (mode 2), rapid/creep speed
- Block transition with intermediate stop and defined delay time

Block transition with old positioning velocity (mode 1)

Parameter setting

- "P-0-4019, Positioning block mode" = 0b0000 0000 0001 0000
  → Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 0001 0010
  → Relative block with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 0001 0100
  → Infinite block in positive direction with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 0001 1000
  → Infinite block in negative direction with sequential block

Function

In this mode, the target position of the start block is run through at the velocity of the start block. Then the positioning velocity is switched to that of the sequential block.

With relative and absolute positioning blocks with block advance, the drive moves towards the target position. As soon as the target position is overrun, the drive switches to the next travel block n+1.

With infinite positioning blocks, the drive moves in positive or negative direction. As soon as the target position is passed, the drive switches to the next positioning block n+1, with block n representing the positioning block that is currently being processed.

If the target position is not in the selected travel direction, the drive moves in the direction of the target position. Thus, the drive always reaches the changeover position.

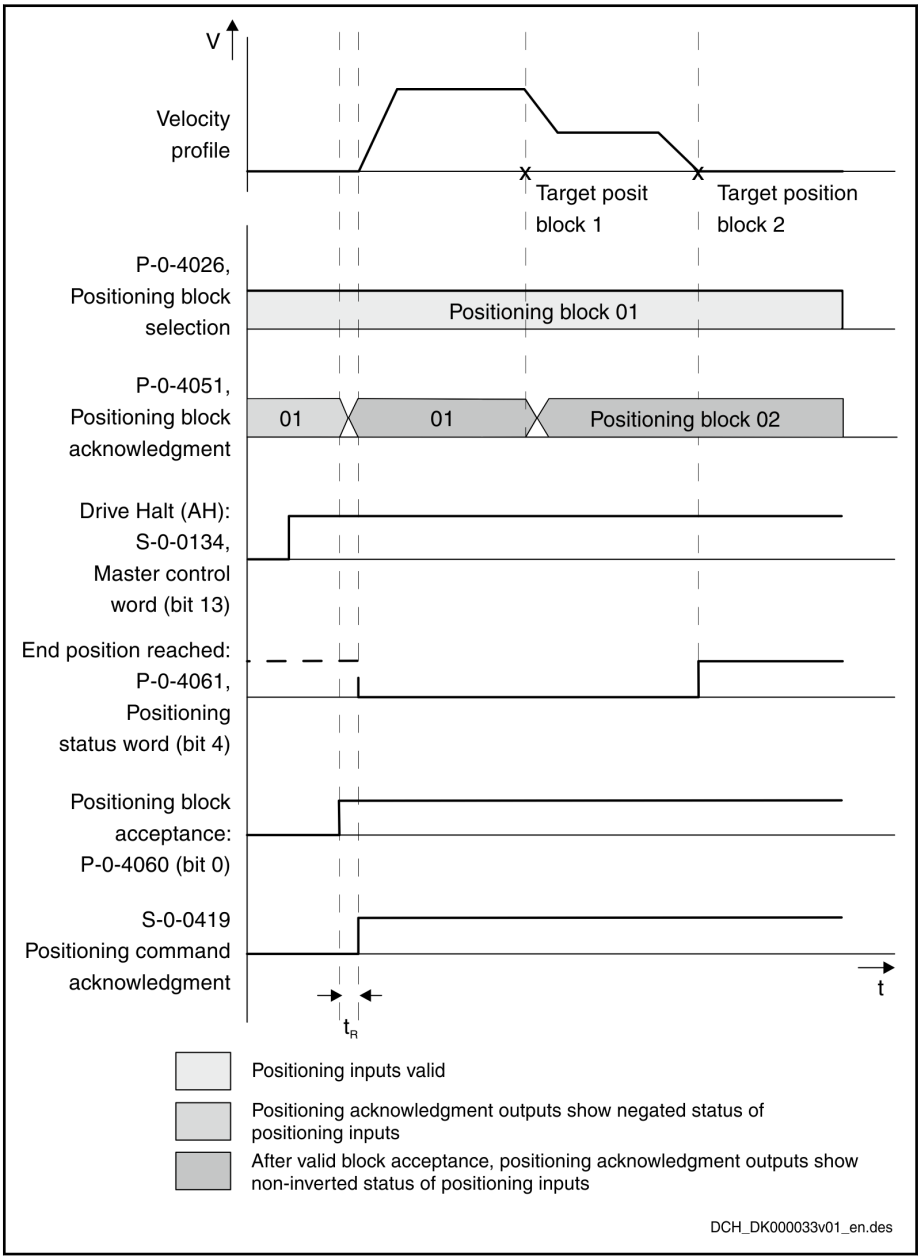


Fig. 6-56: Example: Position-dependent block advance (mode 1)

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Block transition with new positioning velocity (mode 2), rapid/creep speed

Parameter setting

- "P-0-4019, Positioning block mode" = 0b0000 0000 0010 0000
  → Absolute block with sequential block
-

"P-0-4019, Positioning block mode" = 0b0000 0000 0010 0010

→ Relative block with sequential block

- "P-0-4019, Positioning block mode" = 0b0000 0000 0010 0100

  → Infinite block in positive direction with sequential block

- "P-0-4019, Positioning block mode" = 0b0000 0000 0010 1000

  → Infinite block in negative direction with sequential block

Function

In this mode, the target position of the start block is passed at the positioning velocity of the sequential block. The deceleration or acceleration processes required to adjust the velocity are already carried out in the start block.

The drive moves in the direction of the target position x_n (with infinite blocks in the preset direction) set in current positioning block n. In due time before that, the acceleration value is used to accelerate or decelerate to the next positioning velocity v_{n+1} so that the velocity v_{n+1} is reached at the target position x_n.

Switching to the next positioning block does, however, not occur before the target position is overrun.

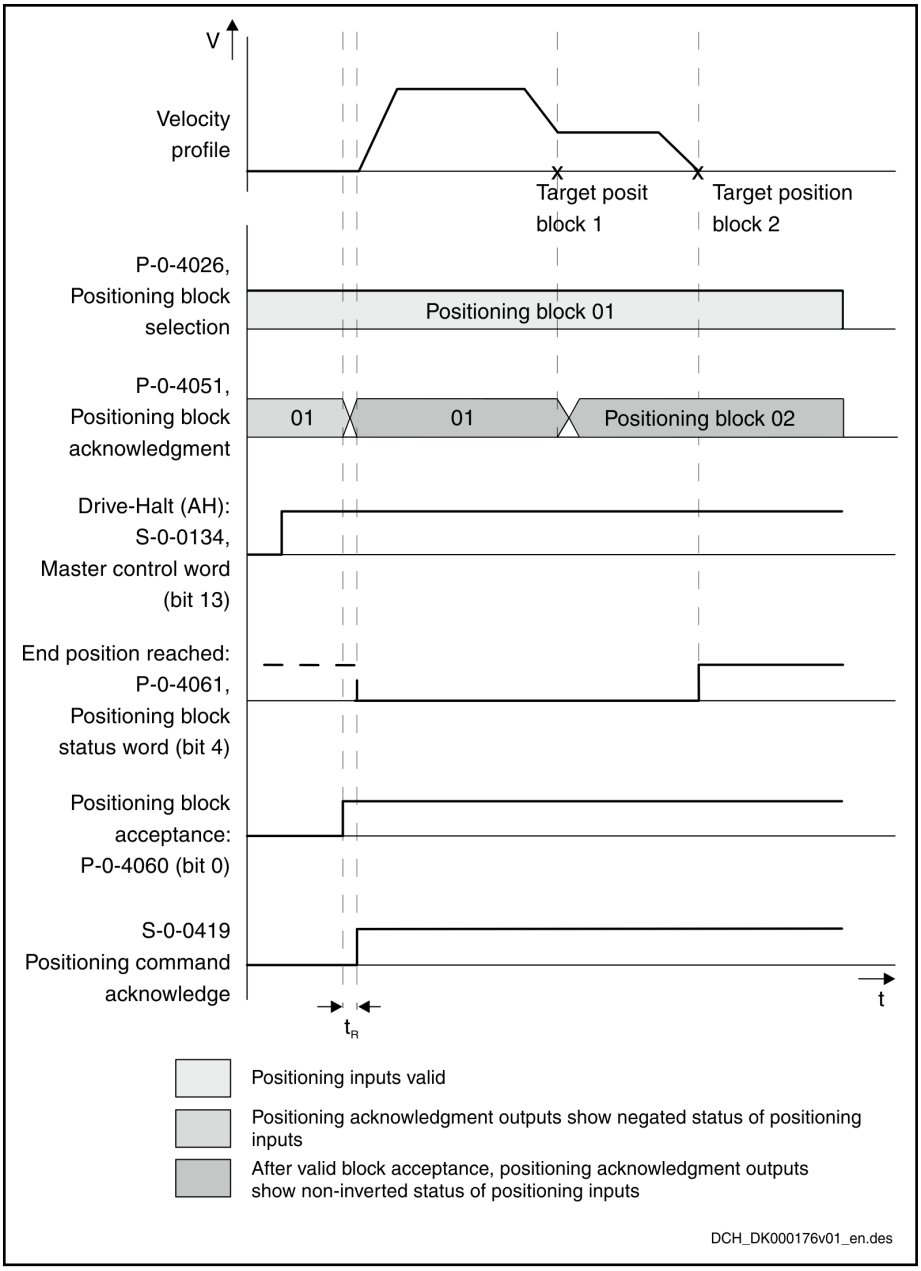


Fig. 6-57: Example: Position-dependent block advance (mode 2)

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Block transition with intermediate stop and defined delay time

Parameter setting

- "P-0-4019, Positioning block mode" = 0b0000 0000 0100 0000
  → Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 0100 0010
  → Relative block with sequential block

Function

In this mode, the drive first positions at the target position of the start block. Once the position command value is at the target position, the sequential block is automatically started without a new start signal having been given

externally. If a delay time (P-0-4018) was parameterized for the positioning block, the sequential block is only started when the delay time is over.

Another operation mode is switching when overrunning the target position with intermediate stop.

In this case, the drive is decelerated to standstill at the target position and then accelerated to the new positioning velocity.

Advancing takes place when the internal command value generator has reached the target position, and a possibly parameterized delay time (P-0-4018) has elapsed. With very small jerk values, the resulting dwell time is relatively long.

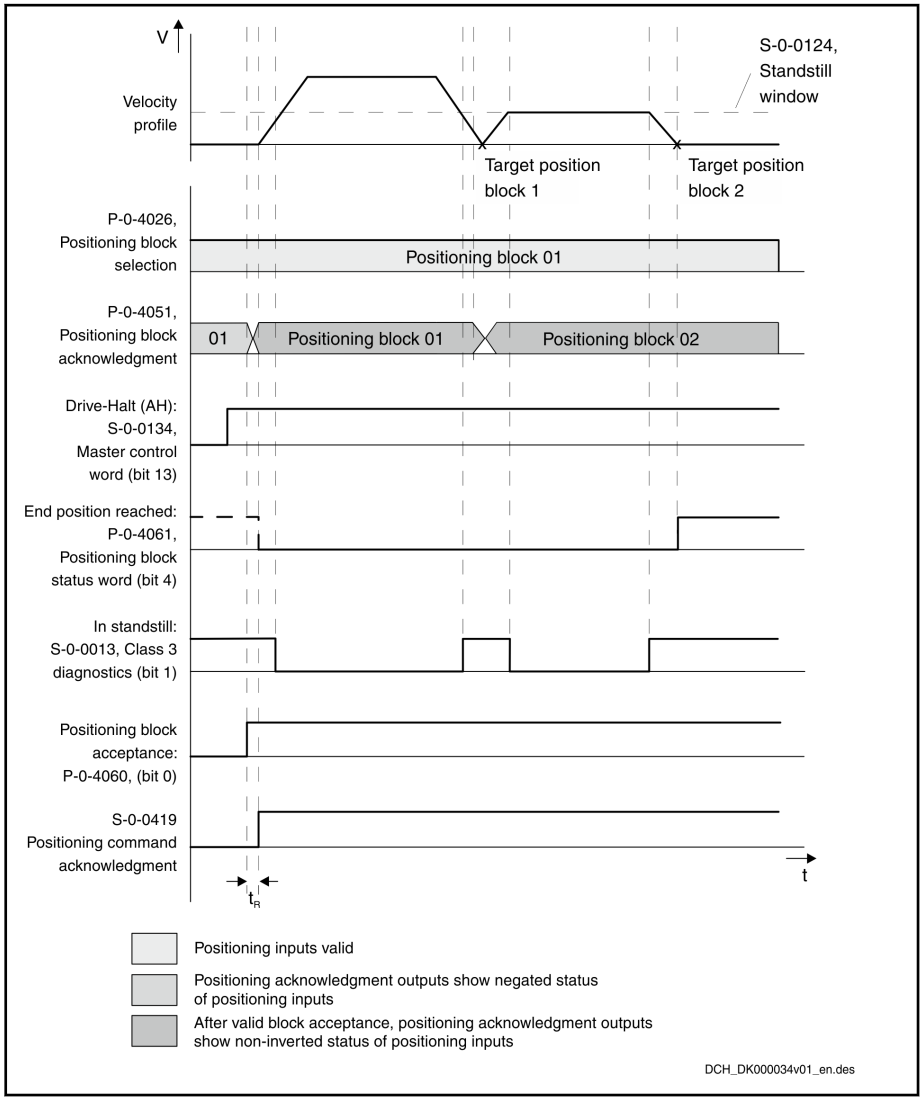


Fig. 6-58: Example: Sequential block advance for target position with intermediate stop

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

☞ This mode should be used if there is a change in direction in the case of two consecutive sequential blocks within one sequential block chain. Otherwise, the position at which the direction is changed will be inevitably overrun.

Switching signal-dependent block advance

For switching signal-dependent block advance, the following positioning modes are possible:

- "P-0-4019, Positioning block mode" = 0b0000 0000 1000 0000
  → Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 1000 0010
  → Relative block with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 1000 0100
  → Infinite block in positive direction with sequential block
- "P-0-4019, Positioning block mode" = 0b0000 0000 1000 1000
  → Infinite block in negative direction with sequential block

☞ Advancing to the block with the next higher block number is triggered by an externally applied switching signal.

Switching with switch cams

The switching signal-dependent block advance allows the transition to a sequential block, triggered by an external switching signal. Two sequential block inputs are available as input for this switching signal.

The status of the hardware signals is displayed in parameter "P-0-4057, Positioning block, input linked blocks".

Function

The drive switches to the next travel block n+1, as soon as the input for the sequential block cam 1 changes from "0" to "1". If the target position is not reached, switching to the new positioning block is carried out while traveling.

The drive switches to the block following the next travel block n+2, as soon as the input for sequential block cam 2 changes from "0" to "1". If a sequential block cam is activated during traveling, the drive switches to the positioning block after the next one.

Dedicated position

A subsequent relative positioning block refers to the position at which the sequential block cam was switched.

☞ The sequential block cams are scanned within the position controller clock cycle (see "Performance data"). The precision of position detection therefore strongly depends on the velocity during overrun.

Assignment table for cams

Cam 2	Cam 1	Drive reaction
0	0	Drive moves to target position of block n
x	0 → 1	Block n+1 is started
0 → 1	x	Block n+2 is started

n Positioning block preselected via the parallel inputs or parameter "P-0-4026, Positioning block selection"

x Not relevant

Tab. 6-4: Drive reaction with different switching signal sequences

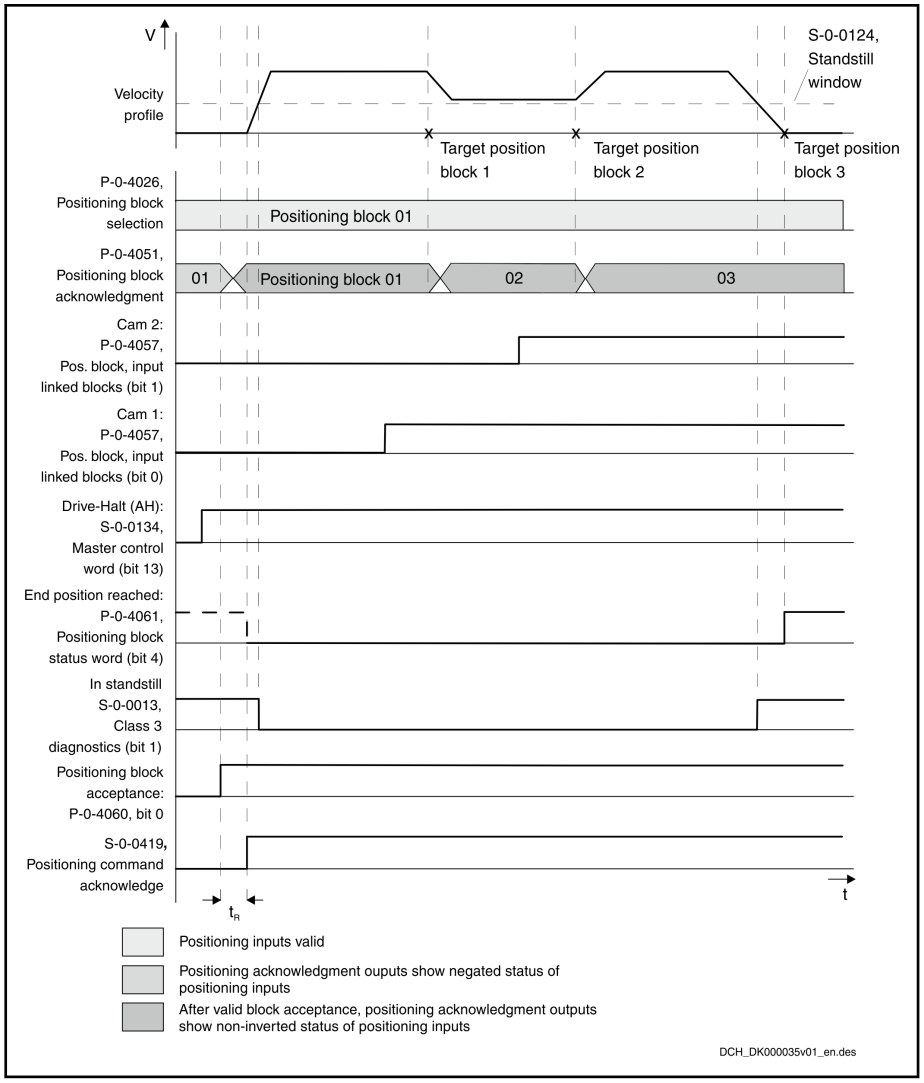


Fig. 6-59: Example: Switching signal-dependent block advance

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Absence of switching signal for block advance

If the start block of a switching signal-dependent sequential block is an absolute or relative positioning block, the drive positions at the target position, if the switching signal for block advance is not received. The drive thus only generates the message "end position reached" after the sequential block chain is completed. If a switching signal is subsequently applied, the drive will execute the sequential block.

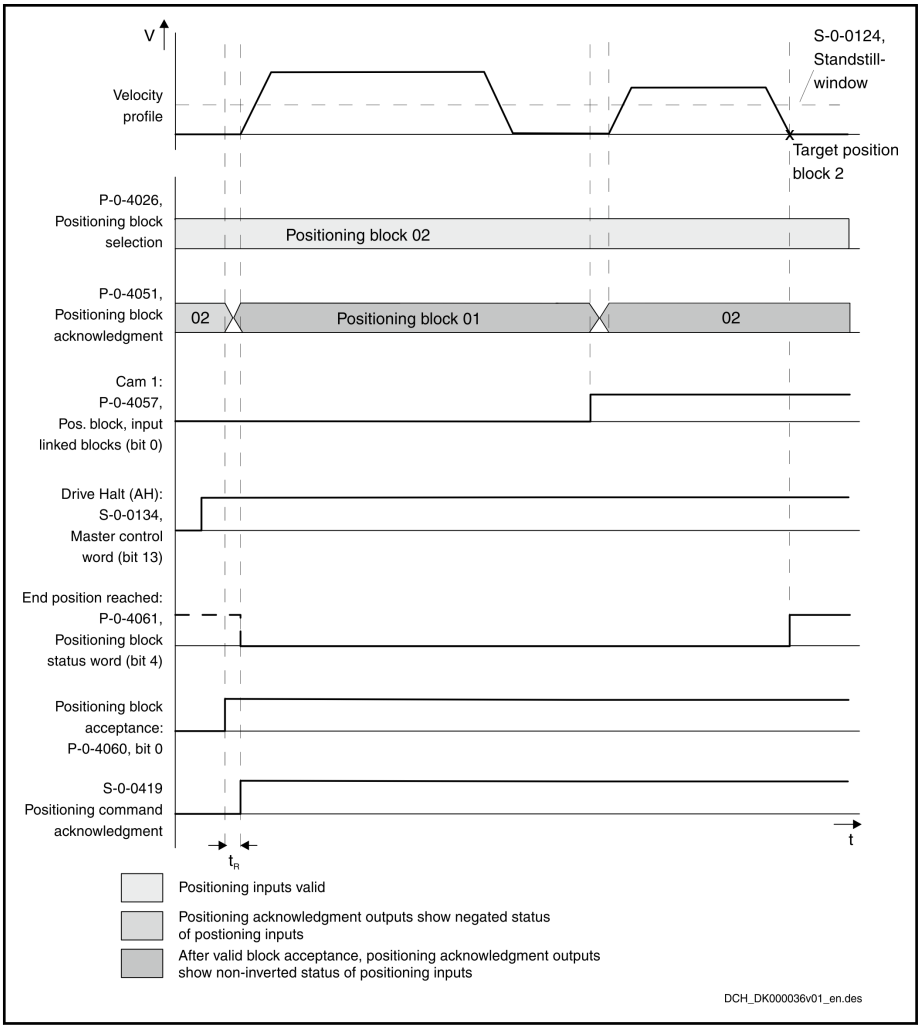


Fig. 6-60: Example: Switching signal-dependent block advance (behavior with failure of switching signal)

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

All conditions for advance are constantly queried and evaluated to be able to switch to the correct sequential block, even after the sequential block chain was interrupted. However, only the first condition for advance occurring during an interruption is recognized. All other conditions are ignored!

Interrupting a sequential block chain

There are two basically different behaviors when a sequential block chain is interrupted:

- Residual path is rejected when interrupted by:
  - Positioning stop (S-0-0346, bit 1 and bit 2 = 1)
  - Jogging +/-
  - Control voltage "Off"

  After interruption with "positioning stop" and "jogging +/-" positioning is always resumed at the current actual position. The sequential block

chain interrupted before is not completed, but the currently selected block is executed. Thereby the incremental dimension reference gets lost!

- **Residual path is maintained** when interrupted by:
  - Withdrawing the controller enable
  - Withdrawing the "drive start" signal
  - Changing the operation mode

Depending on the block type of the sequential block chain that was interrupted and the events occurring during this interruption, the sequential block chain is processed differently after a restart.

☞ In sequential block mode, relative positioning blocks without residual path storage are not allowed, as otherwise the incremental dimension reference would get lost in the case of interruption.

In the case of an interruption, the sequential block chain will be completed upon a restart.

Dedicated position

The dedicated position is the original start position of the sequential block chain.

☞ The incremental dimension reference is retained, as only absolute and relative positioning blocks with residual path storage are used in the sequential block mode!

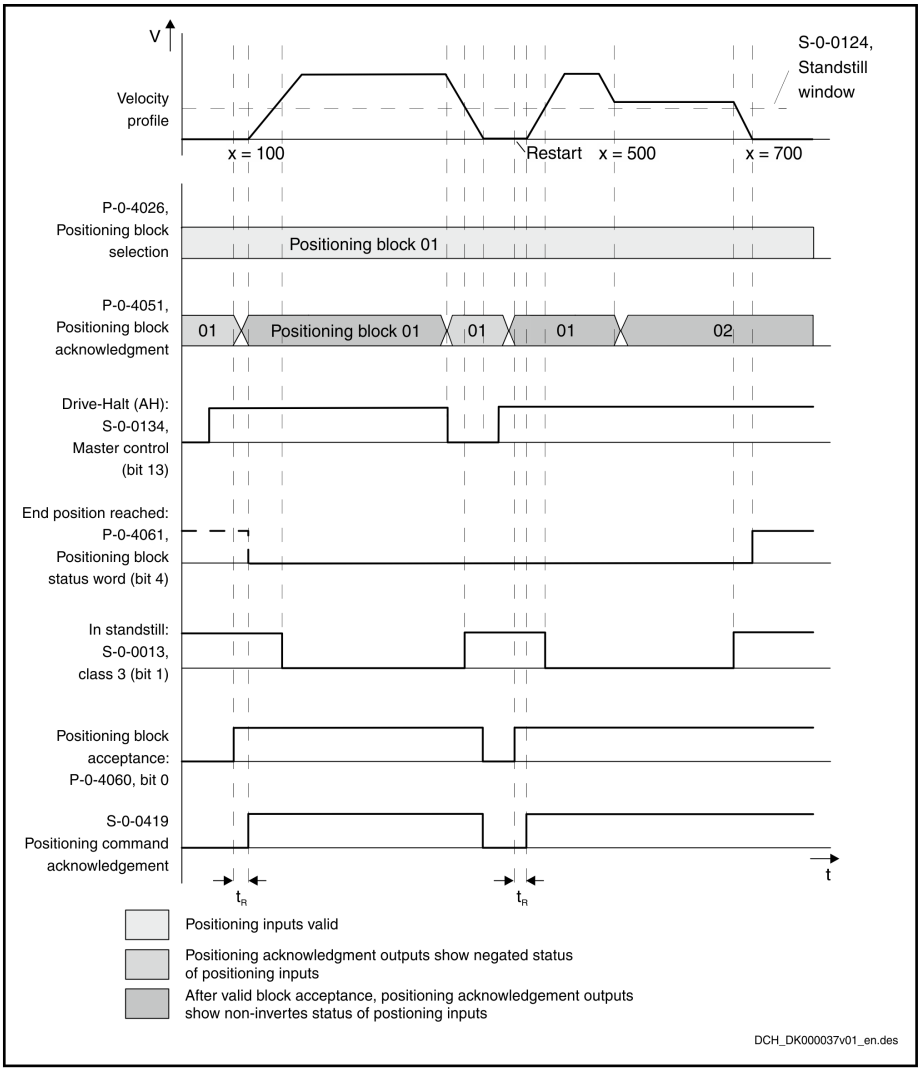


Fig. 6-61: Example: Sequential block interruption with same block selected



Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

Changing to other operation mode

When changing the operation mode during an interruption, the sequential block chain interrupted before is completed at the restart, if no new block was selected before.

In the case of sequential blocks with advance due to target position, only overrunning of the target position of the current positioning block will be detected. Processing of the sequential block is completed from this position.



The advance condition resulting from switching signals is always detected.

Interrupting a sequential block chain with selection of new positioning block

If a new positioning block is selected during an interruption (e.g. with "Drive Halt"), the previously interrupted sequential block chain is not completed upon a restart, but the currently selected block is executed.

Dedicated position

The dedicated position is the current actual position value.

NOTICE

In case the sequential block is interrupted, the incremental dimension reference gets lost, which results in the fact that the residual path is not traveled when the positioning block is restarted, but the complete relative positioning block is started over. The incremental dimension reference is no longer ensured!

The conditions for the interruption of sequential blocks also apply after the control voltage is switched off, if an absolute encoder is used.

Interrupting a sequential block chain with absolute sequential blocks

An interruption with absolute positioning blocks does not cause any problem, as the position data reference is always ensured.

When a new block number is selected in the case of an interruption, the sequential block interrupted before is not completed when bit 0 toggles in "S-0-0346, Positioning control word" or with a positive edge of bit 0 in "P-0-4060, Positioning block control word", but the currently selected block is executed.

When no new block number is selected in the case of an interruption, the sequential block interrupted before is completed when bit 0 toggles in "S-0-0346, Positioning control word" or with a positive edge of bit 0 in "P-0-4060, Positioning block control word".

6.14.5 Notes on commissioning and parameterization

Limit values of the drive

When parameterizing sequential blocks, the maximum values of the drive must be taken into account. These values are:

- Maximum acceleration capability
- Maximum velocity/revving speed

If blocks are parameterized for which the drive would have to generate values greater than the maximum values, this will cause an excessive following error. With the error message "F2028 Excessive deviation" the drive will then signal that it cannot follow the position command value.

Minimum values for acceleration and jerk

Too low acceleration values can cause problems. Therefore, guideline values according to the formula below are to be preferred when determining positioning blocks:

$$\text{Acceleration} > \frac{\text{Velocity difference}^2}{2 \times \text{Target position difference}} \times \frac{(v_{n+1} - v_n)^2}{2 \times (x_{n+1} - x_n)}$$

v_n Velocity of block n
v_{n+1} Velocity of block n+1
x_n Target position of block n
x_{n+1} Target position of block n+1

Fig. 6-62: Minimum acceleration value with sequential block mode (linear)

☞ The above relationship applies to an infinitely large jerk which corresponds to a jerk filter that has been switched off (= 0). If a jerk filter is used, the calculated values have to be doubled in first approximation. The distance to be covered with a block and the associated velocity are in most of the cases determined by the process. If the minimum acceleration value calculated with the above guideline value formula already causes the above-mentioned maximum value to be exceeded, a lower positioning block velocity has to be selected.

Minimum jerk value

If the parameterized acceleration values are too low, this can cause the parameterized velocity not to be reached. In this case, the so-called "triangular mode" is used.

Directional change within a sequential block chain

☞ If a directional change takes place when changing from block n to block n+1 of a sequential block, the mode "switching at target position with halt" should be used for block n to reverse the direction without overshoot.

Explanation of the figure below

Block n with intermediate stop follows block n-1 with mode 1 (block transition with old positioning velocity), because a change in direction occurs when changing from block n to block n+1. As the direction is reversed, the sign of velocity is changed at target position n. If the acceleration parameterized in block n is too low to decelerate from velocity v_{n-1} to value "0" within the travel distance difference x_n-x_{n-1}, the parameterized target position x_n is overrun.

This may cause software or hardware limit switches to trigger.

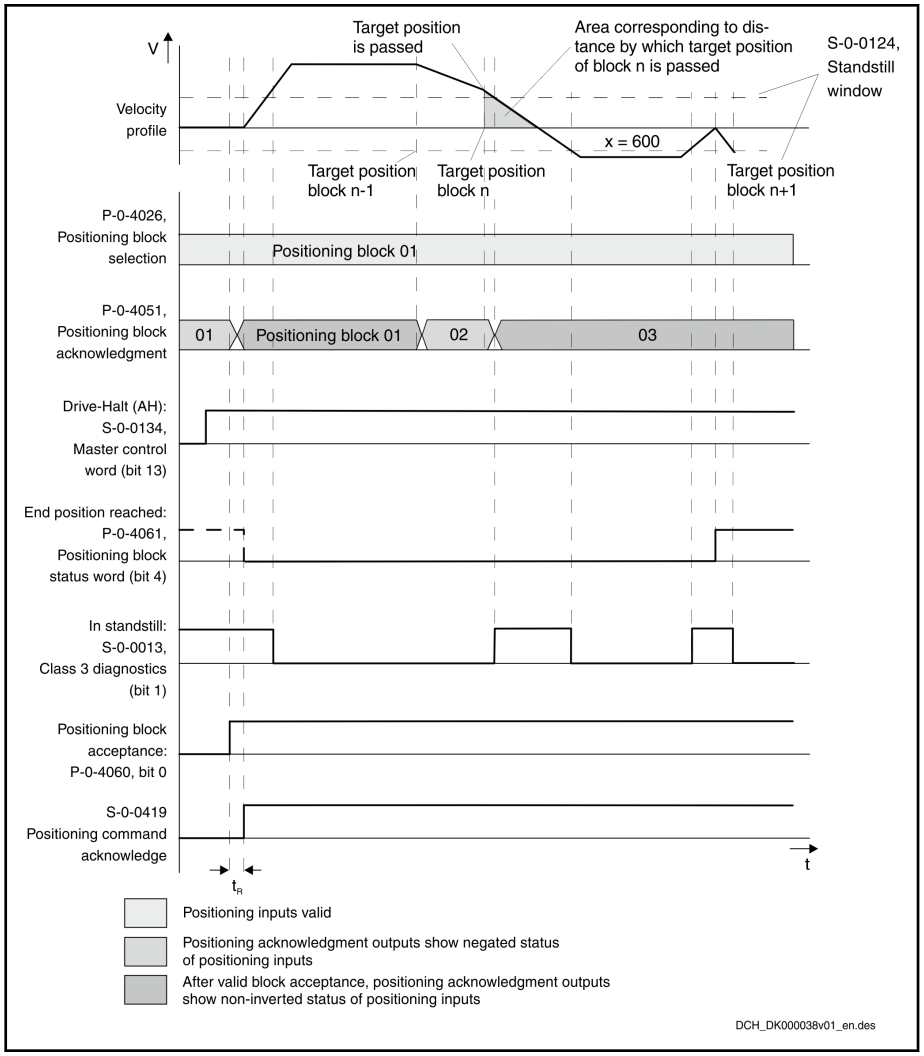


Fig. 6-63: Parameterizing a sequential block with directional change

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

In the case of a sequential block with directional change, it is necessary to take values according to the above formula for the minimum acceleration value into account in order to avoid overshooting of position!

6.14.6 Force command value adjustment

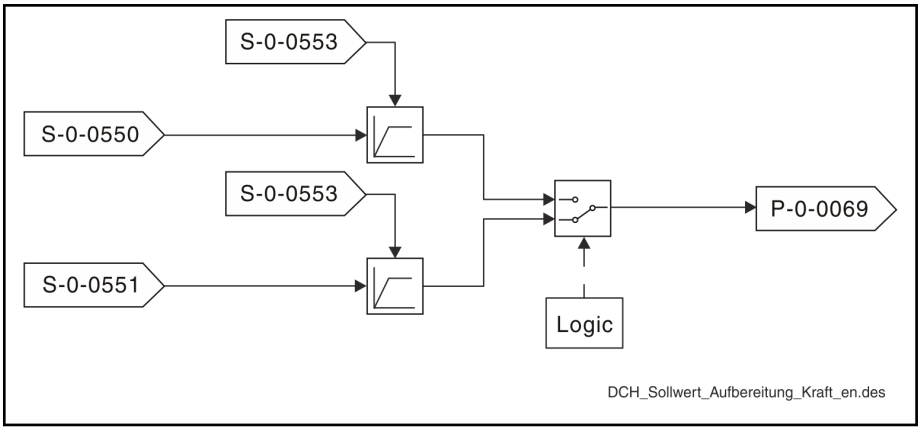


Fig. 6-64: Command value adjustment for closed-loop force control

Command value ramp

The positive and negative torque/force command values are fed via a simple ramp to prevent step-like changes. The ramp time is determined by "S-0-0553, Torque/force command value ramp".

Force command value switching

The logic for switching between the two force command values "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" is described in chapter "Alternating control".

The use of alternating control is not recommended in the positioning block mode, since it has an influence on the block advance.

Output variable

The output variable of command value adjustment for force control is "P-0-0069, Torque/force command value of controller".

6.14.7 Diagnostic messages and monitoring functions

Diagnostic status message

The activated "positioning block mode" is indicated by the following diagnostic message depending on the characteristic:

- A0162, Positioning block mode
- A0206, Positioning block mode, encoder 1
- A0207, Positioning block mode lagless, encoder 1

Positioning block acknowledgment

The positioning block acknowledgment is used as feedback of the execution of the active positioning block.

Acknowledgment with active operation mode

After the positioning block mode has been activated, the complement of the block number of the selected positioning block is acknowledged until a start signal (toggling of bit 0 in "S-0-0346, Positioning control word" or positive edge of bit 0 in "P-0-4060, Positioning block control word") is set. As of the first start signal and when operation is trouble-free, the block number of the positioning block that was started is output. If an error is detected at the start of a positioning block, the faulty positioning block is acknowledged with the complement of the block number. The drive generates a warning and stops.

Acknowledgement with "Drive Halt"

If "Drive Halt" is active, the complement of the block number of the selected positioning block is output in parameter "P-0-4051, Positioning block acknowledgment".

Acknowledgment with secondary operation modes

The acknowledgment is not affected by secondary operation modes, error reaction and command inputs, i.e. parameter "P-0-4051, Positioning block acknowledgment" retains its value.

Acknowledgment with controller enable switched off

After switching off the controller enable, the last accepted positioning block is output at the acknowledge outputs. When the drive is at the target position of the last accepted positioning block, the message "end position reached" is additionally output.

In the example below the same absolute positioning block is started once again.

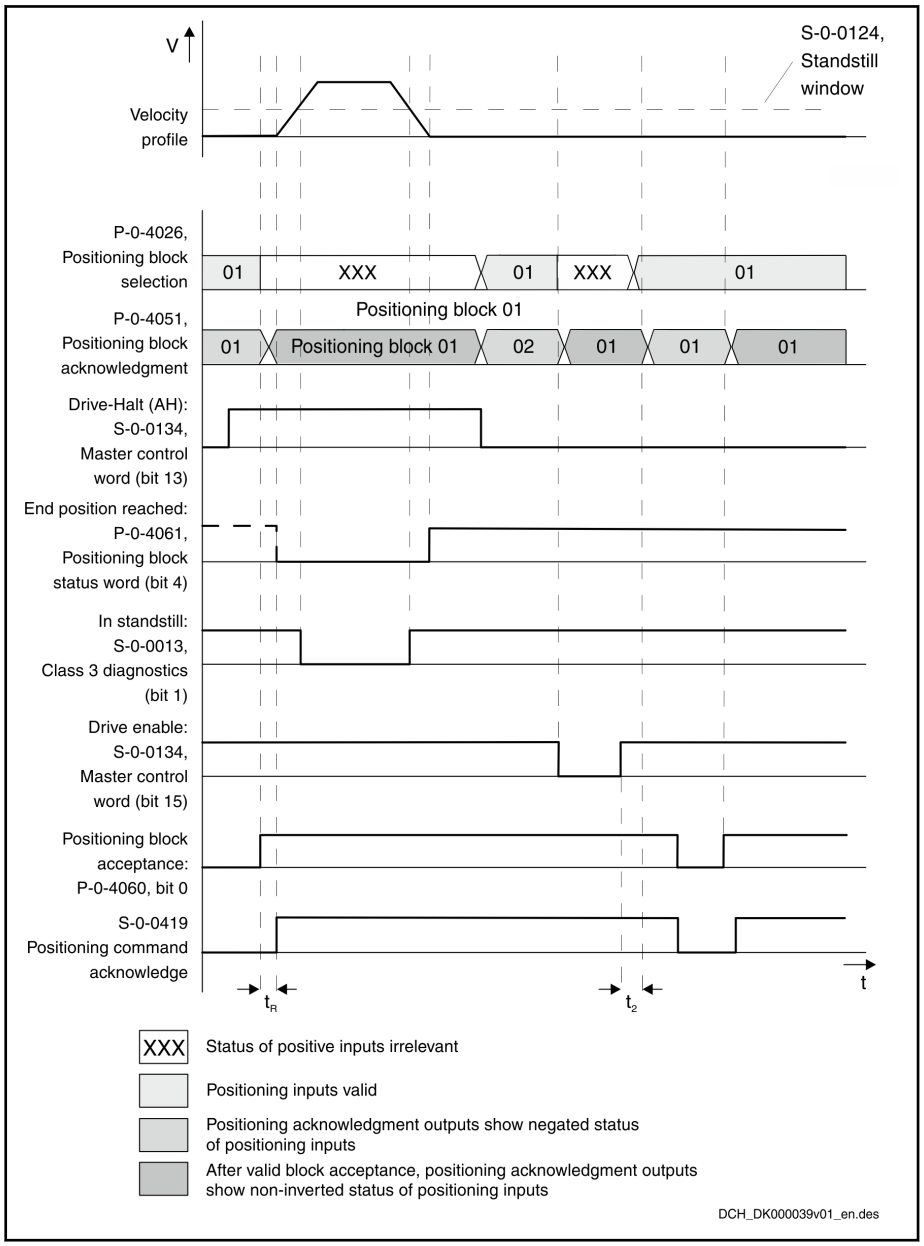


Fig. 6-65: Acknowledgment and message "end position reached" after drive enable switched off

Depending on the master communication, the positioning block is accepted by toggling bit 0 in S-0-0346 or by a positive edge of bit 0 in P-0-4060.

With absolute value encoder

If an absolute value encoder is used, it is possible to decide, after the control voltage is switched off and on, whether the drive still is at the target position of the last accepted positioning block (end position reached).

The "end position reached" message is generated as soon as the drive is ready for operation again (bb contact closed).

With single-turn encoder

If a single-turn encoder is used, the "end position reached" message is not clearly defined after a voltage interrupt until the first target position has been run to or homed.

☞ The "end position reached" message is only retained if the axis has not been moved during the interruption. If the axis is moved into the positioning window during the interruption, the "end position reached" message will also be generated! After activating the controller enable, the positioning block acknowledge changes as described under "Acknowledgment with drive enable switched off".

Status messages

Status bits

In addition to the status messages in the "drive-internal interpolation" mode, the "end position reached" status message is generated in the "positioning block mode" (bit 4 = 1 in parameter "P-0-4061, Positioning block status word"), if the following applies:

- |S-0-0430 - S-0-0051/S-0-0053| < S-0-0057 (in position)

  - and -

- No sequential block has been selected.

Status parameters

The following parameters provide further diagnostic possibilities:

- P-0-4051, Positioning block acknowledgment

  → Acknowledgment of the currently accepted and active positioning block

  Note: In the case of "Drive Halt", the selected positioning block is returned in inverted form (complementary to positioning block selection).

- P-0-4052, Positioning block, last accepted

  → Contains the last accepted positioning block (stored in non-volatile memory)

  Note: For sequential block chains, this is always the first block of the sequential block chain!

- P-0-4053, Positioning block, last active

  → Contains the last active positioning block (stored in non-volatile form)

  Note: For sequential block chains, this is the last active block of the sequential block chain. In the case of single blocks (no sequential block processing), the contents of parameters P-0-4052 and P-0-4053 are always identical!

- P-0-4057, Positioning block, input linked blocks

  → Contains an image of the digital sequential block inputs (switch cam inputs)

Monitoring functions

Monitoring functions specific to the operation mode:

- E2049, Positioning velocity >= limit value
- E2053, Target position out of travel range

- E2054, Not homed
- E2055, Feedrate override S-0-0108 = 0
- E2058, Selected positioning block has not been programmed

Error messages:

- F2028, Excessive deviation

6.14.8 Pertinent parameters/diagnostic messages

Pertinent parameters

- S-0-0138, Bipolar acceleration limit value
- S-0-0346, Positioning control word
- S-0-0393, Command value mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-0059, Additive position command value, controller
- P-0-0069, Torque/force command value of controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-4006, Positioning block target position
- P-0-4007, Positioning block velocity
- P-0-4008, Positioning block acceleration
- P-0-4009, Positioning block jerk
- P-0-4018, Positioning block delay time
- P-0-4019, Positioning block mode
- P-0-4026, Positioning block selection
- P-0-4051, Positioning block acknowledgment
- P-0-4052, Positioning block, last accepted
- P-0-4053, Positioning block, last active
- P-0-4057, Positioning block, input linked blocks
- P-0-4060, Positioning block control word
- P-0-4061, Positioning block status word
- P-0-4063, Positioning block deceleration

Pertinent diagnostic messages

- A0162, Positioning block mode
- A0206, Positioning block mode, encoder 1
- A0207, Positioning block mode lagless, encoder 1
- E2049, Positioning velocity >= limit value

- E2053, Target position out of travel range
- E2054, Not homed
- E2055, Feedrate override S-0-0108 = 0
- E2058, Selected positioning block has not been programmed
- F2028, Excessive deviation

6.15 Closed-loop pressure/swivel angle control

6.15.1 Brief description

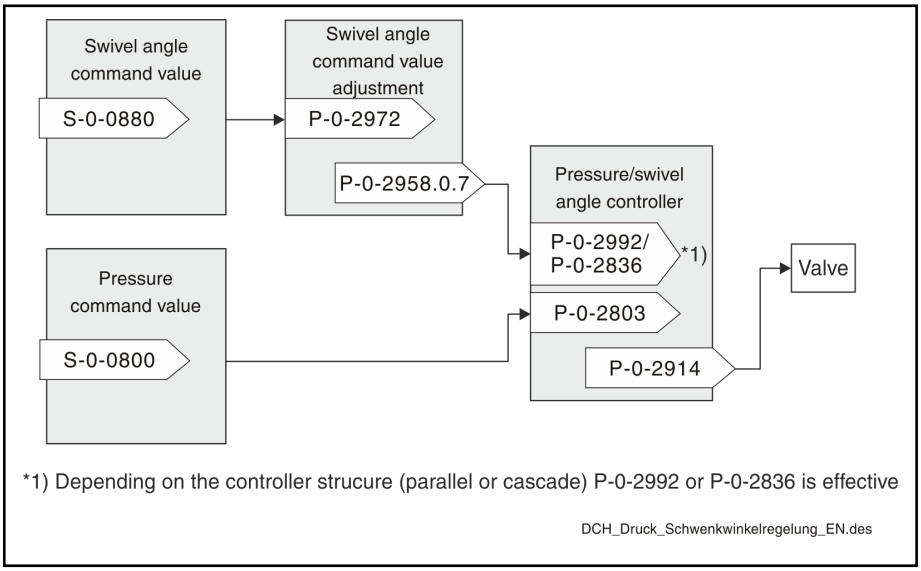


Fig. 6-66: Overview of operation mode of closed-loop pressure/swivel angle control

In the operation mode "pressure/swivel angle control", a swivel angle command value and a pressure command value are fed to a control pump. If required, these command values can be directed via a ramp generator.

The swivel angle command value is adjusted by swivel angle command value processing, before it is fed to the actual swivel angle controller.

For the setup of the pressure/swivel angle controller, two different structures are provided (parallel and cascade structure). In both cases, swivel angle and pressure controller are active simultaneously. A changeover logic switches dynamically between these two control types. While doing so, the changeover logic ensures that always only one of the two variables of "pressure" or "swivel angle" is used for controlling.

The output variable of pressure/swivel angle control can be modified using characteristic curves and functions in output adjustment before it is handed over to the valve controller as valve command value.

Features

- Command value generators for "closed-loop swivel angle control" and "closed-loop pressure control"
- Limitation of given pressure and swivel angle command values to limit values that can be parameterized individually
- Switching between closed-loop swivel angle control and closed-loop pressure control with the help of the "changeover logic"
- Switching between the parallel and the cascade structure is possible
- Output adjustment

Specialties in the device behavior / device state machine

For the pump controller a selection option for the error reaction of the drive is "switching to internal command values". In this case, pressure and swivel angle controller are in the state "drive ready (Ab)" and active in the event of an error. The following specific command values are used for this:

"P-0-2975, Pressure command value (without controller enable)"

"P-0-2976, Swivel angle command value (without controller enable)"

6.15.2 Swivel angle command value adjustment

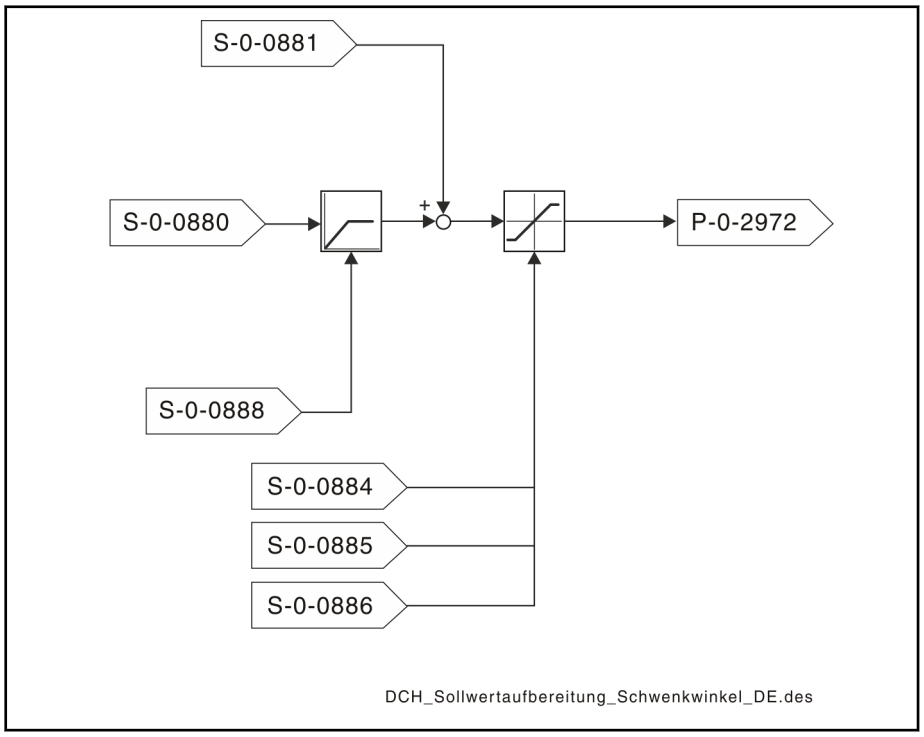


Fig. 6-67: Swivel angle command value adjustment

Command value ramp

The command value provided by "S-0-0880, Swivel angle command value" is fed via a ramp to prevent step-like changes.

The ramp is determined by "S-0-0888, Swivel angle ramp time".

Additive swivel angle command value

Moreover, it is possible to feed forward an additive command value via "S-0-0881, Swivel angle command value, additive". If required, this value can also be cyclically configured.

Command value limitation

The effective swivel angle command value is limited to the value specified in parameter "S-0-0884, Swivel angle limit value, bipolar", or in parameters "S-0-0885, Swivel angle limit value, positive" or "S-0-0886, Swivel angle limit value, negative".

Output variable

The output variable of command value adjustment for swivel angle control is "P-0-2972, Swivel angle command value of controller".

6.15.3 Pressure command value adjustment

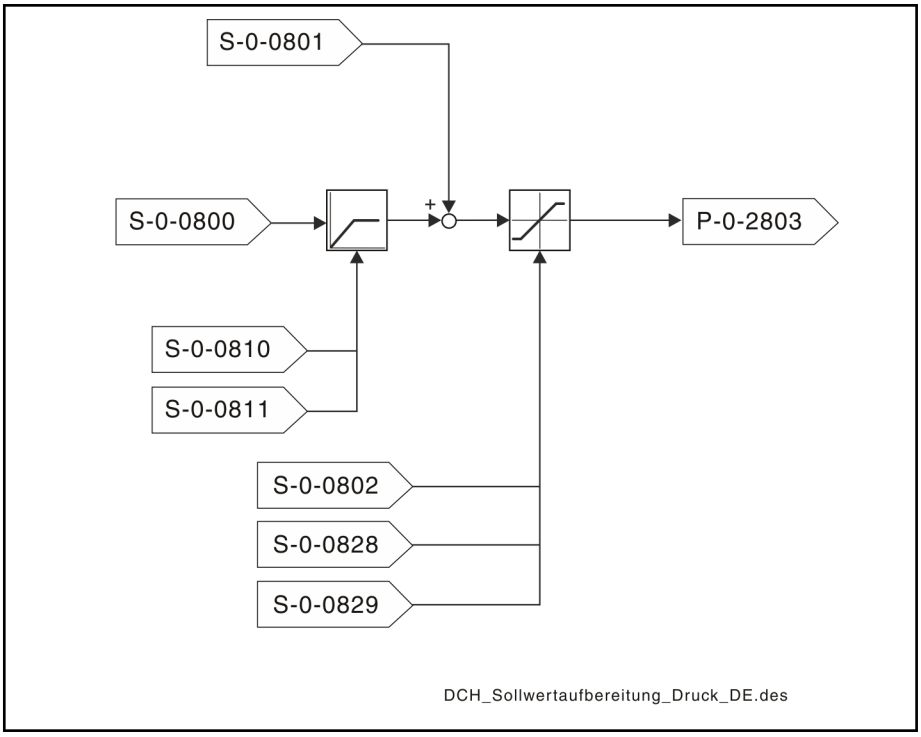


Fig. 6-68: Pressure command value adjustment

Command value ramp

The command value provided by "S-0-0800, Pressure command value" is filtered. The ramp is defined by "S-0-0810, Pressure ramp time" and "S-0-0811, Pressure ramp reference".

Additive pressure command value

Moreover, it is possible to feed forward an unfiltered, additive command value via "S-0-0801, Pressure command value additive". If required, this value can also be cyclically configured.

Command value limitation

The effective swivel angle command value is limited to the value specified in "pressure limit value, bipolar" or in parameters "S-0-0828, Positive pressure limit value", or "S-0-0829, Negative pressure limit value".

Output variable

The output variable of command value adjustment is "P-0-2803, Pressure command value of controller". It is connected downstream of the pressure controller, which is described in more detail in chapter "Drive control".

6.15.4 Swivel angle command value processing

Swivel angle command value processing is described in chapter "Pressure/swivel angle controller (pump controller)."

6.15.5 Diagnostic messages and monitoring functions

Diagnostic status messages

The activated "pressure/swivel angle control" mode is indicated by the following diagnostic message:

"A0175, Pressure/Swivel angle control"

Monitoring functions

Monitoring functions specific to the operation mode:

- "E2065, Pressure command value > limit value"
- "E2073, Swivel angle command value > limit value"

☞ The warning "E2073, Swivel angle command value > limit value" is not issued, if the swivel angle command value is entered in an assignment for an analog input.

6.15.6 Pertinent parameters and diagnostic messages

Pertinent parameters

- S-0-0800, Pressure command value
- S-0-0801, Pressure command value additive
- S-0-0802, Bipolar pressure limit value
- S-0-0810, Pressure ramp time
- S-0-0811, Pressure ramp reference
- S-0-0828, Positive pressure limit value
- S-0-0829, Negative pressure limit value
- S-0-0830, Pressure status word
- S-0-0880, Swivel angle command value
- S-0-0881, Swivel angle command value, additive
- S-0-0884, Swivel angle limit value, bipolar
- S-0-0885, Swivel angle limit value, positive
- S-0-0886, Swivel angle limit value, negative
- S-0-0887, Swivel angle status word
- S-0-0888, Swivel angle ramp time
- P-0-2803, Pressure command value of controller
- P-0-2914, Output of pump pressure controller, cascade structure
- P-0-2972, Swivel angle command value of controller
- P-0-2975, Pressure command value (without controller enable)
- P-0-2976, Swivel angle command value (without controller enable)

Pertinent diagnostic messages

- A0175, Pressure/Swivel angle control
- E2065, Pressure command value > limit value
- E2073 Swivel angle command value > limit value

7 Open and closed-loop drive control

7.1 Overview

7.1.1 Basic principles and terms

Depending on the device characteristic, the following principles of open or closed-loop drive control are supported:

- **p/Q function**

  Generally, no position encoder is provided. Depending on the available pressure sensorics (hardware requirements) it is possible to select open-loop Q control (valve opening) or closed-loop flow control (closed-loop Q control).

- **Control of hydraulic variable displacement pump**

  Generally, no position encoder is provided. Depending on the available pressure sensors (hardware requirement), in addition to the swivel angle, pressure can also be closed-loop controlled.

- **Open-loop axis control** or **open-loop operation**

  No position encoder provided. The valve opening is input in open-loop operation. Optionally, the force can be closed-loop controlled, provided that the relevant sensors are connected. In this case, switching between the respective controllers is carried out by alternating control or a changeover logic.

- **Closed-loop axis control** or **closed-loop operation**

  A position encoder is available, which is used for position feedback (position control). Optionally, velocity and, provided that the required sensors are connected, force/pressure can be closed-loop controlled. The selection of the operation mode determines both, the required controllers (position, velocity, and force) and their changeover (alternating control).

The following table gives an overview of which control types are supported by which device variant in which operation mode:

Operation mode	Control mode	Functional package	Firmware Derivative	Position encoder required	Further sensors
Direct valve control	Open-loop controlled operation	IFB DFE p/Q AXR OL AXR CL	HDE HDB HDC HDP HDM	No	
Flow (open/closed-loop control)	Open-loop flow control	IFB DFE p/Q AXR OL AXR CL	HDE HDB HDC HDP HDM	No	
	Closed-loop flow control	p/Q	HDB		Internal pressure sensors

Operation mode	Control mode	Functional package	Firmware Derivative	Position encoder required	Further sensors
Closed-loop pressure control / direct valve control (p/Q)	Open-loop controlled operation including changeover logic to pressure control	p/Q AXR OL AXR CL	HDB HDC HDP HDM	No	Pressure sensor
Closed-loop pressure control / (open/closed-loop) flow control	Open-loop flow control including changeover logic to closed-loop pressure control	p/Q AXR OL AXR CL	HDB HDC HDP HDM	No	
	Closed-loop flow control including changeover logic to closed-loop pressure control	p/Q	HDB		Internal pressure sensors
Closed-loop pressure/swivel angle control	Closed-loop swivel angle control including changeover logic to closed-loop pressure control for hydraulic variable displacement pumps	DFE	HDB HDC HDP	No	Pressure sensor
(Open/closed-loop) velocity control	Closed-loop velocity control, including alternating control (force control)	AXR CL	HDB HDC HDP HDM	Yes	For closed-loop force control: Pressure sensors or force sensor
	Open-loop velocity control, including alternating control (closed-loop force control)	AXR OL	HDB HDC HDP HDM	No	For closed-loop force control: Pressure sensors or force sensor
	Open-loop velocity control	IFB	HDB HDC HDP HDE HDM	No	
Closed-loop position control with cyclic command value provision	Closed-loop position control, including alternating control (closed-loop force control)	AXR CL	HDB HDC HDP HDM	Yes	For closed-loop force control: Pressure sensors or force sensor
Drive-internal interpolation	Closed-loop position control, including alternating control (closed-loop force control)	AXR CL	HDB HDC HDP HDM	Yes	For closed-loop force control: Pressure sensors or force sensor

Operation mode	Control mode	Functional package	Firmware Derivative	Position encoder required	Further sensors
Drive-controlled positioning	Closed-loop position control, including alternating control (closed-loop force control)	AXR CL	HDB HDC HDP HDM	Yes	For closed-loop force control: Pressure sensors or force sensor
Positioning block mode	Closed-loop position control, including alternating control (closed-loop force control)	AXR CL	HDB HDC HDP HDM	Yes	For closed-loop force control: Pressure sensors or force sensor
Closed-loop torque/force control	Closed-loop torque/force control	AXR OL AXR CL	HDB HDC HDP HDM	No	Pressure sensors or force sensor
Closed-loop torque/force control / direct valve control	Open-loop controlled operation, including alternating control (closed-loop torque/force control)	AXR OL AXR CL	HDB HDC HDP HDM	No	Pressure sensors or force sensor
Closed-loop torque/force control / (open/closed-loop) flow control		AXR OL AXR CL	HDB HDC HDP HDM	No	Pressure sensors or force sensor

Tab. 7-1: Overview of operation modes and possible control types

☞ Further information on the functional packages can be found in the chapter “Overview of functional packages”.

☞ The selection of p/Q function, pressure/swivel angle control and axis control partially depends on the concrete device characteristic. For example, for closed-loop flow control, a specific device with integrated pressure sensors and measured valve characteristic curve is required. This has to be taken into account when the device is ordered. For certain operation modes it is necessary that pressure sensors and/or a position encoder are present.

☞ The changeover between open-loop and closed-loop package is made by selecting the respective functional package.

7.1.2 Principles of open and closed-loop drive control

Depending on the device characteristic, the following principles of open or closed-loop drive control are supported:

- Direct valve control

  The drive is open-loop controlled by the provision of a valve command value.
- Open-loop flow control

A flow command value is provided to the drive. In conjunction with further hydraulic characteristic values, this command value is internally converted into a valve command value (or, in the case of functional package DFE, into a swivel angle command value). The drive is open-loop controlled. Depending on the operating conditions, the actual flow may significantly differ from the flow command value.

- Closed-loop flow control

  The flow generated by the drive is closed-loop controlled.

- Open-loop velocity control

  A velocity command value is provided to the drive. Using the valve standard velocity, this value is converted internally into a valve command value. The drive is open-loop controlled.

- Velocity control

  The velocity of the drive is closed-loop controlled with the help of the velocity controller. For sensing the actual velocity of a drive, a position encoder is required.

- Closed-loop position control

  The drive is operated in closed-loop position control. Depending on the selected operation mode, various options are possible for providing the position command value. Optionally, the inner-loop velocity controller may be used additionally.

- Closed-loop torque/force control

  The drive is operated in closed-loop torque or force control. For sensing the actual torque or force value, either a force sensor is required or the chamber pressures have to be measured by means of pressure sensors and converted into a force taking account of the effective areas.

- Closed-loop pressure control

  The drive is operated in closed-loop pressure control. An appropriate pressure sensor has to be available for sensing the pressure.

- Closed-loop pressure/swivel angle control

  This control type is used for hydraulic variable displacement pumps. With this solution, the provision of a swivel angle command value is used to generate a flow, and a pressure command value is used to limit the pressure.

It is possible to switch between the various control types. Here, the following options have to be distinguished:

- Alternating control

  The function of "alternating control" comprises a logic for switching between:

  – Direct valve control ↔ Closed-loop torque/force control
  – Open-loop flow control ↔ Closed-loop torque/force control
  – Closed-loop flow control ↔ Closed-loop torque/force control
  – Open-loop velocity control ↔ Closed-loop torque/force control
  – Closed-loop velocity control ↔ Closed-loop torque/force control
  – Closed-loop position control ↔ Closed-loop torque/force control

- Changeover logic

  The function of "changeover logic" comprises a logic for switching between:

  – Direct valve control ↔ Closed-loop pressure control

- Open-loop flow control ↔ Closed-loop pressure control
- Closed-loop flow control ↔ Closed-loop pressure control
- Closed-loop swivel angle control ↔ Closed-loop pressure control

The following table gives an overview of which control types are supported in which operation mode:

Operation mode	Open and closed-loop drive control	Position encoder required	Further sensors
Direct valve control	Open-loop controlled operation	No	
Closed-loop torque/force control / direct valve control	Open-loop controlled operation including alternating control in closed-loop torque/force control	No	Pressure sensors or force sensor
Closed-loop pressure control / direct valve control	Open-loop controlled operation including changeover logic to pressure control	No	Pressure sensor
(Open/closed-loop) flow control	Open-loop flow control	No	
	Closed-loop flow control		Pressure sensors
Closed-loop torque/force control / (open/closed-loop) flow control	Open-loop flow control including alternating control in closed-loop torque/force control	No	Pressure sensors or force sensor
Closed-loop pressure control / (open/closed-loop) flow control	Open-loop flow control including changeover logic to closed-loop pressure control	No	Pressure sensor(s)
	Closed-loop flow control including changeover logic to closed-loop pressure control		
Closed-loop torque/force control	Closed-loop torque/force control	No	Pressure sensors or force sensor
(Open/closed-loop) velocity control	Open-loop velocity control	No	
	Open-loop velocity control including alternating control in closed-loop torque/force control	No	For closed-loop force control: Pressure sensors or force sensor
	Closed-loop velocity control including alternating control in closed-loop torque/force control	Yes	For closed-loop force control: Pressure sensors or force sensor
Closed-loop position control with cyclic command value provision	Closed-loop position control including alternating control in closed-loop torque/force control	Yes	For closed-loop force control: Pressure sensors or force sensor
Drive-controlled positioning	Closed-loop position control including alternating control in closed-loop torque/force control	Yes	For closed-loop force control: Pressure sensors or force sensor
Drive-internal interpolation	Closed-loop position control including alternating control in closed-loop torque/force control	Yes	For closed-loop force control: Pressure sensors or force sensor

Positioning block mode	Closed-loop position control including alternating control in closed-loop torque/force control	Yes	For closed-loop force control: Pressure sensors or force sensor
Closed-loop pressure/swivel angle control	Closed-loop swivel angle control including changeover logic to closed-loop pressure control	No	Pressure sensor

Tab. 7-2: Overview of operation modes and possible control types

☞ The selection of p/Q function, pressure/swivel angle control and axis control partially depends on the concrete device characteristic. For example, for closed-loop flow control, a specific device with integrated pressure sensors and measured valve characteristic curve is required. This has to be taken into account when the device is ordered. For certain operation modes it is necessary that pressure sensors and/or a position encoder are present.

☞ The changeover between open-loop and closed-loop base package is made by selecting the respective functional package.

7.1.3 Features of the control loops

Performance (controller cycle times)

The internal controller cycle times are determined by the base clock cycle and the position controller clock cycle. The possible settings depend on:

- the firmware derivative
- the activation of functional packages

and are determined by:

- the position controller cycle: "P-0-0556, Config word of axis controller" (bit 2 and bit 5)
- the ratio of base clock cycle to position controller clock cycle: "P-0-0556, Config word of axis controller" (bit 15)

  1:1 timing: Base clock cycle = position controller clock cycle

  1:2 timing: Base clock cycle = position controller clock cycle * 2

	Setting of performance (P-0-0556, bits 2 and 5)	Base clock cycle	Position controller clock cycle
1:1 timing: (P-0-0556, bit 15 = 1)	Adjustable performance [1)]	400 µs	400 µs
	Basic performance [1)]	500 µs	500 µs
	Economy performance	1000 µs	1000 µs
	Low performance	2000 µs	2000 µs
1:2 timing: (P-0-0556, bit 15 = 0)	Economy performance	500 µs	1000 µs
	Low performance	1000 µs	2000 µs

1) For firmware derivatives HDB and HDP, the settings "Adjustable Performance" and "Basic Performance" with 1:1 timing are only possible with Open Loop.

Tab. 7-3: Overview of performance settings

☞ If "adjustable performance" is selected, the corresponding cycle time of the base clock cycle can be read from "P-0-2811, Setting of base clock cycle".

Overview of controller types

The various controller types are calculated in different clock cycles. The above performance settings determine the actually achievable cycle times.

Controller type	Controller clock cycle
Valve controller [2)]	100 µs
Flow controller	Base clock cycle
Pressure controller	Base clock cycle
Velocity controller	Base clock cycle
Torque/force controller	Base clock cycle
Position controller	Position controller clock cycle
Swivel angle controller	Base clock cycle

2) The valve controller is not present with device type HMC.

Tab. 7-4: Overview of controller types and clock cycle times

Valve controller

The valve controller is contained in all WRxx-, SY(H)DFED and HPC devices. The valve controller is matched to the relevant hydraulic valve in the factory and requires no application-specific adjustments.

Flow controller

The flow controller is available in two variants. It is characterized by the following features:

- Functional package p/Q: Calculation of the valve actuating signal by means of flow equation and flow characteristic curve of the valve
- Functional package DFE: PD controller with internal conversion into swivel angle

Swivel angle controller

The swivel angle controller is characterized by the following features.

- PD-controller

Pressure controller

The pressure controller is available in two variants. It is characterized by the following features:

- Functional packages AXR OL, AXR CL and p/Q: PI-controller with switchable I-component and associated logic
- Functional package DFE: PD-controller with swivel angle feedback

Position controller with inner-loop velocity controller

The position loop is characterized by the following features:

- Kv with D-component and fine positioning, including associated logic for controlling the I-component
- Velocity feedforward
- Inner-loop velocity controller as PI-controller, including associated logic for controlling the I-component

Active damping

The control behavior can be improved using the feedback of state variables (velocity, acceleration or force).

This function is available for:

- Open and closed-loop velocity control
- Closed-loop position control

Torque/force controller

The torque/force controller is characterized by the following features:

- Normalization of the control difference to velocity; thus, the controller parameter components and the controller output are already referred to velocity
- PI-controller with switchable I-component and associated logic
- Possibility of velocity feedforward
- Quadrant limitation

Pertinent parameters

- P-0-0556.000.000, Config word of axis controller
- P-0-2811.000.000, Setting of base clock cycle

7.1.4 General notes on commissioning and notes for users

Additive command values and possibilities of accessing inner-loop control loops

In closed-loop operation, it is possible to feed forward additive command values in addition to the command values available in the control loop. These parameters can be found in the description of the relevant operation mode. If required, these additive command values can also be cyclically configured.

Notes on commissioning for control loop setting

The correct setting of the control loops has a decisive influence on the properties of the hydraulic axis.

With the functional package Axis Controller Closed Loop, IndraWorks makes available a wizard for initial parameterization.

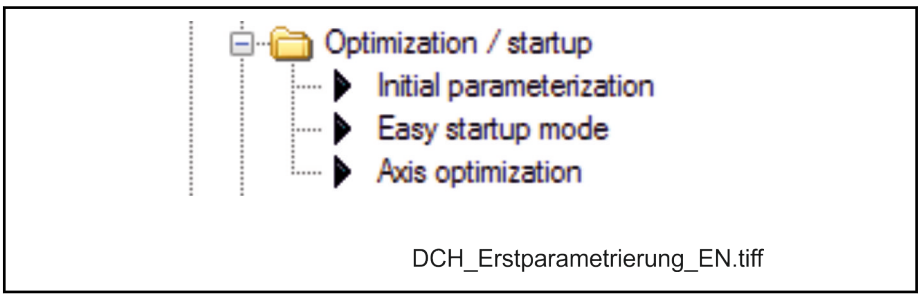


Fig. 7-1: Wizard for initial parameterization

This offers comprehensive support for parameterizing an axis control, including the determination of controller parameters for position and force controller.

For manual control loop setting, the following order should be adhered to:

1. First, the parameters of output adjustment should be adapted to the hydraulic system to be controlled: Valve standard velocity, direction-dependent gain and valve characteristic curve.
2. For direct valve control no further settings are necessary.
3. In the case of devices with flow control, for p/Q applications, the control output calculation has to be parameterized first, followed by the setting of the pressure controller and changeover logic.
4. For axis controllers in closed-loop operation, the output adjustment has to be set, then the position controller has to be parameterized. For applications in continuous path controls, the inner-loop velocity controller has to be used; otherwise, it needs not to be activated. For stabilizing and increasing the control loop gain, active damping can be activated. Afterwards force controllers and alternating control can be activated, if necessary.
5. For details on how to proceed for the control loop adjustment, see chapter "Commissioning".

7.2 Axis controller

7.2.1 Output adjustment

Structure **Valve standard velocity and direction-dependent gain**

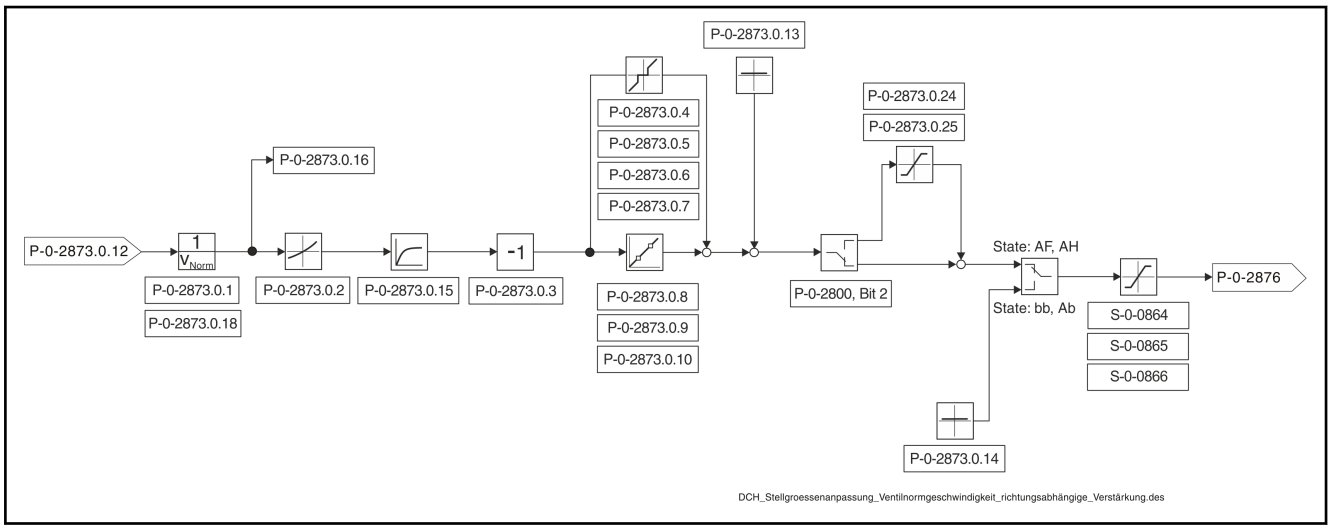


Fig. 7-2: Output adjustment with valve standard velocity and direction-dependent gain

Settings in "P-0-2873.0.20, Control variable adjustment control word": Bit 1..0 = 00b.

The conversion of velocity into a valve opening is carried out using "P-0-2873.0.1, Valve standard velocity", the setting of the velocity ratio between retraction and extension of the cylinder is made in "P-0-2873.0.2, Direction-dependent gain".

Positive valve standard velocity and negative valve standard velocity

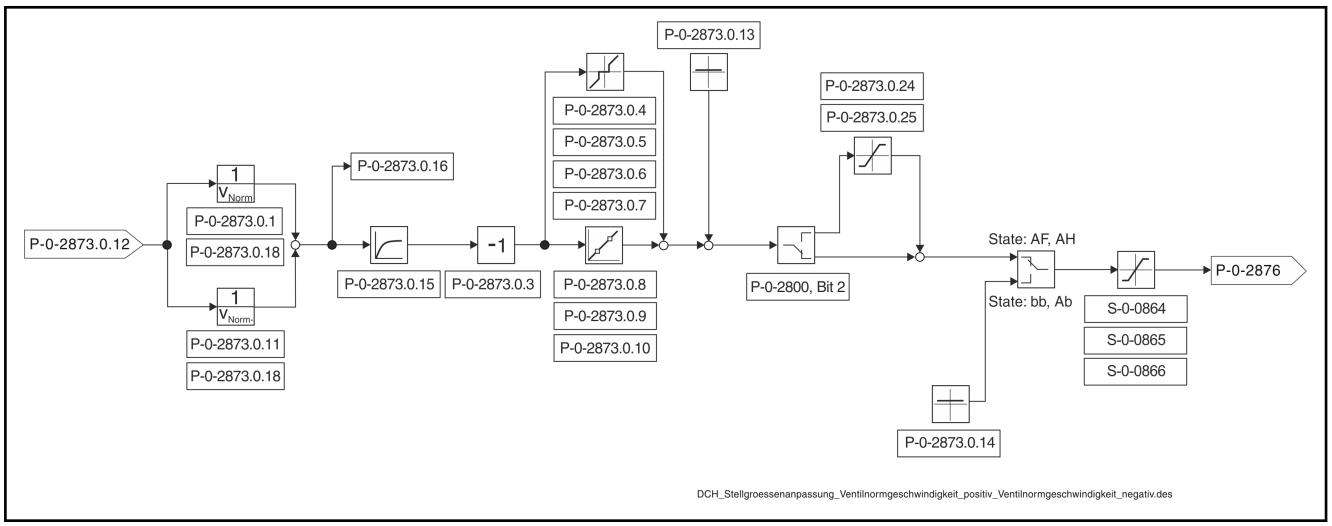


Fig. 7-3: Output adjustment with positive valve standard velocity and negative valve standard velocity

Settings in "P-0-2873.0.20, Control variable adjustment control word": Bit 1..0 = 01b.

The conversion of a velocity into a valve opening as well as the setting of the velocity ratio between retraction and extension of the cylinder is carried out using two separate valve standard velocities for extending, "P-0-2873.0.1,

Valve standard velocity", and retracting, "P-0-2873.0.11, Valve standard velocity (negativ)".

Special case for operation mode "direct valve control"

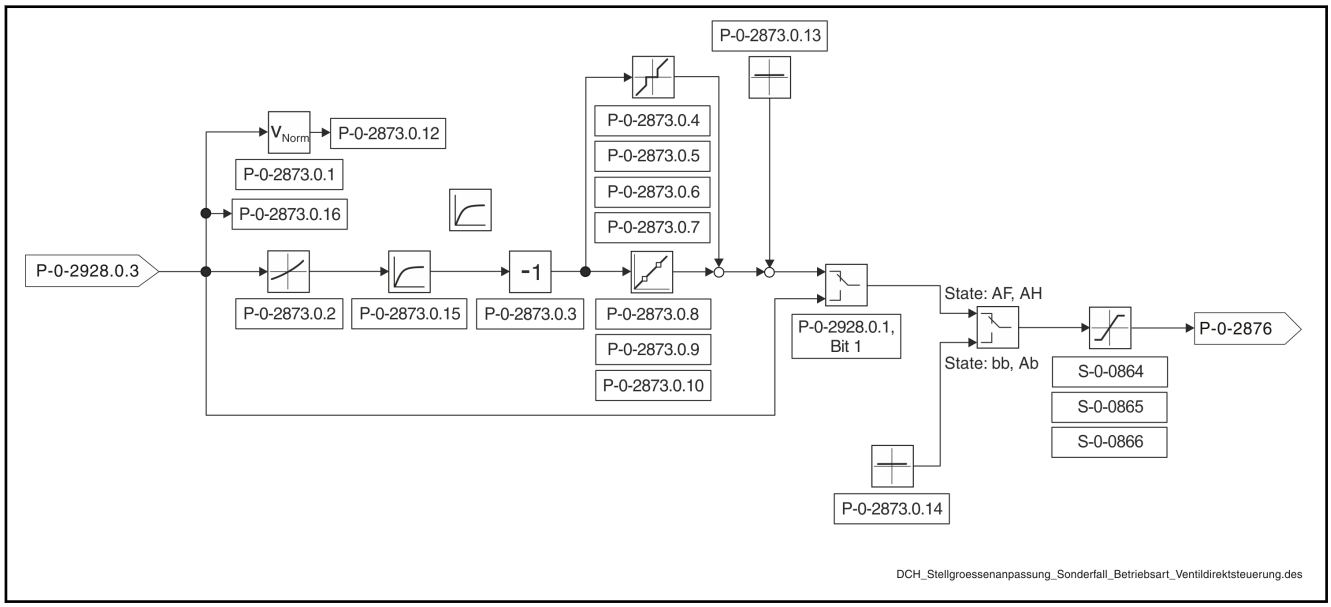


Fig. 7-4: Output adjustment for the special case of "direct valve control operation mode"

In the direct valve control mode, the generator already furnishes a valve opening; no conversion is required. Consequently, the valve standard velocity is not relevant, it is merely used for calculating "P-0-2873.0.12, Input of output adjustment" (velocity unit). It is possible to output the valve command value directly without utilizing direction-dependent gain, filter, inversion, characteristic curve adjustment, and offset. For this, bit 1 = 1 has to be set in "P-0-2928.0.1, Valve command value control word".

Description

Output adjustment can be used to adjust the actuating variable to the valve or the controlled system. Apart from direction-dependent gain, inversion, filtering, offset and limitation of the actuating variable, the non-linearity of the valve can be compensated for. The adjustment is independent of the selected operation mode. When the operation mode is changed over, all settings are maintained.

The velocity ratio between open-loop controlled retracting and extending of the cylinder usually has to be adjusted. In this case, influences are, for example, the area ratio of the cylinder or the load-dependence with vertical axes. This can be used to keep the loop gain constant during extending and retracting.

The velocity ratio can be adjusted in two ways:

- "P-0-2873.0.1, Valve standard velocity" and "P-0-2873.0.2, Direction-dependent gain", see fig. 7-2 "Output adjustment with valve standard velocity and direction-dependent gain" on page 385.
- "P-0-2873.0.1, Valve standard velocity" and "P-0-2873.0.11, Valve standard velocity (negativ)", see fig. 7-3 "Output adjustment with positive valve standard velocity and negative valve standard velocity" on page 385.

Valve standard velocity

"P-0-2873.0.1, Valve standard velocity" is the velocity, at which the hydraulic drive can move with maximum valve opening (100 %). Since the valve activation is based on percentage values, the output value of the individual control-

ler is normalized to percent with the help of the valve standard velocity. The normalized value is shown in parameter "P-0-2873.0.16, Output adjustment command value". If parameter "P-0-2873.0.1, Valve standard velocity" is to be changed, the active valve standard velocity can be adjusted using parameter "P-0-2873.0.18, Valve standard velocity ramp". If the ramp is set to 0, the adjustment is made abruptly.



This parameter is valid for the positive and the negative direction, except in "P-0-2873.0.20, Control variable adjustment control word". This parameter contains the settings for different valve standard velocities for forward and backward travel (bit 1..0 = 01b).

Valve standard velocity (negative)

Parameter "P-0-2873.0.11, Valve standard velocity (negativ)" is the velocity, at which the hydraulic drive can move with maximum valve opening (-100 %) in the negative direction. If parameter "P-0-2873.0.11, Valve standard velocity (negativ)" is changed, the active valve standard velocity is adjusted via parameter "P-0-2873.0.18, Valve standard velocity ramp". If the ramp is set to 0, the adjustment is made abruptly.

Direction-dependent gain

The factor "P-0-2873.0.2, Direction-dependent gain" is used to adjust the velocity ratio for open-loop controlled retracting and extending of the cylinder.

The factor can be determined in two ways:

- The control variable is measured at identical velocity during extending and retracting. Parameter P-0-2873.0.2 results from the quotient of the control variable during retracting and the control variable during extending.
- The actual velocity is measured during extending and retracting while the control variable is identical in terms of amount. Parameter P-0-2873.0.2 results from the quotient of the velocity during extending and the velocity during retracting.

If the control variable is negative, it is multiplied by this factor. If the factor is 1, the behavior of the axis depends on the direction. This is mostly useful for double-rod cylinders.

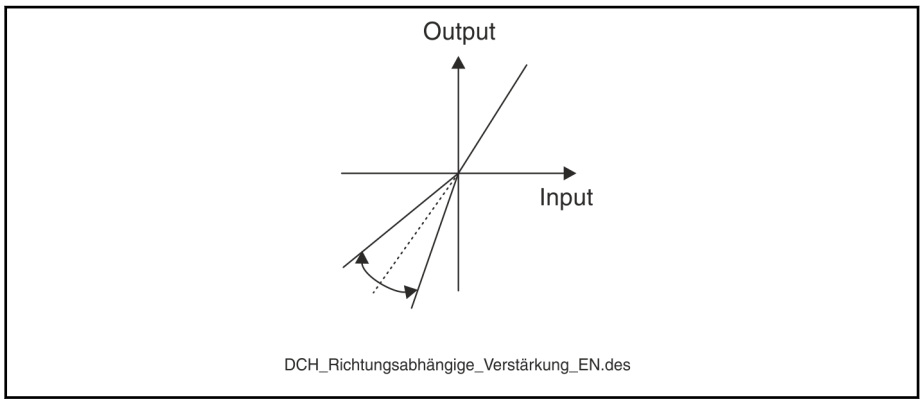


Fig. 7-5: Direction-dependent gain

Filter

The control variable can be smoothed using parameter "P-0-2873.0.15, Filter time of valve control output". When the value 0 is entered here, the filter is deactivated. The filter is used, for example, with drives, on which the natural frequency of the valve is significantly greater than that of the hydraulic drive (e.g. cylinder).

Inversion

The control variable is multiplied by "P-0-2873.0.3, Control variable inversion". If the value -1 is entered here, the control variable is inverted.

Overlap

This principle compensates the dead band characteristic of valves with a positive overlap. As a result, the control variable needs not to pass the dead band of the valve to initiate a reaction on the part of the cylinder.

Pertinent parameters

- P-0-2873.0.4, Valve overlap type
- P-0-2873.0.5, Valve overlap A-side
- P-0-2873.0.6, Valve overlap B-side
- P-0-2873.0.7, Valve overlap threshold

The valve overlap threshold determines, from which input value on the value "P-0-2873.0.5, Valve overlap A-side" is output for positive values, and the value "P-0-2873.0.6, Valve overlap B-side" for negative values. Above the valve overlap threshold, the values are linearly extrapolated up to +/-100 %.

The following valve overlap types are supported:

- Valve overlap type 0 (value = 0): deactivates valve overlap compensation
- Valve overlap type 1 (value = 1): within the "valve overlap threshold" 0 % is output. Within this range the valve is always in its central position, thus shutting off the hydraulic drive.

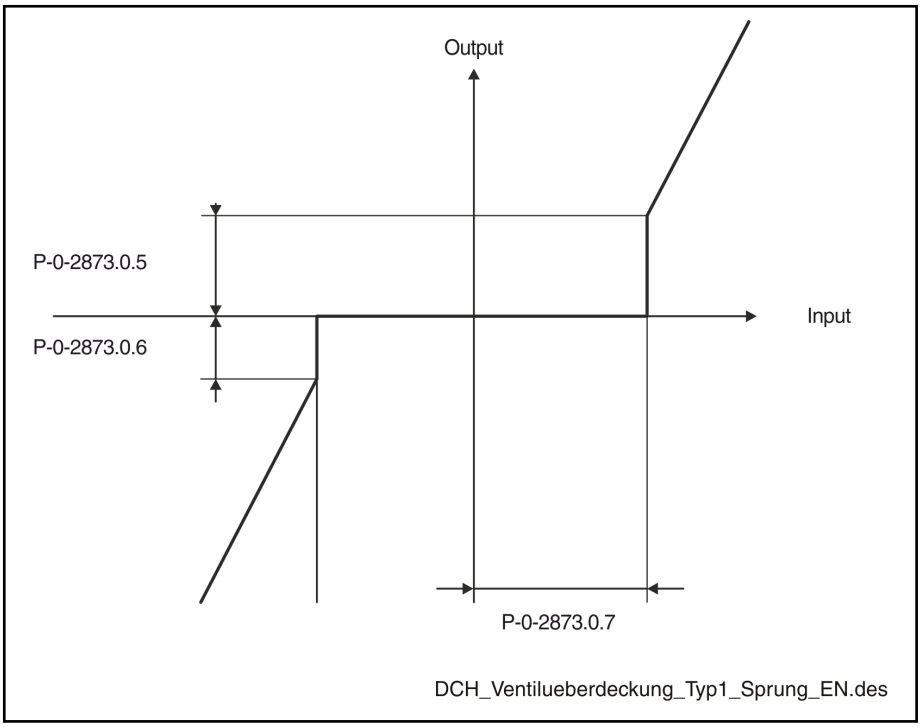


Fig. 7-6: Valve overlap type 1 “jump“

- Valve overlap type 2 (value = 2):

  Within the "valve overlap threshold" linear interpolation is carried out between the overlap values and the zero point.

For HDS:

In this case, the interpolation is carried out only between the overlap values, i.e. with non-symmetrical values, the characteristic curve does not pass through the zero point.

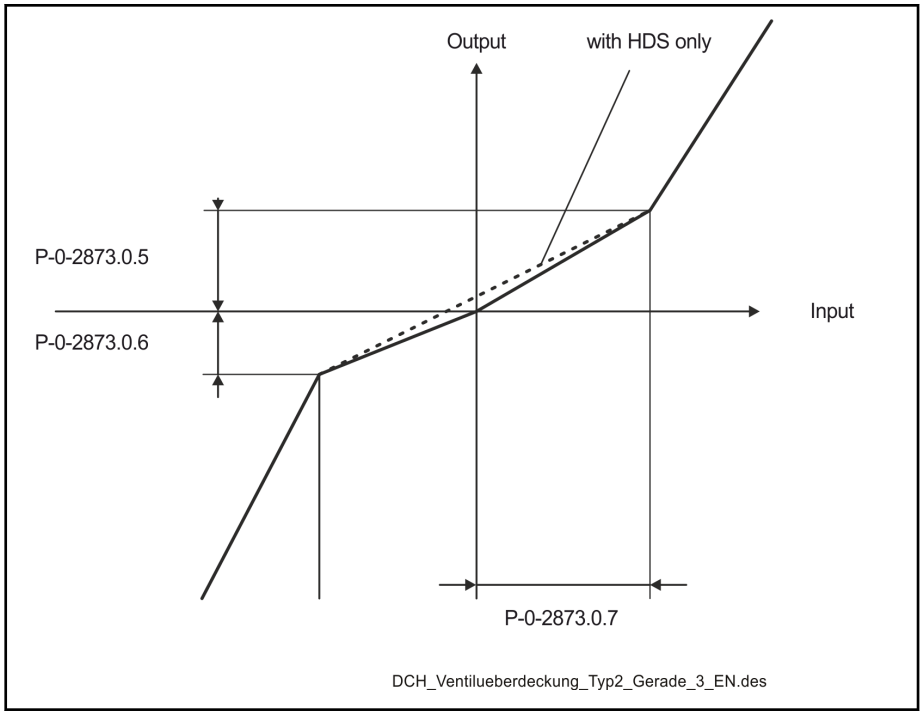


Fig. 7-7: Valve overlap type 1 "jump"

Characteristic curve

Typically, the characteristic curve of a valve is linear. This means that the resulting flow behaves linearly in relation to the valve opening. For some applications, however, valves with progressive or inflected characteristic curve are selected in order to obtain a higher resolution within lower velocity ranges. This non-linear behavior is documented as valve characteristic curve in the data sheet of the valve.

In order to achieve the best possible performance of the upstream controller, the non-linearity of valves should be compensated for. For this, it is possible to enter the characteristic of the valve as valve characteristic curve.

Alternatively, it is possible to enter a compensation characteristic curve.

The use of the characteristic curve is activated by selecting the characteristic curve type by means of parameter "P-0-2873.0.8, Characteristic of type":

- 0: Characteristic curve deactivated.
- -1: Symmetrical; only the positive branch of the input characteristic curve is used. For the negative values, the curve is mirrored to the negative.
- -2: Asymmetrical; both, the positive and the negative branch of the input characteristic curve are used. The curve points start within the maximum negative range and end within the positive maximum range.

"Parameter P-0-2873.0.20, Control variable adjustment control word", bit 2, can be used to select whether the curve is to be entered as compensation characteristic curve or as valve characteristic curve.

The points of the selected characteristic curve are entered as pairs of values in the two list parameters "P-0-2873.0.9, Characteristic of flow" and "P-0-2873.0.10, Characteristic of control variable".

Input as compensation characteristic curve

- "P-0-2873.0.9, Characteristic of flow" acts as x-axis and has to be monotonically increasing.

- "P-0-2873.0.10, Characteristic of control variable" acts as y-axis and needs not to be monotonic.

Input as valve characteristic curve

- "P-0-2873.0.10, Characteristic of control variable" acts as x-axis and has to be monotonically increasing.
- "P-0-2873.0.9, Characteristic of flow" acts as x-axis and has to be monotonically increasing.

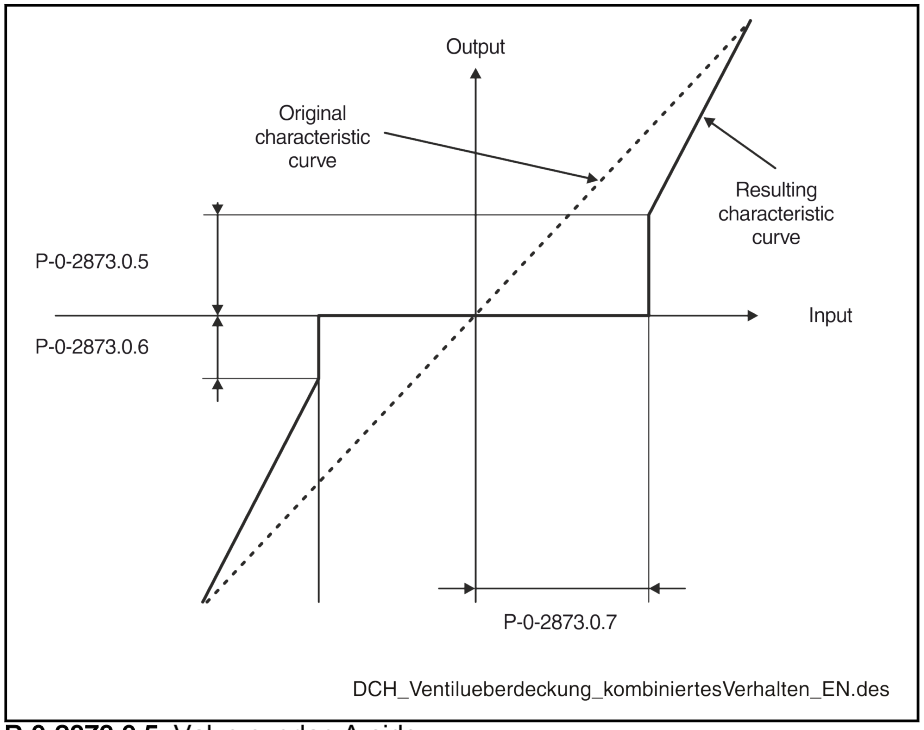
☞ Take the following points into account when entering the characteristic curve:

- To activate the characteristic curve, at least two values must have been entered.
- The length of the two list parameters "P-0-2873.0.9, Characteristic of flow" and "P-0-2873.0.10, Characteristic of control variable" has to be identical.
- The intermediate values of the valve characteristic curve are determined by linear interpolation.

If an invalid characteristic curve is entered, an internal changeover to linear characteristic takes place (input value = output value). This is, for example, the case, if monotonicity is not observed or if the list parameters have different lengths. The validity of the characteristic curve is signaled in "P-0-2871, Control variable adjustment status word", bit 0.

It is possible to switch the type of characteristic curve of an existing characteristic curve over by means of "P-0-2873.0.20, Control variable adjustment control word", bit 2. In such a case, the monotonicity, which is required for achieving the target state, is checked and, if necessary, established. If this is impossible, the characteristic curve is deactivated and an internal changeover to a linear behavior takes place. The incorrect characteristic curve is signaled by "P-0-2871, Control variable adjustment status word".

☞ If both, overlap and characteristic curve are activated, a combined behavior is obtained. Within the valve overlap threshold, only the overlap value is effective; the characteristic curve does not contribute to this, even if curve points exist within this range. The characteristic curve only becomes effective outside the valve overlap threshold. For this, the original characteristic curve is scaled to the range outside the overlap threshold. The resulting characteristic curve starts with the value of overlap at the overlap threshold and approximates the original characteristic curve over the remaining range.



P-0-2873.0.5 Valve overlap A-side
P-0-2873.0.6 Valve overlap B-side
P-0-2873.0.7 Valve overlap threshold

Fig. 7-8: Valve overlap, combined characteristic

Valve control variable offset

With "P-0-2873.0.13, Valve control variable offset" a constant percentage value can be added to the "valve controller command value".

This can be used to correct a zero point drift.

Limitation with pressure control (not with HDS)

In order to avoid undesirable cylinder movements during active pressure control, for example, the valve command value can be limited in positive or negative direction depending on the relevant valve characteristic. Further detail can be found in chapter 7.2.3 "Pressure controller" on page 395.

Standstill value without controller enable

"P-0-2873.0.14, Control disabled offset" determines the value, which is used for activating the valve as long as the drive is not in a closed-loop control mode (status bb or Ab). In particular when high-response valves without overlap are used or in the case of vertical axes, a value unequal to 0 % is required to achieve the standstill of an axis without controller enable.



- This parameter does not ensure a shutdown of the drive. To implement machine safety, this can only be ensured by providing additional circuit measures (usually check valves).
- Some hydraulic circuits or applications can also require values that significantly deviate from zero, e.g. shut-off valves of the cylinder on one side only or desired retraction of the cylinder.

In addition, it is possible to output a test value "P-0-2873.0.17, Control variable adjustment of command value, maintenance". It has the same function as "P-0-2873.0.14, Control disabled offset", but is automatically reset by the device after a timeout time of 200 ms.

Spool limit value

Here, you can preset the limitation of the valve control variable. The limitation can be set separately for the positive and the negative range using the pa-

rameters "S-0-0866, Negative spool limit value" and "S-0-0865, Positive spool limit value". If symmetrical limitation is desired, you can use parameter "S-0-0864, Bipolar spool limit value". Here, the smaller of the limitation values is effective.

☞ The limitation can be used to avoid undesired fast movements during commissioning.

Pertinent parameters

- P-0-2870, Control variable adjustment control word
- P-0-2871, Control variable adjustment status word
- P-0-2873.0.1, Valve standard velocity
- P-0-2873.0.2, Direction-dependent gain
- P-0-2873.0.3, Control variable inversion
- P-0-2873.0.4, Valve overlap type
- P-0-2873.0.5, Valve overlap A-side
- P-0-2873.0.6, Valve overlap B-side
- P-0-2873.0.7, Valve overlap threshold
- P-0-2873.0.8, Characteristic of type
- P-0-2873.0.9, Characteristic of flow
- P-0-2873.0.10, Characteristic of control variable
- P-0-2873.0.11, Valve standard velocity (negativ)
- P-0-2873.0.12, Input of output adjustment
- P-0-2873.0.13, Valve control variable offset
- P-0-2873.0.14, Control disabled offset
- P-0-2873.0.15, Filter time of valve control output
- P-0-2873.0.16, Output adjustment command value
- P-0-2873.0.17, Control variable adjustment of command value, maintenance
- P-0-2873.0.18, Valve standard velocity ramp
- P-0-2873.0.20, Control variable adjustment control word
- P-0-2876, Output control variable adjustment
- S-0-0864, Bipolar spool limit value
- S-0-0865, Positive spool limit value
- S-0-0866, Negative spool limit value

7.2.2 Flow controller

Conversion of flow into a valve control variable

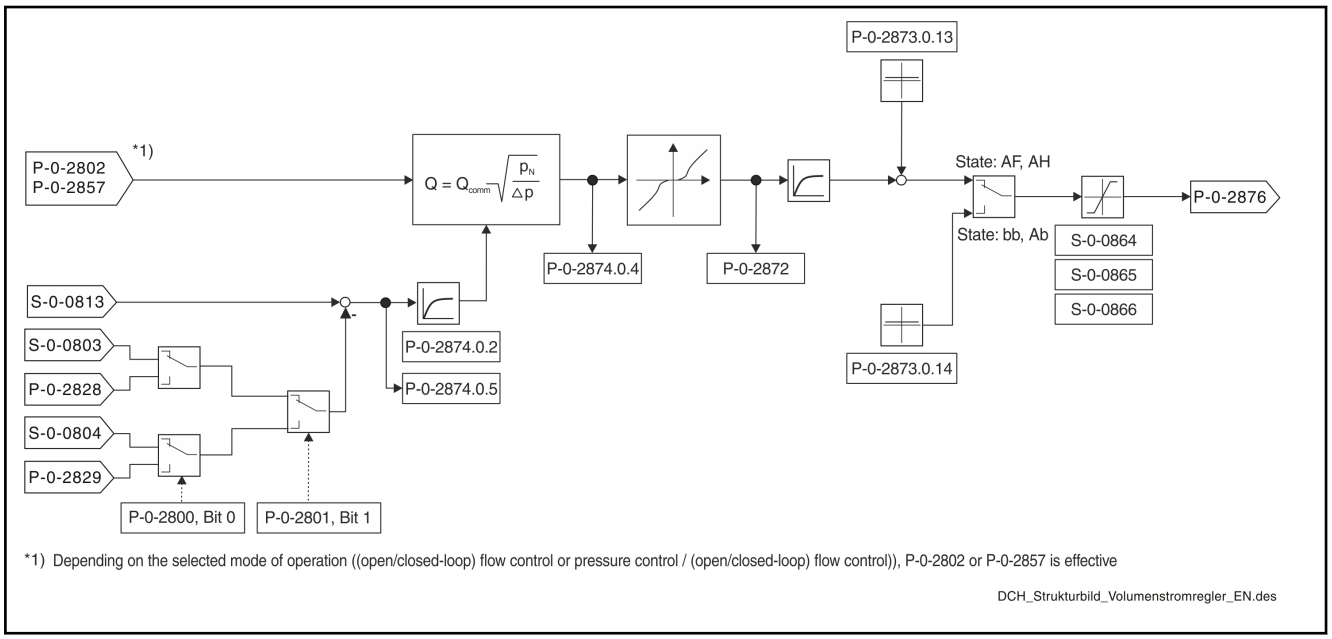


Fig. 7-9: Conversion of flow into a valve control value und output adjustment

This function calculates the resulting flow "P-0-2874.0.4, Output of Q calculation " from a given flow (Q-actuating internal) taking account of the corresponding delta p across the control land (flow equation). The delta-p is determined from the difference between the chamber pressure (A or B) and the system pressure or the tank pressure.

To prevent oscillations of the flow control in the case of axes with a low natural frequency (large mass and small cylinders), it is possible to switch to applicative chamber pressures "P-0-2828, Pressure feedback value A (applicative)"+"P-0-2829, Pressure feedback value B (applicative)".

These applicative chamber pressures should be written by a control or a similar device, and not come directly from pressure sensors. Fluctuations in the system pressure thereby continue to be compensated. By means of bit 0 in parameter "P-0-2800, p/Q controller control word" the applicative chamber pressures for the control can be selected.

Based on the resulting flow "P-0-2874.0.4, Output of Q calculation " the required valve control variable "P-0-2872, Output of valve characteristic curve " for the specified flow (Q-new) is determined from the inverse valve characteristic curve.

Flow calibration

The valve, and hence the polynomial valve characteristic curve, is calibrated during production and the valve characteristic curve thus corrected is saved in the device.

Output adjustment of flow controller

The valve control variable "P-0-2872, Output of valve characteristic curve " calculated from the stored characteristic curve is passed to output adjustment "P-0-2873.0.16, Output adjustment command value". Output adjustment uses this value to calculate the effective valve command value "P-0-2914, Output of pump pressure controller, cascade structure".

Pertinent parameters

- P-0-2800, p/Q controller control word
- P-0-2801, p/Q controller status word
- P-0-2802, Flow command value internal
- P-0-2828, Pressure feedback value A (applicative)
- P-0-2829, Pressure feedback value B (applicative)
- P-0-2857, Output of changeover logic p/Q
- P-0-2872, Output of valve characteristic curve
- P-0-2873.0.13, Valve control variable offset
- P-0-2873.0.14, Control disabled offset
- P-0-2873.0.15, Filter time of valve control output
- P-0-2873.0.16, Output adjustment command value
- P-0-2874.0.1, Q calculation delta p limitation
- P-0-2874.0.2, Q calculation time constant 1
- P-0-2874.0.4, Output of Q calculation
- P-0-2874.0.5, Delta p of pressure feedback value
- P-0-2876, Output control variable adjustment
- P-0-2914, Effective valve command value
- S-0-0803, Pressure feedback value A
- S-0-0804, Pressure feedback value B
- S-0-0813, System pressure
- S-0-0842, Flow feedback value
- S-0-0862, Spool feedback value
- S-0-0864, Bipolar spool limit value
- S-0-0865, Positive spool limit value
- S-0-0866, Negative spool limit value
- S-0-0867, Spool status word

7.2.3 Pressure controller

Closed-loop pressure control

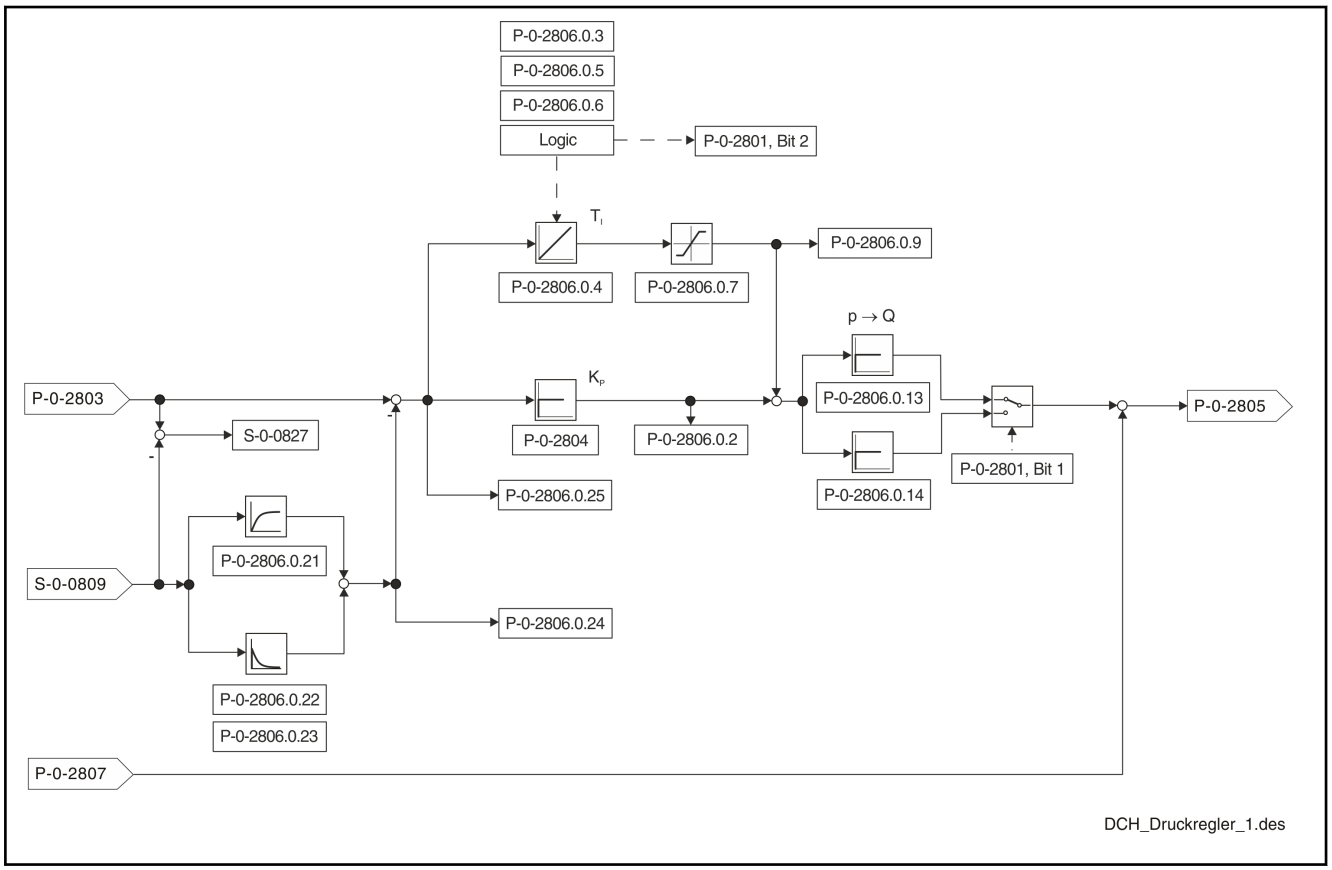


Fig. 7-10: Closed-loop pressure control

The pressure controller can only be used in conjunction with closed-loop flow control or direct valve control.

The pressure controller controls the respective chamber pressure. This means that the actual pressure value is always referred to the relevant chamber. The influence of leakage oil can be compensated for with the help of the integrator.

When the “min value principle with active integrator” (new mode) is selected in the changeover logic, the integrator is always calculated, even if the pressure controller is not active. The integrator needs not to be charged (initialized) when the changeover logic switches to the pressure controller. The integrator is limited to the smaller of the two values of "P-0-2806.0.7, Pressure controller integrator limit", or the internal flow command value/valve command value! The limitation is bipolar and the integrator enable conditions are effective. However, if the “min value principle” or the “switch-on threshold” or the “min value principle and switch-on threshold” has been selected in the changeover logic, the integrator only calculates, when the pressure controller is active. The integrator is limited to P-0-2806.0.7, Pressure controller integrator limit. The switch-on condition for the integrator depends on the change in the actual pressure value. This means that when a quasi-steady-state is reached, the integrator is activated and it is switched off again when the accuracy window is reached. The relevant parameters have to be adapted to the individual application. With regard to the limitation, it must be noted that it determines the maximum change (pressure per time unit). It is there-

fore possible that the limitation has to be set to a greater value than the maximum system pressure.

☞ If controlling is based on the pressure in chamber B, it must be noted that the two pressures are represented internally with a negative sign. For the control error, this means that with a positive value the actual pressure is greater than the command pressure, and with a negative value, the actual pressure is less than the command pressure.

☞ The sign of the flow or the valve command value determines, whether the pressure in chamber A or B is closed-loop-controlled. Positive means chamber A; negative, chamber B.

☞ For a flow control, for example, you can determine the volume for a pressure step-change by 100 bar by integrating the actual flow, thus determining the approximate amount of oil that is required to change the pressure. This volume corresponds to about 1 % of the entire volume (leakage oil falsifies the result), because with a modulus of elasticity of 10000 bar, a change in the oil volume by 1 % corresponds to a change in the amount of pressure of 100 bar.

Valve control variable limitation while pressure control is active

If cylinder movements are to be avoided during pressure control in conjunction with certain valve types (e.g. Q5-spool), the valve command value has to be limited depending on the relevant valve characteristics. For this, a limit value can be specified by means of two parameters (P-0-2873.0.24, Limitation of valve control variable, A-side and P-0-2873.0.25, Limitation of valve control variable, B-side). The limitation is only effective, if it was enabled via bit 2 in P-0-2800 (p/Q controller control word) and pressure control is active.

If the pressure is controlled at valve port A (bit 1 = 0 in P-0-2801, p/Q controller status word), the limitation is only effective on the B-side (P-0-2873.0.25, Limitation of valve control variable, B-side). If the pressure is controlled at valve port B (bit 1 = 1 in P-0-2801), the limitation is only effective on the A-side (P-0-2873.0.24, Limitation of valve control variable, A-side). If the valve command value is currently limited, this is indicated by bit 4 in "P-0-2871, Control variable adjustment status word“, and the integrator is stopped in the pressure controller.

Actual value filtering

A noisy actual pressure value can be smoothed by means of parameter "P-0-2806.0.21, Filter time of pressure feedback value". When the value 0 is entered here, the filter is deactivated.

A DT1-component, which is calculated with parameters "P-0-2806.0.22, Derivative action time, actual pressure value DT1" and "P-0-2806.0.23, Filter time of pressure feedback value DT1", can be added to the filtered actual pressure value. This component can be used to minimize overshoots. This function is activated by entering a value unequal to zero in parameter P-0-2806.0.23.

The filtered actual pressure value is shown in parameter "P-0-2806.0.24, Pressure feedback value, filtered".

Setting the I-component when activating the pressure controller (not in conjunction with “min value principle with active integrator")

When the pressure controller is activated, the I-component is set to zero by default. In certain cases, it may be useful to initialize the I-component with a greater value, e.g. when the drive encounters resistance while moving and is to continue its movement under closed-loop pressure control. This initialization value can be set in dependence upon the pressure change rate when the pressure controller is activated.

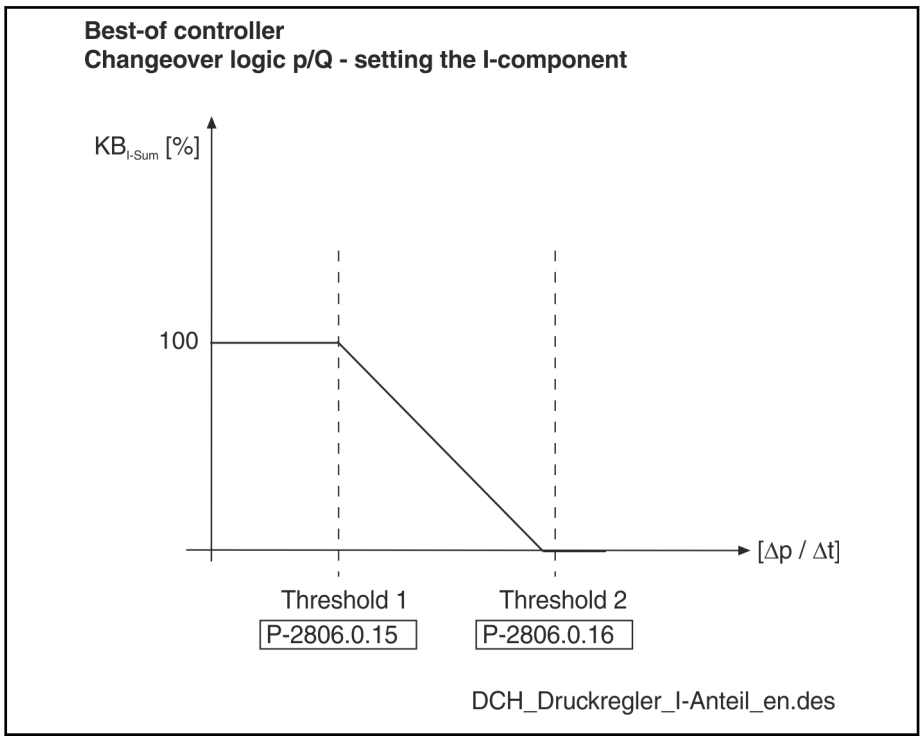


Fig. 7-11: Determination of the scaling factor for initializing the pressure controller I-component

The initialization of the I-component of the pressure controller is calculated according to the following formula:

$$I_component = (Q_{comm} - p_{actuating}) * KB_{I-sum} - P_component$$

Fig. 7-12:

With

I_component

I-component of the pressure controller (corresponds to P-0-2806.0.9)

Q_{comm}

internal flow command value as input for the changeover logic, see "changeover logic p/Q"

p_{var}

internal pressure control variable as input for the changeover logic, see "changeover logic p/Q"

P_component

P-component of the pressure controller (corresponds to P-0-2806.0.2)

☞ High pressure change rates indicate that the drive has hit a positive stop. Traversing further is rather improbable. In this case, the valve opening must be reduced as quickly as possible to avoid overshooting of the actual pressure value. Initializing the I-component with a value >0 would be rather unfavorable in this case. If, when the pressure controller is activated, the pressure change rate is small, it must be expected that the drive hit an obstacle, which can be pushed away. Here, initializing the I-component with a greater value would be useful. In this way, it can be achieved that the drive continues to travel as continuously as possible under closed-loop pressure control.

Pertinent parameters

- S-0-0809, Pressure feedback value
- S-0-0827, Pressure control deviation
- P-0-2800, p/Q controller status word
- P-0-2801, p/Q controller status word
- P-0-2803, Pressure command value of controller
- P-0-2804, Pressure controller P-gain
- P-0-2805, Output of pressure controller
- P-0-2806.0.2, Output pressure controller P-gain
- P-0-2806.0.3, Pressure controller integrator enable lowpass filter
- P-0-2806.0.4, Pressure controller integration time constant
- P-0-2806.0.5, Pressure controller integrator pressure change threshold
- P-0-2806.0.6, Pressure controller integrator accuracy window
- P-0-2806.0.7, Pressure controller integrator limit
- P-0-2806.0.9, Output pressure controller I-part
- P-0-2806.0.13, Pressure controller calculation p->Q value side A
- P-0-2806.0.14, Pressure controller calculation p->Q value side B
- P-0-2806.0.15, Pressure controller preload integrator, threshold 1
- P-0-2806.0.16, Pressure controller preload integrator, threshold 2
- P-0-2806.0.21, Filter time of pressure feedback value
- P-0-2806.0.22, Derivative action time, actual pressure value DT1
- P-0-2806.0.23, Filter time of pressure feedback value DT1
- P-0-2806.0.24, Pressure feedback value, filtered
- P-0-2806.0.25, Pressure control deviation, filtered
- P-0-2806.0.26, Output pressure controller in PD branch
- P-0-2807, Pressure controller pilot flow control command value
- P-0-2871, Control variable adjustment status word
- P-0-2873.0.24, Limitation of valve control variable, A-side
- P-0-2873.0.25, Limitation of valve control variable, B-side

7.2.4 Position control

Structure

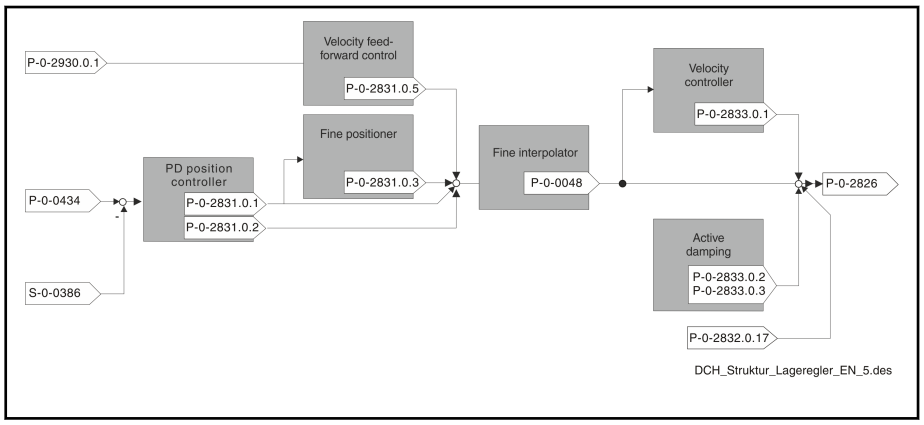


Fig. 7-13: Overview of position controller with inner-loop velocity controller

For closed-loop position control, apart from the position controller itself, further components can be activated:

Fine positioning (integrator), velocity feedforward, the inner-loop velocity controller and active damping.

Position controller with velocity feedforward

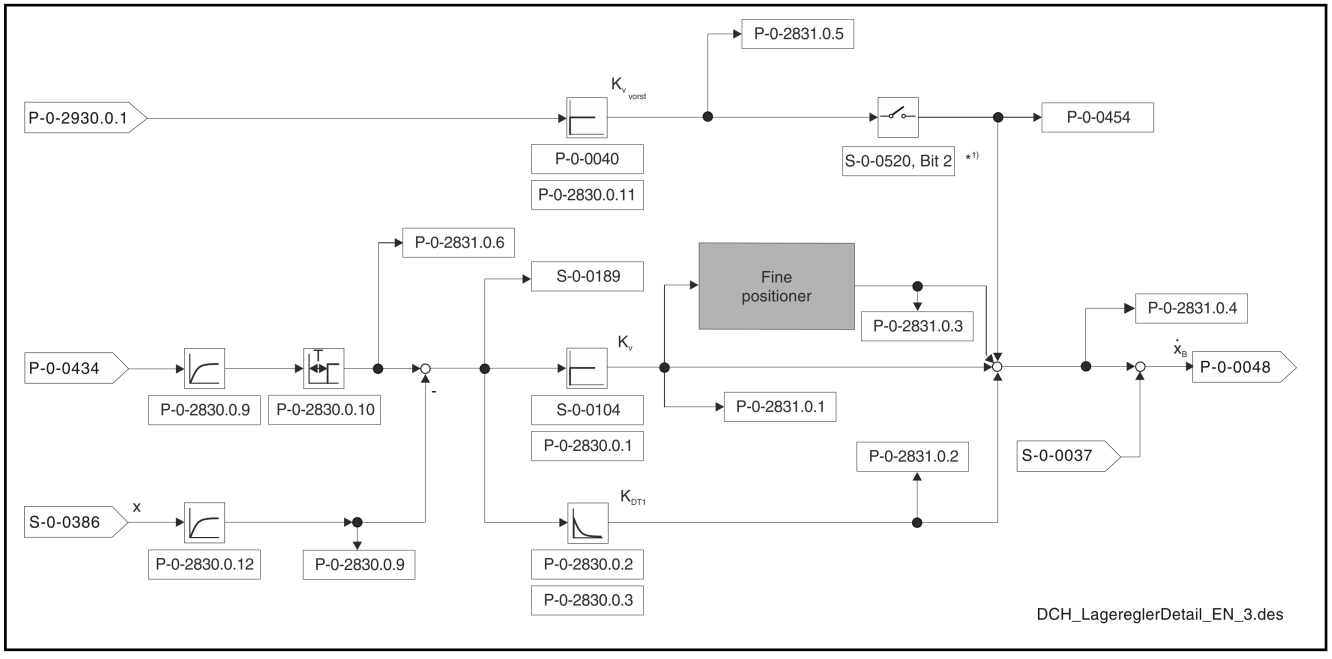


Fig. 7-14: Detail of position controller

[1)]Alternatively, velocity feedforward can be activated with the appropriate position operation mode ("lagless").

The position command value can be filtered, if required. For this, a T1-filter (P-0-2830.0.9) and a dead time filter (P-0-2830.0.10) are available. The filtered value can then be read in parameter “ Position command value of controller, delayed“ (P-0-2831.0.6). The actual position value can also be filtered, if necessary. A T1-filter (P-0-2830.0.12) is provided for this. The filtered value can be read in parameter "active position feedback value" (P-0-2831.0.9).

PDT1 position controller

A DT1-component, which is calculated with parameters “ Position loop time constant D-component“ (P-0-2830.0.2) and “ Position controller filter time D-component“ (P-0-2830.0.3), can be added to the proportional controller (Position loop Kv-factor, S-0-0104). This may become necessary, if the natural frequency of the cylinder-mass system is higher than the natural frequency of the valve.

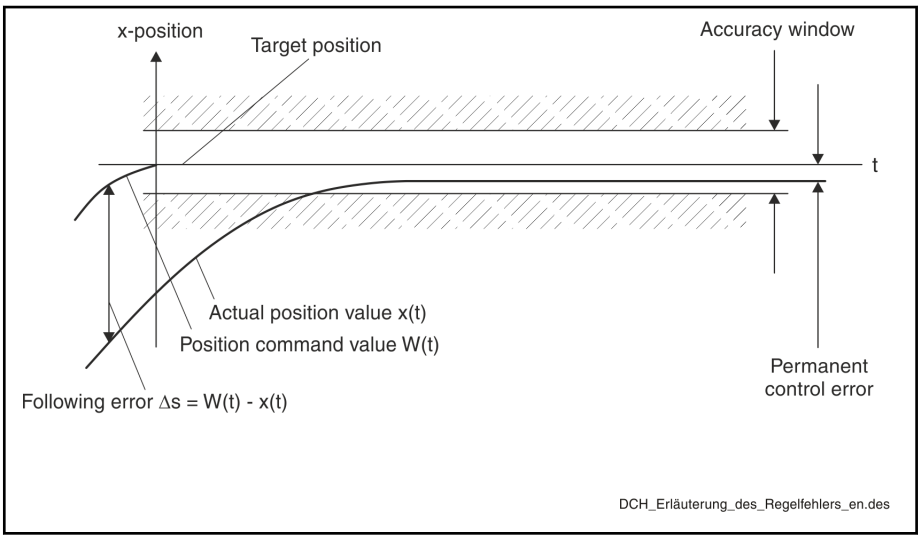


Fig. 7-15: Explanation of the control error

Depending on the controlled system, a permanent control error persists. This can be minimized by means of the fine positioner.

If, while a position operation mode is active, the Kv parameter is changed, the active Kv value is adjusted via a ramp using the parameter " Position controller Kv-factor change ramp" (P-0-2830.0.1). If the Kv change is set to "0", the adjustment is made abruptly.

Feedforward

With the help of feedforward control (command value feedforward), the command velocity - scaled with a percentage factor (P-0-0040) - can be processed in parallel to the position controller. In this way, any following distance can be minimized. Also here, a ramp (P-0-2830.0.11) is used when the scaling is changed. Feedforward is activated by means of the respective operation mode selection or a feedforward value unequal to "0".

Fine positioner

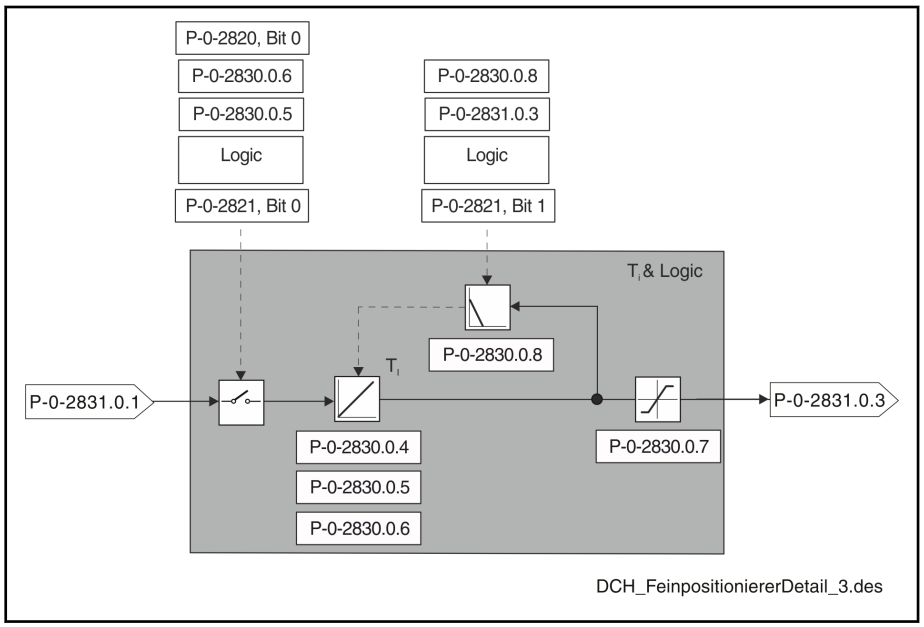


Fig. 7-16: Position controller fine positioner

Integrator for fine positioning

For exact positioning of a hydraulic axis it may be required to activate a special algorithm for fine positioning. Because at higher travel speeds the integrator has an unfavorable influence on the control behavior, it is only activated at lower travel speeds and close to the target position. The accuracy is specified by the accuracy window (P-0-2830.0.6).

The input of the integrator is parameter " Output position controller Kv-part" (P-0-2831.0.1). The slope of the I-component is determined by the integration time constant (P-0-2830.0.4).

Apart from not having reached the accuracy window yet, a switch-on condition for the integrator is a value below that given for the integrator velocity threshold (P-0-2830.0.5).

When fine positioning is switched off (e.g. by the relevant control bit P-0-2820, bit 0), the value is ramped down in the integrator (P-0-2830.0.8).

The output of the fine positioning integrator can be additionally limited (P-0-2830.0.7). This means that the integrator sums up to, but will not exceed the maximum of this limit value.



If the value "0" is set for the limitation of the I-component, the limitation is switched off.

The current value of the integrator can be read out, e.g. for optimization (P-0-2831.0.3).

Model monitoring/following distance monitoring

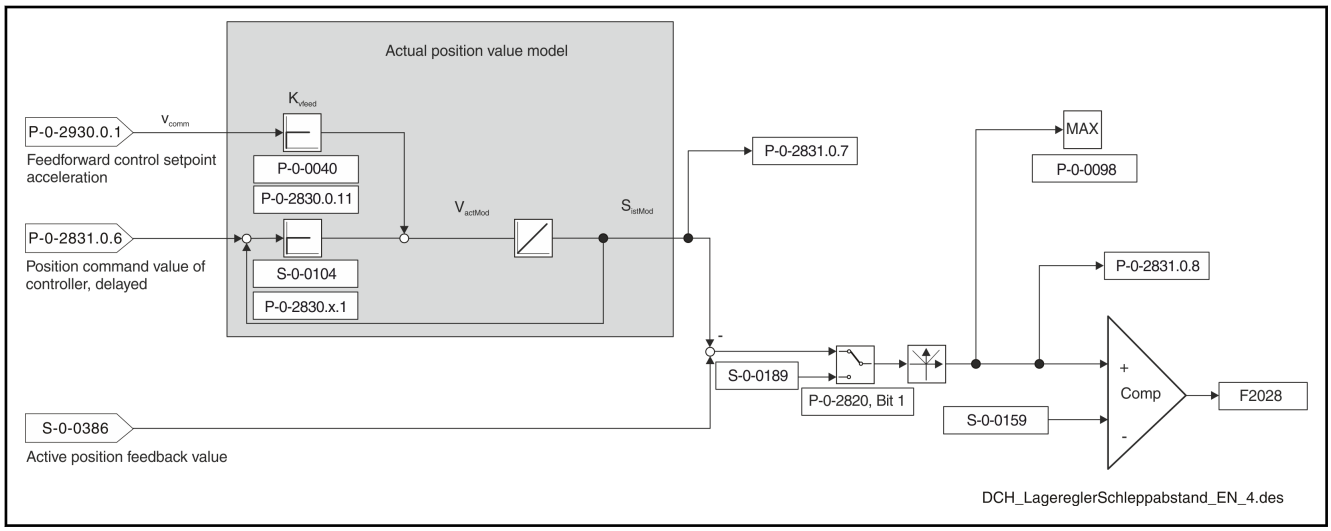


Fig. 7-17: Actual position value model with monitor

In the position operation modes (e.g. cyclic position), the axis is monitored for being able to follow the position command value. The following modes can be set for monitoring.

Model monitoring ("P-0-2820, Control word of position controller, bit 1 = 0"). In this mode an actual position value model is calculated and compared with the actual position value. If this deviation exceeds the value entered in parameter "S-0-0159, Monitoring window of following distance", the axis cannot follow the given command value and the error "F2028 Excessive deviation" is generated.

Following distance monitoring ("P-0-2820, Control word of position controller, bit 1 = 0"). In this mode, error "F2028 Excessive deviation" is generated, if parameter "S-0-0189, Following distance" exceeds the monitoring window.

If parameter "S-0-0159, Monitoring window of following distance" = 0, monitoring for "excessive control deviation" is deactivated.

The calculated actual position value can be read out in parameter "P-0-2831.0.7, Actual position value model".

Parameter "P-0-0098, Max. deviation" represents the maximum deviation between calculated and real actual position value in the " model monitoring" mode. In the "following distance monitoring" mode, the maximum following distance is shown.

Fine interpolator (not with HDS)

Since the velocity controller operates in the base clock cycle by default and is therefore called twice as fast as the position controller (see also chapter Features of the control loops (overview of open and closed-loop drive control)), the fine interpolator calculates the corresponding intermediate values for "P-0-0048, Velocity command value of controller". See also figure above, “Overview of position controller with inner-loop velocity controller”. Due to the operating principle of the fine interpolator the command value is delayed by one position controller clock cycle when the fine interpolator is active. The fine interpolator is switched on via bit 0 of "P-0-0556, Config word of axis controller". By default, the fine interpolator is switched off. While the fine interpolator is switched off the command value is passed on to "P-0-0048,

Velocity command value of controller" without delay. The fine interpolator is not available for HDS.

Velocity controller

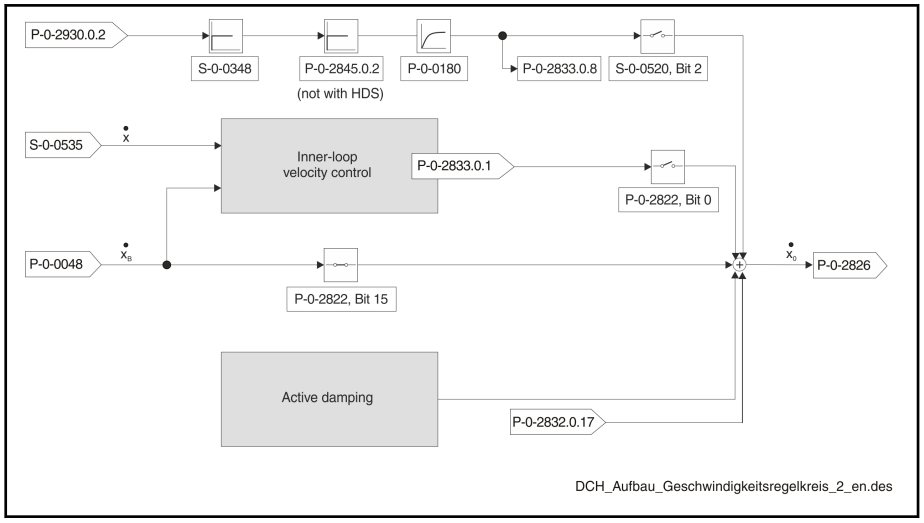


Fig. 7-18: Structure of the velocity control loop

The inner-loop velocity control can be used to achieve a constant path velocity.

If an operation mode with feedforward control has been selected, a command acceleration can additionally be fed forward to the output with the help of acceleration feedforward. This command velocity is scaled with a mass ("S-0-0348, Acceleration feedforward gain") and converted into a velocity via force normalization ("P-0-2845.0.2, Scaling force to velocity"). If required, the velocity can additionally be filtered. The proportion can be read from parameter "P-0-2833.0.8, Correction value: Velocity controller feedforward control". This feedforward function is not available for the firmware derivative HDS.

For axes with a low natural frequency, active damping can be utilized to improve the control quality.

An additive velocity command value (P-0-2832.0.17) may be used, which is effective at the output of the controller. For the firmware derivative HDS this additive velocity command value is not available.

Inner-loop velocity control

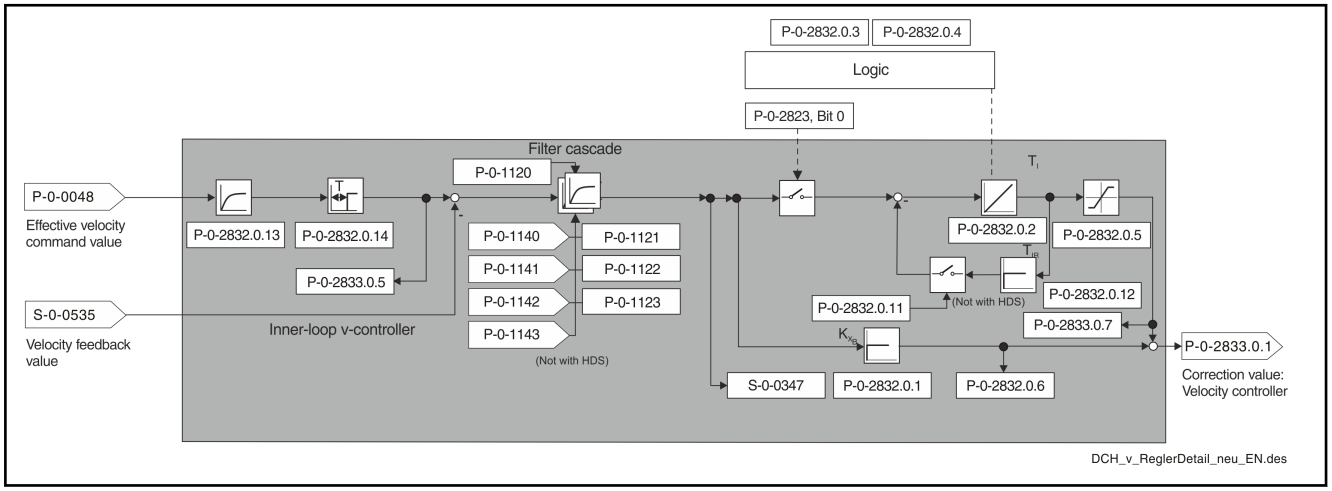


Fig. 7-19: Inner-loop velocity controller

Description The inner-loop velocity controller is a PI-controller. It is used to correct the deviation in velocity between the command and the actual value.

The velocity command value is fed through a parameterizable low-pass filter and an adjustable delay, before the actual velocity is subtracted and the control deviation calculated. Then the control deviation goes through a configurable filter cascade (not with HDS). From the filtered signal, the P- or the I-component is calculated.

The P-component results from multiplication by the V-controller proportional gain (P-0-2832.0.1).

If the absolute control error (S-0-0347) is greater than the V-controller accuracy window (P-0-2832.0.4), and actual acceleration (S-0-0536) is less than the acceleration threshold (P-0-2832.0.3), the integrator is activated with the V-controller integration time constant (P-0-2832.0.2).

If the integrator feedback time constant (T_{IR} P-0-2832.0.12) ≠ 0 and the amount of the actual velocity is less than "P-0-2832.0.11, Velocity controller integrator feedback threshold", the integrator feedback is active. It is useful for avoiding slip-stick effects of the cylinder. This feedback function is not available for the firmware derivative HDS.

This integrator, too, can be limited by means of a parameter (P-0-2832.0.5).

The inner-loop velocity control is switched on in the velocity controller control word (P-0-2822, bit 0).

Filter cascade (not with HDS)

The control deviation can be filtered with up to 2 IIR filters (2nd order) (not with HDS).

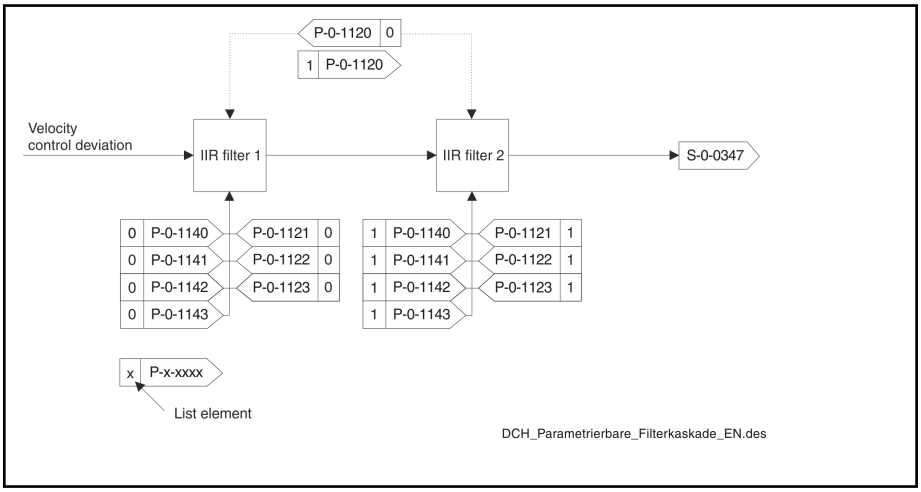


Fig. 7-20: Parameterizable filter cascade

Parameter "P-0-1120, Velocity control loop filter: Filter type" is used for selecting the desired filter by means of the relevant list element.

- **0:** No filtration
- **1:** Low-pass activated

  "P-0-1121, Velocity control loop filter: Limit frequency of low pass"
- **2:** Band-stop filter activated

  "P-0-1122, Velocity control loop filter: Bandwidth of band-stop filter"

  "P-0-1123, Vel. cont. loop filter: Center frequency of band-stop filter"
- **10:** Filter of second order activated

  "P-0-1140, Velocity control loop filter: Numerator natural frequency"

"P-0-1141, Velocity control loop filter: Denominator natural frequency"

"P-0-1142, Velocity control loop filter: Numerator damping"

"P-0-1143, Velocity control loop filter: Denominator damping"



With parameters P-0-1121, P-0-1122, P-0-1123, P-0-1140, P-0-1141, P-0-1142 and P-0-1143, list element 0 is used for filter 1, and list element 1 for filter 2.

Low pass

Parameterization of the cutoff frequency of the two filters; the value is entered in Hz. This means that the actual frequency (f=1/T) is to be entered, at which damping of -3 dB is to take place (attenuation of the amplitude to 0.707 of the input amplitude!).

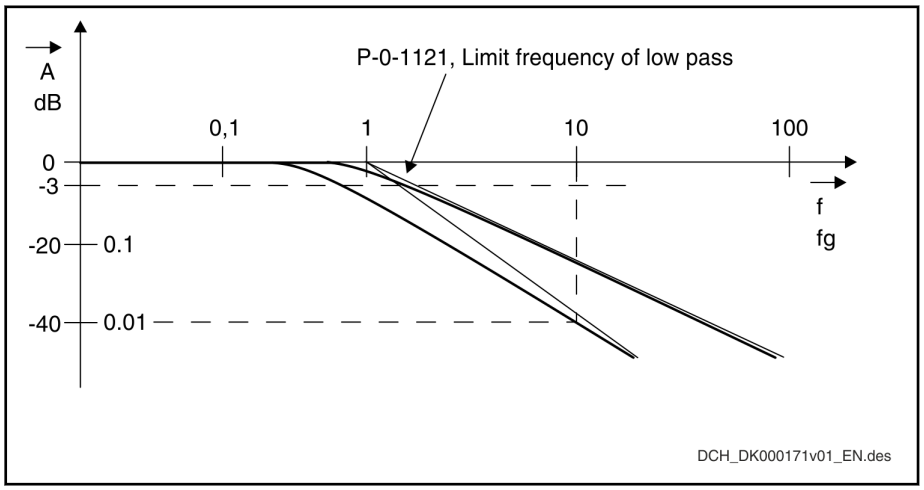


Fig. 7-21: Low pass

Band-stop filter

In conjunction with band-stop filters, the mid-band frequency and the bandwidth can be set. The reject frequency is attenuated most strongly; the bandwidth determines the frequency range in which the attenuation is less than -3 dB. Due to the filter structure, greater bandwidths result in lower attenuation of the reject frequency!

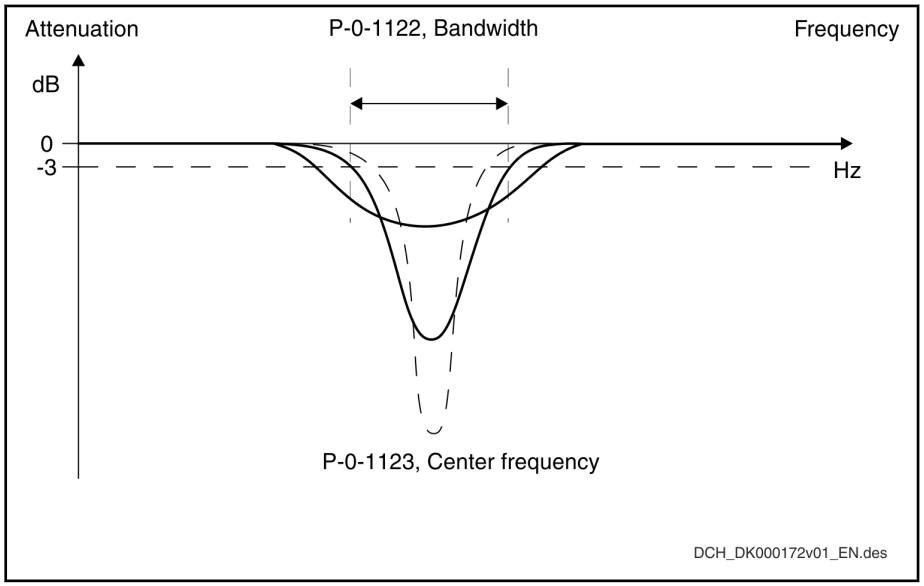


Fig. 7-22: Band-stop filter

Filter of second order

With 2nd order filters, the numerator natural frequency "P-0-1140, Velocity control loop filter: Numerator natural frequency", the denominator natural frequency "P-0-1141, Velocity control loop filter: Denominator natural frequency", numerator damping "P-0-1142, Velocity control loop filter: Numerator damping" and denominator damping "P-0-1143 Velocity control loop filter: Denominator damping" can be set.

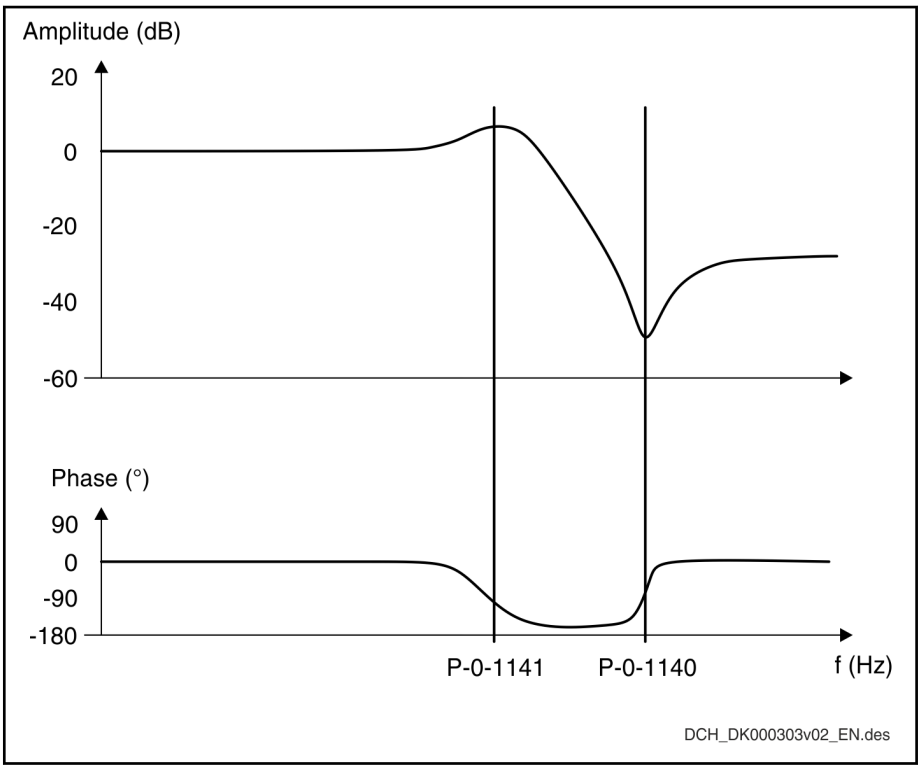


Fig. 7-23: Filter of second order

Features of filters of second order

The ratio of nominator frequency (f_N) to numerator frequency (f_Z) defines a reduction (or increase) above the two frequencies. The reduction (red in [dB]) is determined as follows:

$$Abs=40*\log(f_N/f_Z);$$

$f_N>f_Z \rightarrow Abs>0 \rightarrow$ Increase
$f_N=f_Z \rightarrow Abs=0$
$f_N<f_Z \rightarrow Abs<0 \rightarrow$ Reduction

Fig. 7-24: Calculation of red (reduction in [dB])

The amount of the denominator frequency (f_N or P-0-1141, Velocity control loop filter: Denominator natural frequency) and the numerator frequency (f_Z or P-0-1140, Velocity control loop filter: Numerator natural frequency) is determined as follows:

$$|F(f=f_Z)|_{\text{in dB}} = 20\log 10\left(\sqrt{\frac{4D_Z^2}{\left(1-\left(\frac{f_Z}{f_N}\right)^2\right)^2+\left(\frac{2D_N f_Z}{f_N}\right)^2}}\right);$$

$$|F(f=f_N)|_{\text{in dB}} = 20\log 10\left(\sqrt{\frac{\left(1-\left(\frac{f_N}{f_Z}\right)^2\right)^2+\left(\frac{2D_Z f_N}{f_Z}\right)^2}{4D_N^2}}\right);$$

Fig. 7-25: Calculation of the denominator frequency

If the damping rate D_N or D_Z is greater than 1/root(2), there is no exceeding of or breakdown below the numerator frequency f_Z or the denominator frequency f_N (remark: The smaller the damping rates, the closer are the frequencies, at which the max. increase or the max. breakdown occurs, to the numerator frequency or denominator frequency; that is, in the case of damping equal to ZERO, the frequencies are identical).

Realization of a band-stop filter with defined reduction (red in dB) and notch depth K (breakdown in dB at mid-band frequency f_M)

$$f_Z = f_m;$$

$$f_N = f_m * 10^{\frac{Abs}{40}};$$

$$D_Z = 10^{K/20} * 0.5 * \sqrt{\left(1-\frac{1}{10^{Abs/20}}\right)^2 + \frac{f_{BB}^2}{f_m^2 * 10^{Abs/10}}};$$

$$D_N = \frac{f_{BB}}{2 * f_m * 10^{Abs/40}};$$

Special case Abs=0: $f_N = f_m;$

$$D_Z = 10^{K/20} * 0.5 * \frac{f_{BB}}{f_m};$$

$$D_N = \frac{f_{BB}}{2 * f_m};$$

Fig. 7-26: Further formulas

Explanation of the symbols used:

f_m	Mid-band frequency [Hz]
f_{BW}	Bandwidth [Hz] (-3 dB)
K	Notch depth [dB]
Red	Reduction [dB]

For the special case Red = "0" and K = "-infinite" the filter then acts like a band-stop filter, which can be parameterized by means of "P-0-1122, Velocity control loop filter: Bandwidth of band-stop filter" and "P-0-1123, Vel. cont. loop filter: Center frequency of band-stop filter".

When using the smoothing filters, note that each filter causes a phase shift in the control loop and therefore has a negative effect on the phase margin in the control loop (control loop stability).

Parameters/diagnostic and status messages

Pertinent parameters

- P-0-0040, Velocity feedforward
- P-0-0048, Velocity command value of controller
- P-0-0098, Max. deviation
- P-0-0434, Position command value of controller
- P-0-0435, Control word of position controller
- P-0-0454, Velocity feedforward actual value
- P-0-0556, Config word of axis controller
- P-0-1120, Velocity control loop filter: Filter type
- P-0-1121, Velocity control loop filter: Limit frequency of low pass
- P-0-1122, Velocity control loop filter: Bandwidth of band-stop filter
- P-0-1123, Vel. cont. loop filter: Center frequency of band-stop filter
- P-0-1140, Velocity control loop filter: Numerator natural frequency
- P-0-1141, Velocity control loop filter: Denominator natural frequency
- P-0-1142, Velocity control loop filter: Numerator damping
- P-0-1143, Velocity control loop filter: Denominator damping
- P-0-2820, Control word of position controller
- P-0-2821, Position controller status word
- P-0-2830.0.1, Position controller Kv-factor change ramp
- P-0-2830.0.2, Position loop time constant D-component
- P-0-2830.0.3, Position controller filter time D-component
- P-0-2830.0.4, Position controller integration time constant
- P-0-2830.0.5, Position controller integrator velocity threshold
- P-0-2830.0.6, Position controller integrator position window
- P-0-2830.0.7, Position controller integrator limit
- P-0-2830.0.8, Position controller integrator washout ramp
- P-0-2830.0.9, Position command filter time
- P-0-2830.0.10, Position command dead time
- P-0-2830.0.11, Velocity feedforward change ramp
- P-0-2831.0.1, Output position controller Kv-part
- P-0-2831.0.2, Output position controller D-part
- P-0-2831.0.3, Output position controller I-part
- P-0-2831.0.4, Output of position controller
- P-0-2831.0.5, Correction value: velocity feedforward control
- P-0-2831.0.6, Position command value of controller, delayed
- P-0-2831.0.7, Actual position value model

- P-0-2831.0.8, Following distance for monitoring
- P-0-2822, Velocity controller control word
- P-0-2823, Velocity controller status word
- P-0-2826, Output of velocity controller
- P-0-2832.0.1, Velocity controller P-gain
- P-0-2832.0.2, Velocity controller integration time constant
- P-0-2832.0.3,
  Velocity controller integrator acceleration threshold
- P-0-2832.0.4, Velocity controller integrator velocity window
- P-0-2832.0.5, Velocity controller integrator limit
- P-0-2832.0.11, Velocity controller integrator feedback threshold
- P-0-2832.0.12, Velocity controller integrator feedback time constant
- P-0-2832.0.13, Velocity command filter time
- P-0-2832.0.14, Velocity command dead time
- P-0-2832.0.17, Additive velocity command value
- P-0-2833.0.1, Output velocity controller
- P-0-2833.0.5, Velocity command value of controller, delayed
- P-0-2833.0.6, Output velocity controller P-part
- P-0-2833.0.7, Output velocity controller I-part
- P-0-2833.0.8, Correction value: Velocity controller feedforward control
- P-0-2845.0.2, Scaling force to velocity
- P-0-2830.0.12, Filter time of position feedback value
- P-0-2831.0.9, Position feedback value, filtered
- P-0-2930.0.2, Feedforward control setpoint acceleration
- S-0-0037, Additive velocity command value
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0040, Velocity feedback value of encoder 1
- S-0-0091, Bipolar velocity limit value
- S-0-0104, Position loop Kv-factor
- S-0-0189, Following distance
- S-0-0347, Velocity error
- S-0-0535, Active velocity feedback value
- S-0-0520, Axis control word
- S-0-0348, Acceleration feedforward gain

Pertinent diagnostic messages

- F2028 Excessive deviation
- E2059 Velocity command value limit active
- E2070 Acceleration limit active
- F8079 Velocity limit value exceeded

7.2.5 Active damping

Description

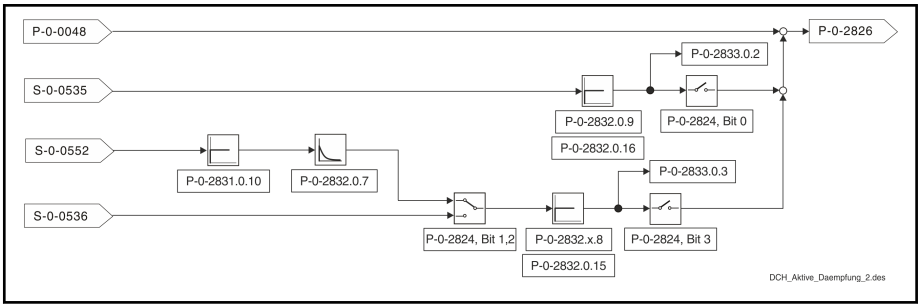


Fig. 7-27: Active damping

The feedback of state variables can be used to achieve a greater control loop gain and thus a better control behavior (reference reaction and disturbance response, faster signal transitions). Especially for systems with a relatively low natural frequency (f_{system} < 15 Hz) active damping helps to improve the dynamic behavior. However, a prerequisite is that the valve is "sufficiently" fast in relation to the cylinder-mass system. (f_{valve} > 2* f_{system})

Types of feedback

With active damping, the actual values of velocity ("P-0-2832.0.9, Active damping: Velocity gain"), acceleration ("P-0-2832.0.8, Active damping: Acceleration gain") or force ("P-0-2832.0.8, Active damping: Acceleration gain" and "P-0-2832.0.10, Moved mass") can be fed back to the control with a scaling factor.

If the scaling parameters are changed, the active values are adjusted using corresponding ramp times with the parameters "P-0-2832.0.15, Active damping: Acceleration gain ramp time" or "P-0-2832.0.16, Active damping: Velocity gain ramp time". If the ramp time is set to "0", the adjustment is made abruptly.

The feedback can be positive or negative, which is determined by the sign of the relevant parameter.

Active damping should not be used together with the inner-loop velocity controller.

The type of feedback is set via the control word "P-0-2824, Active damping: Control word". Either acceleration feedback or force feedback can be used. Both feedback types can be combined with velocity feedback.

Pertinent parameters

- P-0-0048, Velocity command value of controller
- P-0-2824, Active damping: Control word
- P-0-2826, Output of velocity controller
- P-0-2832.0.7, Active damping: Force/time constant
- P-0-2832.0.8, Active damping: Acceleration gain
- P-0-2832.0.9, Active damping: Velocity gain
- P-0-2832.0.10, Moved mass
- P-0-2832.0.15, Active damping: Acceleration gain ramp time
- P-0-2832.0.16, Active damping: Velocity gain ramp time
- P-0-2833.0.2, Portion of active damping: Velocity
- P-0-2833.0.3, Portion of active damping: Acceleration/force
- S-0-0535, Active velocity feedback value
- S-0-0536, Active acceleration feedback value

- S-0-0552, Torque/force feedback value

7.2.6 Torque/force controller

Structure

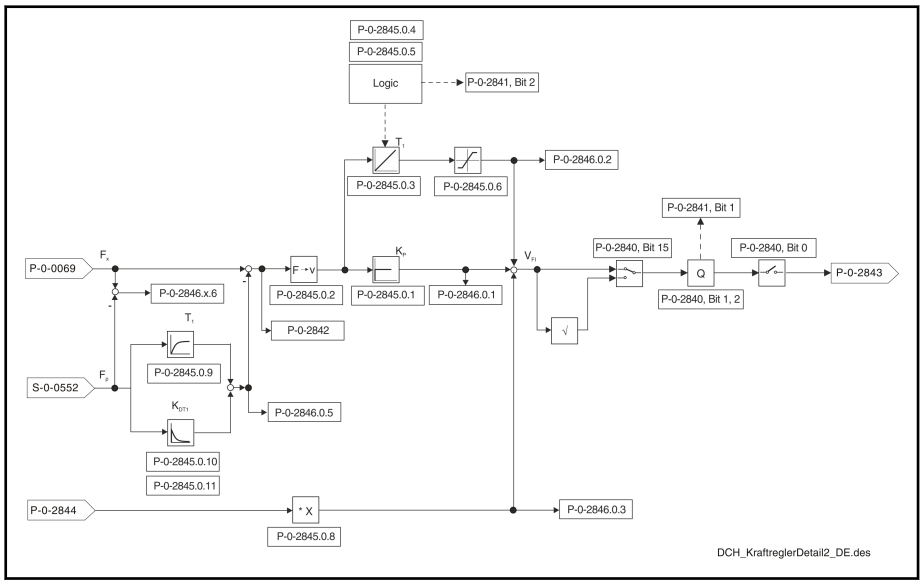


Fig. 7-28: Force controller

Description

The force controller is active under the following conditions and in the following operation modes:

- Always:
  - Operation mode of “torque/force control”
- When alternating control was activated:
  - All position operation modes
  - Velocity control
  - Combined operation modes of “Torque/force control / etc.”

When the force controller is active (for conditions, see also chapter "Alternating control"), bit 0 of parameter "P-0-2841, Force controller status word" is set to "true". The force controller then controls "S-0-0552, Torque/force feedback value" on the basis of the set "P-0-0069, Torque/force command value of controller".

Filter

A noisy actual force value can be smoothed by means of parameter "P-0-2845.0.9, Force feedback filter time". When the value 0 is entered here, the filter is deactivated. The smoothed actual force value is shown in parameter "P-0-2846.0.5, Torque/force feedback value, filtered".

DT1 "derivative mode"

A DT1-component, which is calculated with parameters "P-0-2845.0.10, Derivative action time, actual force value DT1" and "P-0-2845.0.11, Filter time of force feedback value DT1" can be added to the filtered actual force value. This component can be used to minimize overshoots. This function is activated by entering a value unequal to zero in parameter P-0-2845.0.11.

Normalization of force to velocity (F → v)

Parameter "P-0-2842, Force control deviation" is the difference between "effective torque/force command value" and "torque/force feedback value, filtered". With the help of parameter "P-0-2845.0.2, Scaling force to velocity" the "force control deviation" is normalized to velocity units, because this unit is used for further calculations within the controllers. This normalization factor

is internally calculated from the cylinder geometry data entered, "S-0-0819, Cylinder stroke" and "S-0-0820, Piston area A" or "S-0-0821, Piston area B", respectively.

It results in the fact that with a "P-0-2845.0.1, Force controller P-gain" of 1, overshoot-free controlling can be realized. This provides a good starting value for further optimization.

P-gain

Parameter "P-0-2845.0.1, Force controller P-gain" is used for setting the proportional control action of the controller. Parameter "P-0-2846.0.1, Output force controller P-part" shows the proportional component of the force controller.

Integrator

Despite optimization of the P-gain, a permanent control deviation due to disturbances or offsets may be present. This can be corrected by means of the integrator.

The integrator can be set with the following parameters:

- P-0-2845.0.3, Force controller integration time
- P-0-2845.0.4, Force controller integrator force change threshold
- P-0-2845.0.5, Force controller integrator force window
- P-0-2845.0.6, Force controller limitation integrator

By specifying "force controller integrator force change threshold" and "force controller integrator accuracy window" you can define the enable condition for the integrator. The integrator is only activated when the change of the actual force value is smaller than the specified force threshold, and the "force control deviation" is still greater than the "force controller integrator accuracy window". As long as the integrator is activated, bit 2 "enable condition I-controller true" of the status word (P-0-2841) is set to "TRUE".

When the control deviation is within the envisaged accuracy window, the I-term is stopped to prevent the drive from oscillating at values around the command value.

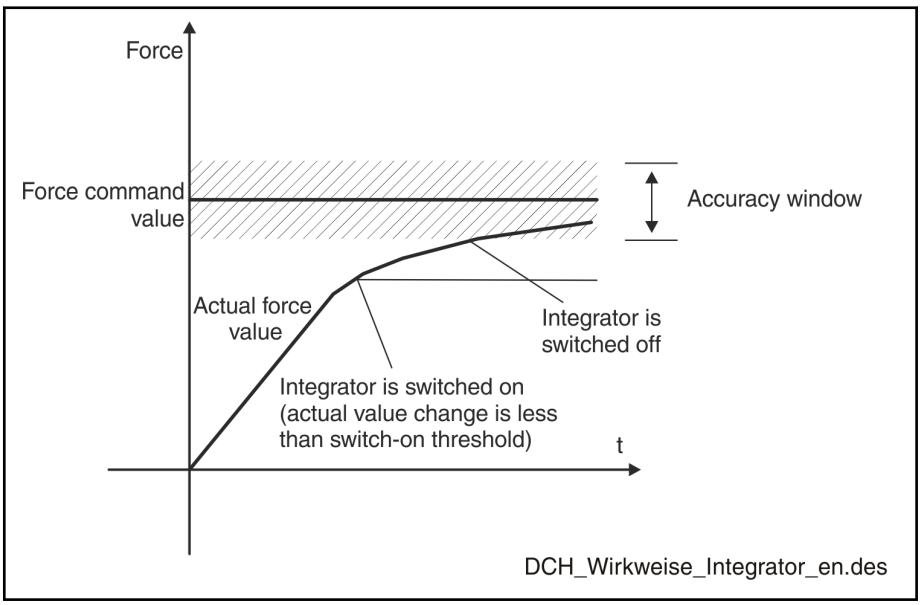


Fig. 7-29: Operating principle of integrator

"P-0-2846.0.2, Output force controller I-part" can be limited by **"P-0-2845.0.6, Force controller limitation integrator"** irrespective of the sign.

☞ The consideration of "P-0-2845.0.4, Force controller integrator force change threshold" as switch-on condition for the integrator can also be deactivated by means of "P-0-2840, Force controller control word", bit 0.

Jump-free transition via I-component (not with HDS)

Jump-free transition via the I-term can be activated by means of bit 3 in parameter "P-0-2840, Force controller control word" With an integration time of 0 ms, the jump-free transition is deactivated. When force control starts, the control output issued last is taken over into the I-term of the force controller and reduced via parameter "P-0-2845.0.3, Force controller integration time". The force control takes over control without actuating value breakdown. The use of jump-free switching over is recommended for traversing to a so-called “soft stop”, i.e. the axis is to continue to move after the force controller has taken over control.

Velocity feedforward

"P-0-2846.0.3, Output force controller velocity feedforward part" is established by multiplying "P-0-2844, Force controller velocity feedforward control" by "P-0-2845.0.8, Force controller scaling of velocity feedforward control". This is applied for drives that are displaced at a measurable, impressed velocity. In this case, the measured velocity value is cyclically assigned to "P-0-2844, Force controller velocity feedforward control". The resulting velocity feedforward component is added to the controller output.

Valve root function (with HDS only)

This function is relevant only for the HDS derivative. It takes account of the valve's dependence on load. Load dependence means that with a constant valve command value at different load pressures, different amounts of oil flow across the valve. The selection of this function improves the control result when velocity feedforward is selected in conjunction with changing force command values. The function is activated by setting bit 15 in the control word of the force controller.

Quadrant limitation

Quadrant limitation can be used to determine, whether the axis may only build up or only reduce force.

As long as quadrant limitation is active, bit 1 of the status word (P-0-2841) is set to "TRUE".

Pertinent parameters

- P-0-0069, Torque/force command value of controller
- P-0-2840, Force controller control word
- P-0-2841, Force controller status word
- P-0-2842, Force control deviation
- P-0-2843, Output of force controller
- P-0-2844, Force controller velocity feedforward control
- P-0-2845.0.1, Force controller P-gain
- P-0-2845.0.2, Scaling force to velocity
- P-0-2845.0.3, Force controller integration time
- P-0-2845.0.4, Force controller integrator force change threshold
- P-0-2845.0.5, Force controller integrator force window
- P-0-2845.0.6, Force controller limitation integrator
- P-0-2845.0.8, Force controller scaling of velocity feedforward control
- P-0-2845.0.9, Force feedback filter time
- P-0-2845.0.10, Derivative action time, actual force value DT1
- P-0-2845.0.11, Filter time of force feedback value DT1

- P-0-2846.0.1, Output force controller P-part
- P-0-2846.0.2, Output force controller I-part
- P-0-2846.0.3, Output force controller velocity feedforward part
- P-0-2846.0.5, Torque/force feedback value, filtered
- P-0-2846.0.6, Force control deviation, unfiltered
- S-0-0552, Torque/force feedback value

7.2.7 Changeover logic

Structure

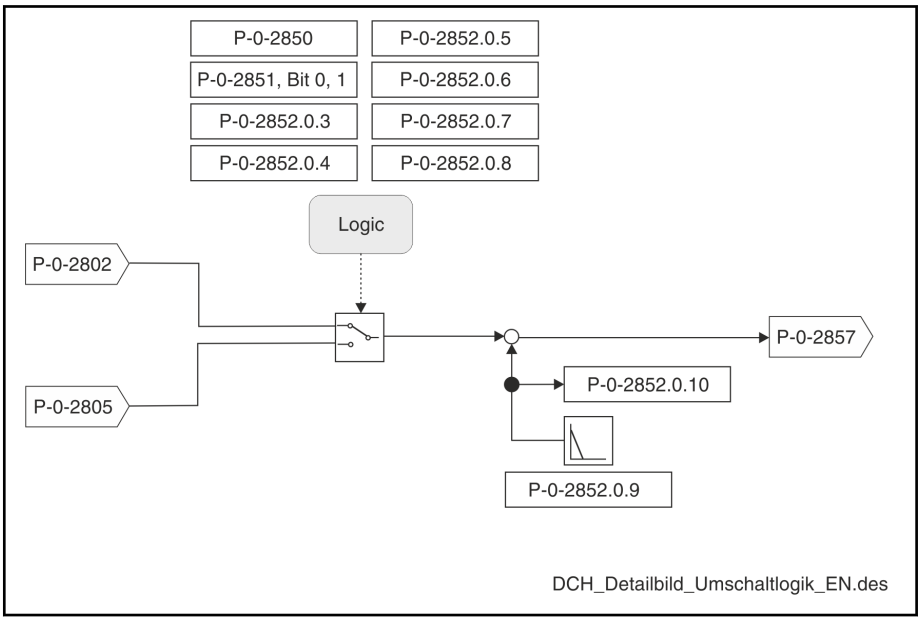


Fig. 7-30: Detail of changeover logic for closed-loop pressure control/(open/closed-loop) flow control

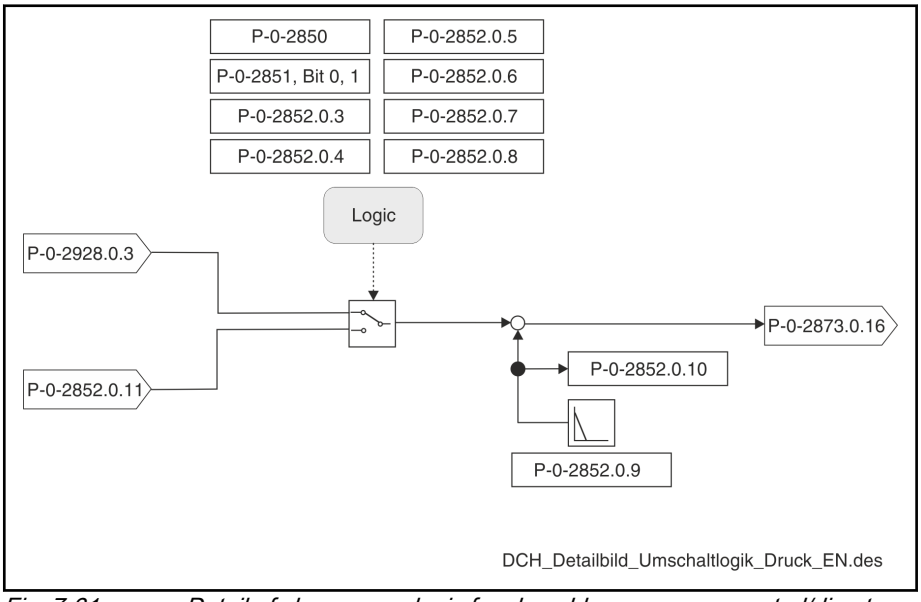


Fig. 7-31: Detail of changeover logic for closed-loop pressure control/direct valve control

The changeover logic switches between (open/closed-loop) flow control and closed-loop pressure control or direct valve control and closed-loop pressure

control. This is checked in every cycle of the pressure controller. This means that the changeover logic could theoretically switch in every cycle.

To change to the pressure controller, several modes are provided:

- "No selection": The changeover logic is switched off
- "Min value principle" or "min value principle with active integrator": Depending on the output signal to be generated for the valve the controller/the output signal is selected that results in a lower activation.
- "Pressure switch-on threshold": The changeover logic switches to the pressure controller depending on a defined relative or absolute threshold.
- "Min value principle and pressure switch-on threshold": The conditions for both the switch-on threshold and the minimum value principle have to be fulfilled in order that closed-loop pressure control is activated.

☞ The switch-on threshold is a reliable change-over criterion for many applications.

The following setting options are available for changing over from the pressure controller to direct valve control or the flow controller:

- "No selection": This will result in an immediate changeover from the pressure controller.
- "Minimum value": Depending on the output signal to be generated for the valve the controller/the output signal is selected that results in a lower activation.
- "Pressure switch-off threshold": The changeover logic switches over from the pressure controller depending on a defined relative or absolute threshold.
- "Pressure switch-off threshold or minimum value": The criterion that occurs first initiates switching back.
- "Changeover to Q by P-0-2800 bit 1": It is possible to trigger an edge reversal of bit 1 in "P-0-2800, p/Q controller control word" and thus to force switching back from the pressure controller.
- "Change of the internal Q command value": If the sign changes, the pressure controller is automatically deactivated and the axis follows the respective command value.
- "Change of Q sign or minimum value": A combination of these two options.
- "Change of Q sign or pressure switch-off threshold": A combination of these two options.
- "Change of Q sign or pressure switch-off threshold or minimum value": A combination of these three options.
- "Change of Q sign or P-0-2800 bit 1 with a positive edge": A combination of these two options.
- "Minimum value or P-0-2800 bit 1 with a positive edge": A combination of these two options.
- "Minimum value or pressure switch-off threshold or P-0-2800 bit 1 with a positive edge": A combination of these three options.

☞ The switch-on and the switch-off thresholds relative refer to the internal pressure command value.

Pertinent parameters

- P-0-2800, p/Q controller control word
- P-0-2801, p/Q controller status word
- P-0-2850, p/Q changeover logic control word
- P-0-2851, p/Q changeover logic status word
- P-0-2852.0.3, Pressure controller switch-on threshold, relative
- P-0-2852.0.4, Pressure controller switch-on threshold, absolute
- P-0-2852.0.5, Pressure controller active switch-on threshold
- P-0-2852.0.6, Pressure controller switch-off threshold, relative
- P-0-2852.0.7, Pressure controller switch-off threshold, absolute
- P-0-2852.0.8, Pressure controller active switch-off threshold
- P-0-2852.0.9, Pressure controller ramp time switching logic
- P-0-2852.0.10, Correction value: pressure controller changeover logic ramp
- P-0-2857, Output of changeover logic p/Q

7.2.8 Alternating control

Structure

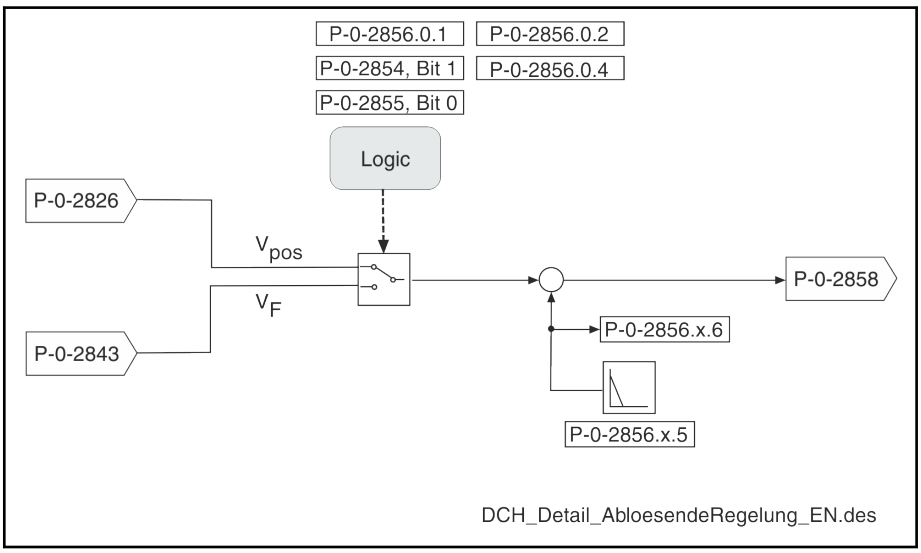


Fig. 7-32: Detail of alternating control

Description

Alternating control can be utilized for various operation modes:

- All position operation modes
- Direct valve control with force limitation (not with HDS)

Alternating control can be activated by setting parameter "P-0-2853, Alternating control, control word 1 bit 0" (HDx only) or by means of the function blocks "ForceLimitOnXX".

If the switching conditions are fulfilled (see "Switching condition" on page 417), the axis automatically changes over to force control and uses the given "P-0-0069, Torque/force command value of controller" for controlling. If the switching back conditions are fulfilled (see "Switching back condition" on page 417), the axis switches back to position or velocity control.

Force command value switching

Depending on the setting in "P-0-2854, Alternating control, control word 2", either "S-0-0550, Torque/force command value, positive" or "S-0-0551, Torque/force command value, negative" is used as command value for alternating control and taken over in "P-0-0069, Torque/force command value of controller". If both directions are activated, either the positive or the negative torque/force command value is used depending on the sign of the velocity controller output. The command value is selected only, when the force controller is not active.

Command value ramp (not with HDS)

When a new command value is entered, the value of the ramp can be cross-faded with the help of "S-0-0553, Torque/force command value ramp". With a ramp of “0”, the change takes place abruptly.



If the parameters "S-0-0550, Torque/force command value, positive" and "S-0-0551, Torque/force command value, negative" are cyclically assigned, internal fine interpolation of the command values can be activated by setting the ramp to 0. This can be used for smoothing jumps in slow cycle times.

Switching condition

For switching to force control you can select whether changing over is to take place at "P-0-2856.0.1, Alternating control, changeover threshold" or "P-0-2856.0.2, Alternating control, relative changeover window", referred to the current "P-0-0069, Torque/force command value of controller". The selection of absolute or relative switchover is made by means of bit 2 in parameter "P-0-2854, Alternating control, control word 2".

When "P-0-2856.0.3, Alternating control, active changeover threshold", which is derived from the input, is reached, the respective bit 3 or bit 4 of parameter "P-0-2854, Alternating control, control word 2" is set and when the adjustable "P-0-2856.0.4, Alternating control, switch-on delay" is exceeded, changing over to force control takes place. The changeover is effected over an adjustable cross-fading ramp (see "Cross-fading ramp" on page 417).



Parameter "P-0-2856.0.4, Alternating control, switch-on delay" is used to suppress pressure peaks in order to prevent undesirable premature switching.

Switching back condition

Switching back to closed-loop position or velocity control takes place when

- the axis moves in the positive direction, "P-0-2826, Output of velocity controller" is less than "P-0-2843, Output of force controller", and the change back lock is deactivated via bit 1 in parameter "P-0-2854, Alternating control, control word 2" or
- the axis moves in the negative direction, "P-0-2826, Output of velocity controller" is greater than "P-0-2843, Output of force controller", and the change back lock is deactivated via bit 1 in parameter "P-0-2854, Alternating control, control word 2".

Cross-fading ramp

When changing over to force control or switching back takes place, a control value jump may occur at the controller output. To prevent this, a defined "P-0-2856.0.5, Alternating control, ramp time" is used to cross-fade to the respective active controller output during the switch-over. The entry must be made in "ms" referred to the value of "P-0-2873.0.1, Valve standard velocity". If the ramp time is set to zero, the ramp is deactivated and changing over takes place immediately.

Behavior of the position interpolator

There are 3 different modes, which determine, how the position interpolator of the current operation mode is to behave during force control:

- BREAK: The position interpolator is stopped during force control

- CONT: The position controller continues to operate as usual also during force control
- JUMP: When changing over to force control the position interpolator immediately jumps to the target value

The behavior of the position interpolator can be configured using parameter "P-0-2853, Alternating control, control word 1" (HDx only) or by means of the function blocks "ForceLimitOnXX".

Pertinent parameters

- P-0-0069, Torque/force command value of controller
- S-0-0550, Torque/force command value, positive
- S-0-0551, Torque/force command value, negative
- S-0-0553, Torque/force command value ramp
- P-0-2826, Output of velocity controller
- P-0-2843, Output of force controller
- P-0-2853, Alternating control, control word 1
- P-0-2854, Alternating control, control word 2
- P-0-2855, Alternating control, status word
- P-0-2856.0.1, Alternating control, changeover threshold
- P-0-2856.0.2, Alternating control, relative changeover window
- P-0-2856.0.3, Alternating control, active changeover threshold
- P-0-2856.0.4, Alternating control, switch-on delay
- P-0-2856.0.5, Alternating control, ramp time
- P-0-2856.0.6, Alternating control, ramp value
- P-0-2858, Output of alternating control

7.3 Synchronization controller

7.3.1 System overview

Introduction

The synchronization controller allows the synchronized operation of a defined group of axes (synchronized group). The positions of the axes are controlled in relation to each other.

The basic behavior of the synchronization controller is parameterized via settable . This allows applications of various technologies such as press technology, steelworks and rolling mill technology or general mechanical engineering to be realized.

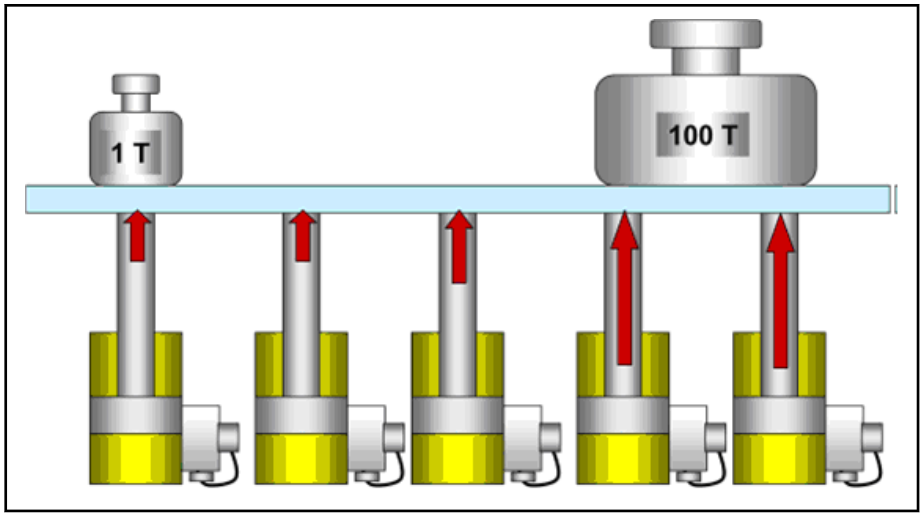


Fig. 7-33: Illustration of axes controlled via the synchronization controller

Explanations of terms

Synchronization axis Virtual controller axis, represents the synchronized group.

Slave axes Axes assigned to the synchronized group.

Synchronized group Group of slave axes allocated to the synchronization axis.

Master axis The slave axis that currently serves as reference axis for synchronization in the synchronization mode. In modes 5 and 6, the actual reference value is not provided by a slave axis, but is generated from the average value of all actual positions of the synchronized group.

Actual reference value Is the actual value of the current master axis or, in the case of modes 5 and 6, the average value of the actual values of all slave axes.

Synchronization error Amount of the difference between the slave axis with the greatest actual position and the slave axis with the smallest actual position. This can be read out on function block ML_Synch via the output ActualSynchError.

Synchronization lag error Difference between the command value and the actual reference value of the synchronization axis.

Break distance If the actual reference value can no longer follow the command value, e.g. due to blocking, a synchronization lag error builds up. If the synchronization lag error exceeds a parameterized limit value, the command value of the synchronization axis is stopped to prevent a shutdown as a result of a single-axis error or a synchronization error. The command value generation is not resumed before the synchronization lag error has fallen again below the switch-off threshold. This option is used when blocking or targeted approaching of a positive stop is expected. The break mechanism can be configured using the parameters BreakWindow and FollowWindow.

Synchronization mode The synchronization mode parameterizes the general behavior of synchronous operation.

Operating principle

General description

The command values of the synchronized group are commanded via the synchronization axis. From an external point of view, the synchronized group is thus a controller axis. The synchronization controller calculates the command values of each individual slave axis taking account of the selected synchronization mode and the current actual values. The synchronization master is a

controller axis that has to be created additionally. The synchronized group represents the axes that are operated as real axes.

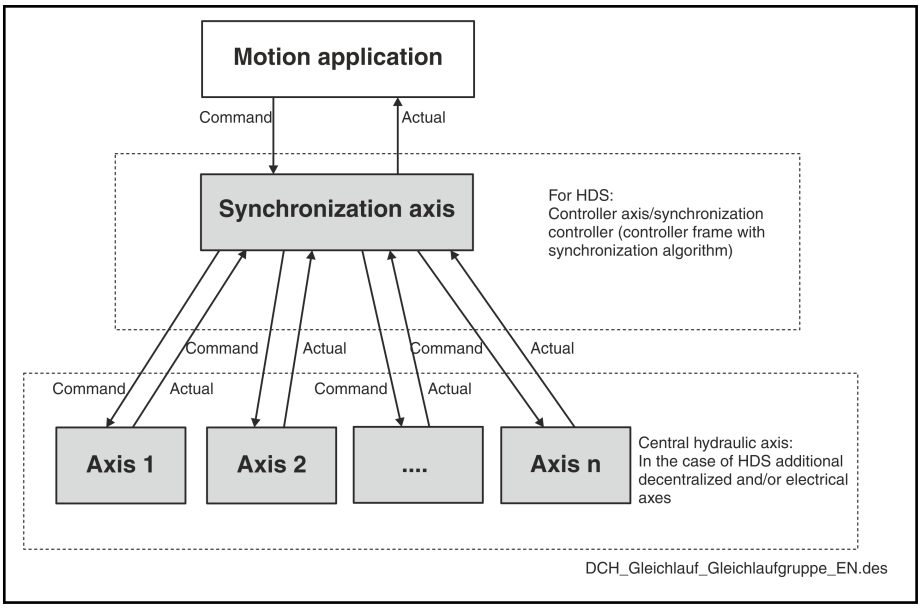


Fig. 7-34: Diagram of the actuation of a synchronized group via a motion application

Number of available axes

HDS:

Up to 98 axes (depending on control unit): n ≤ 98

HDM (HMC double-axis controller):

2 axes: n = 2

General principle of synchronization

With the hydraulic synchronization controller (synchronization) the controller axis can connect the following axis types as slaves:

- Local axes (HDM only)
- Real axes as HydraulicDrive with position control (HDS only)
- Real axes as IndraDrive with position control (HDS only)
- Real axes as IndraDrive with PFC02 (HDS only)
- Controller axes with hydraulic central controller (HDS only)
- Controller axes with central Sytronix controller (HDS only)
- Controller axes with hydraulic synchronization controller (HDS only)

7.3.2 Specific characteristics of synchronization

Connection of slave axes and parameterization

Connection of slave axis

Parameter "P-0-2860.0.3, Synchronization list slave axes" lists the slave axes that are assigned to the synchronized group.

HDS

For HDS, up to 99 structure indices (SIs) are generated of each parameter. The assignment between SI and slave axis is made via the logical axis number. In the case of HDS, the maximum number of axes is 99.

☞ For HDS the slave axis can be integrated directly with the help of the wizard.

HDM (HMC double-axis controller) The HDM supports only local axes 1 and 2 as slave axes. Thus 2 SIs (1 and 2) are generated of each parameter, which correspond to the relevant axes.

General notes on parameterization

Values that are to be specific per slave axis can be parameterized in the respective structure instance of the parameter number.

Structure instance 0 (x = 0, e.g.: P-0-2862.0.1) represents the value for all slave axes and is therefore copied to all structure instances of the slave axes.

Example:

P-0-2861.x.y

HDS For IndraMotion MLC, the "x" stands directly for the logical axis number of the slave axis (1-99).

With x = 0 for P-0-2861.0.y, the value is copied to all SIs of the relevant parameter.

HDM (HMC double-axis controller) In the case of HDM, the "x" stands directly for the number of the local axis that is used as slave axis (1-2).

With x = 0 for P-0-2861.0.y, the value is copied to all SIs of the relevant parameter.

Individual axis parameterization

Identical axes are usually moved in synchronized operation. If this is not the case, individual axis parameterization can be activated for the slave axis by means of P-0-2861.x.1. Should individual axis parameterization be activated for a slave axis, the parameters of this axis are no longer overwritten via SI = 0.

Activation of synchronization axis

As the power is switched on for the synchronization axis, synchronization is activated. After that, it is no longer possible to operate the slave axes individually since they are controlled by the synchronization function. In the event of an error, synchronization can be reactivated by switching the power on again.

It must be noted that in this case the slave axes may have to be set up again. Once synchronization has been activated, slave axes cannot be added to or removed from the synchronized group. To change the axes in the synchronized group, synchronization has to be deactivated.

☞ Before synchronization is activated, all slave axes require a separate power-on.

Synchronization modes

Mode	Synchronization mode	Local axes (HDM) or real axes (HDS)	Real axes IndraDrive (HDS only)	Real axes IndraDrive PFC02 (HDS only)	Controller axes (HDS only)
0	Master principle	x	x	x	x
2	Max value principle	x	x	x	x
3	Min value principle	x	x	x	x
4	Following principle	x	x	x	x

5	Mean value priniple with alternating force/position control	x	-	x	x
6	Mean value priniple with alternating force/position control and summation value principle	x	-	x	x

Tab. 7-5: Synchronization modes

Mode 0 - master command value principle

The master axis is always the first slave axis of the synchronized group handed over in the array. The slave axes follow the master axis and are corrected via the PI-component of the synchronization controller. The PI-component is generated separately for each slave axis and is calculated from the difference of (actual position of master axis - actual position of slave axis).

Mode 2 - max value principle

The master axis is always the slave axis with the greatest actual position value. During the movement, smooth switching of the master axis may take place. This mode is used mainly for vertical axes and encoder orientation "Max value bottom". The slave axes therefore follow the slowest axis, which usually has to carry the largest load.

Mode 3 - min value principle

The master axis is always the slave axis with the smallest actual position value. During the movement, smooth switching of the master axis may take place. This mode is used mainly for vertical axes and encoder orientation "Max value top". The slave axes therefore follow the slowest axis, which usually has to carry the largest load.

Mode 4 - following principle

The master axis is always the slave which lags behind in dependence on the traversing movement. During the movement, smooth switching of the master axis may take place. Depending on the direction of travel, the master is automatically selected according to the min value or the max value priniple. Before the first traversing movement the min value principle is applied. This mode is used mainly for horizontal axes.

Mode 5 - mean value principle with alternating position/force control

For mode 5, force limitation of the slave axes is used additionally in order to enable alternating position/force control. The force limitation is activated when the power of the synchronization axis is switched on. The actual reference value for synchronization is the mean value of all actual positions of the slave axes. The basic force of the slave axes can be set by means of "P-0-2863.x.6, Synchronization force base value". The synchronization group can be operated actively, i.e. in position control, or be passively displaced by an impressed movement in force limitation. The transition takes place automatically. This mode is employed, for example, for parallel holding devices.

Mode 6 - mean value principle with alternating position/force control and summation value principle

Like mode 5, with the difference that the sum of all forces is kept constant at all times. Due to this restriction, the synchronization error cannot always be corrected completely in dependence on P-0-2863.x.6. Mode 6 is employed, for example, for roll and strip tension controls.

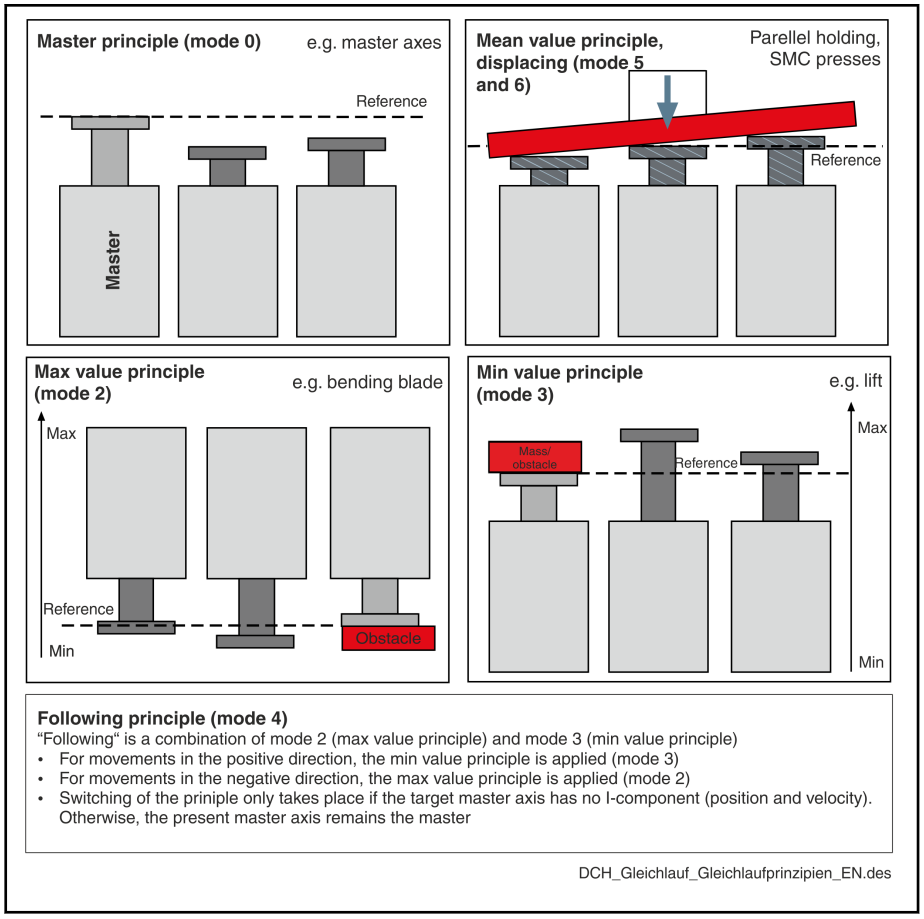


Fig. 7-35: Illustration of the various principles of synchronous operation

The function "command value correction" is available in all synchronization modes, except for the master principle.

Overview of controller structure

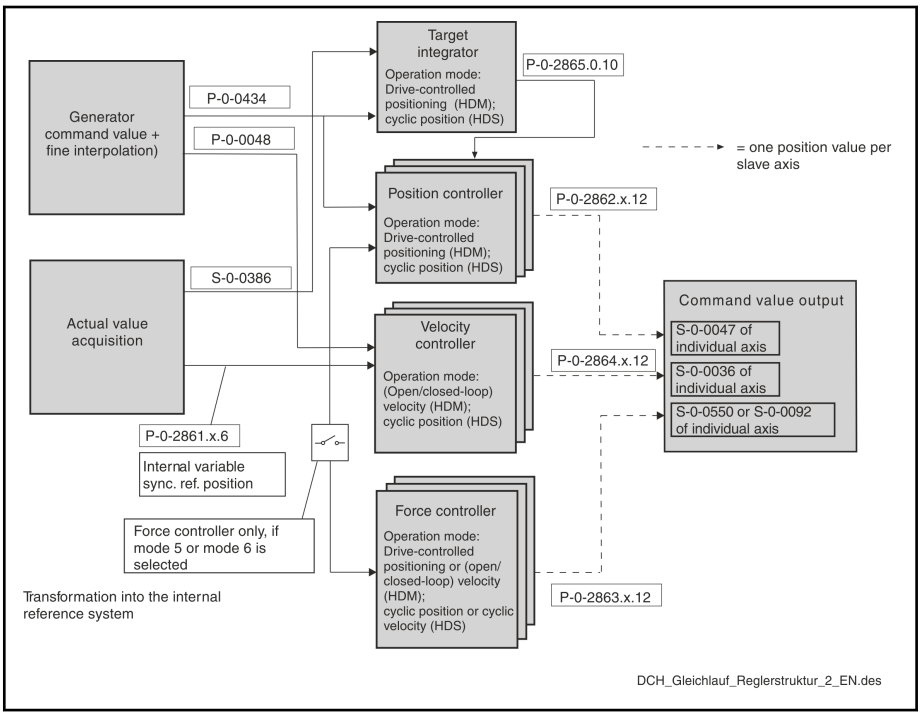


Fig. 7-36: Overview of synchronization structure

Actual value acquisition

General

When the power of the synchronization axis is switched on, all slave axes are mathematically transformed to one level. Offsets are determined and saved on the basis of the current setpoint positions. This transformation is applied to both, position command values and actual values. The master axis of synchronization for the various modes is selected on the basis of the transformed actual positions. For this reason, the slave axis with the largest actual position in absolute terms can also be the axis with the smallest transformed actual position.

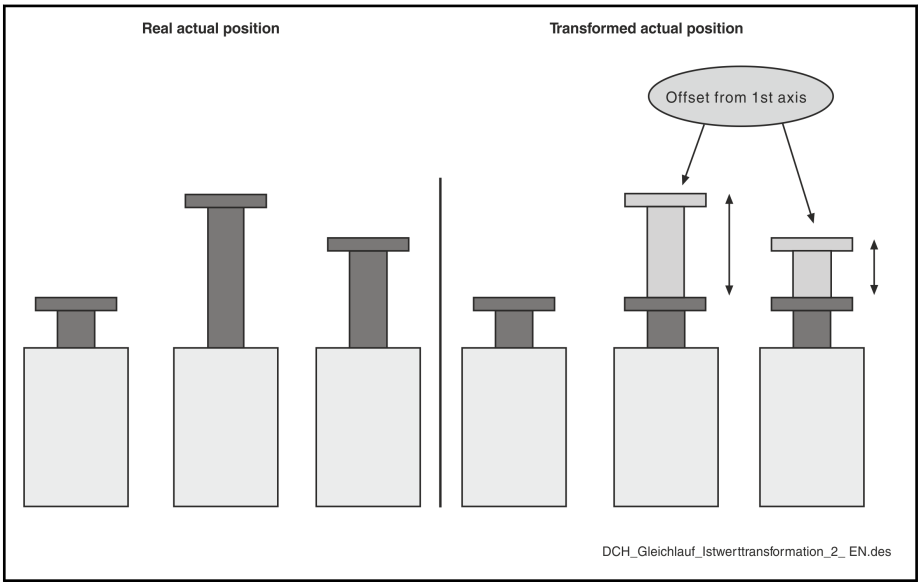


Fig. 7-37: Illustration of actual value transformation

No synchronization movement takes place when power is switched on for synchronization. If required, this must be performed before by means of single-axis movements. The synchronization group can therefore perform an offset synchronization movement upon a motion command to the synchronization axis.

Frequently used parameters

P-0-2861.x.6, Synchronization slave axis feedback value

P-0-2861.x.5, Synchronization command value, additive

P-0-2860.0.10, Synchronization current fault absolute

P-0-2860.0.12, Synchronization actual reference position

As of IndraWorks 14 VRS: Derived from the (virtual) actual synchronization position, the (virtual) actual velocity of synchronization is available in parameter S-0-0535.

Parameter "P-0-2861.x.5, Synchronization command value, additive" can be used to re-position the axes in relation to each other while synchronization is active (e.g.: aligning the axes during operation, tilting of the axes). Writing must take place via a ramp.

Command value provision

The calculated command values, inclusive of synchronization correction, are cyclically transmitted to the slave axes.

In the cyclic position operation mode this is parameter P-0-2862.x.12 of the synchronization axis, which is copied to the target position of the respective slave axis (S-0-0047).

In the cyclic velocity operation mode this is parameter P-0-2862.x.12 of the synchronization axis, which is copied to the cyclic setpoint velocity of the respective slave axis (S-0-0036).

In modes 5 and 6 parameter P-0-2863.x.12 of the synchronization axis is additionally copied to the cyclic force (limitation) command value of the relevant slave axis (parameter S-0-0550 in the case of IndraDrives).

7.3.3 Operation modes

General

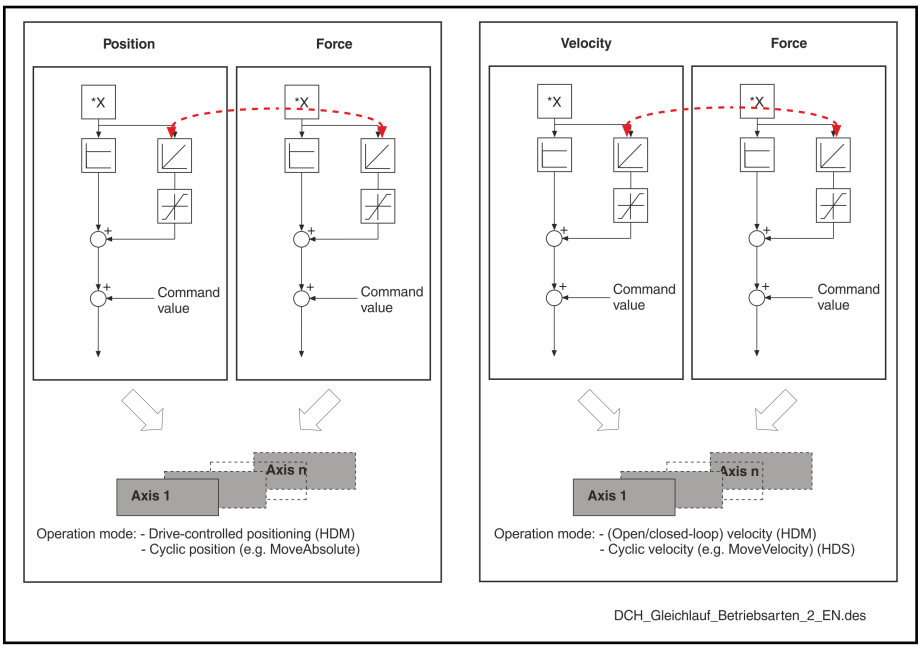


Fig. 7-38: Operation modes

Positioning command

As long as no axis is in force limitation, the integrator of the position branch is active. When an axis is in force limitation, the integrator of the position branch is stopped and the integrator of the force branch is active.

The integration component of the stopped integrator is ramped down.

Velocity command

As long as no axis is in force limitation, the integrator of the velocity branch is active. When an axis is in force limitation, the integrator of the velocity branch is stopped and the integrator of the force branch is active.

The integration component of the stopped integrator is ramped down.

Pertinent parameters

- P-0-2860.0.1, Synchronization control word
- P-0-2860.0.2, Synchronization status word
- P-0-2860.0.3, Synchronization list slave axes
- P-0-2860.0.4, Synchronization mode
- P-0-2860.0.5, Synchronization integration window
- P-0-2860.0.6, Synchronization down ramp integrator position
- P-0-2860.0.7, Synchronization down ramp integrator velocity
- P-0-2860.0.8, Synchronization down ramp integrator force
- P-0-2860.0.9, Synchronization monitoring window
- P-0-2860.0.10, Synchronization current fault absolute
- P-0-2860.0.11, Synchronization deviation actual reference value
- P-0-2860.0.12, Synchronization actual reference position
- P-0-2860.0.13, Synchronization break distance
- P-0-2860.0.14, Synchronization model loop gain
- P-0-2860.0.15, Synchronization model scaling velocity feedforward control

- P-0-2860.0.16, Synchronization threshold command value follow-up
- P-0-2860.0.20, Synchronization slave axis status word
- P-0-2860.0.21, Synchronization model deviation
- P-0-2860.0.22, Synchronization maximum model deviation
- P-0-2861.0.1, Synchronization slave axes control word
- P-0-2861.0.2, Synchronization slave axes status word
- P-0-2861.0.3, Synchronization deviation actual reference value
- P-0-2861.0.4, Synchronization factor relative synchronism
- P-0-2861.0.5, Synchronization command value, additive
- P-0-2861.0.6, Synchronization slave axis feedback value

7.3.4 Closed-loop control

Synchronization position controller

Detail of synchronization position controller

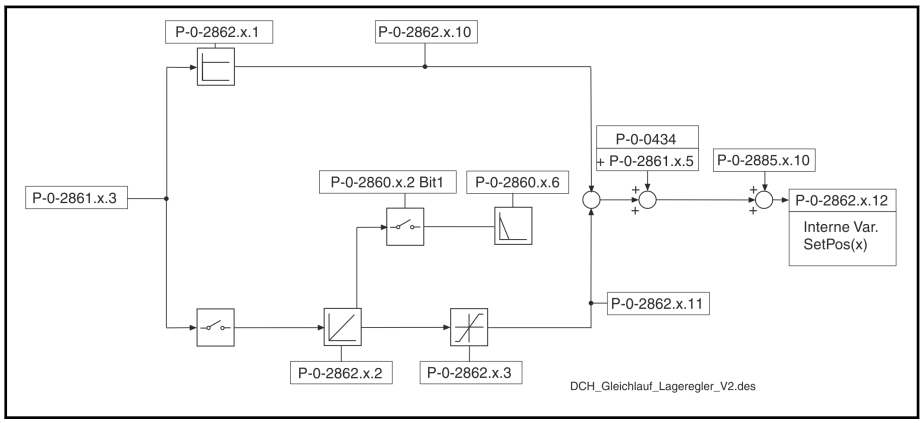


Fig. 7-39: Synchronization position controller

Description

☞ Before starting to optimize the synchronization parameters you should optimize the control parameters of the slave axes. The higher the control quality of the individual axis, the better the results of synchronization control.

The synchronization controller utilizes a PI-controller for correcting the synchronization difference. The current synchronization difference is displayed in parameter "P-0-2861.x.3, Synchronization deviation actual reference value". The integrator is active as long as the deviation from the master axis is greater than the set integration window "P-0-2860.0.5, Synchronization integration window". If the deviation is within the integration window, the integrator is stopped and the current integration component is maintained.

As long as synchronous operation is used, the integrator of fine positioning of all slave axes should be deactivated. As the integrator performs control activities also while the synchronization axis is at a standstill, it is possible that the integrator of finest positioning of the slave axes and the integrator of synchronization control work in parallel, thus interfering with each other. This can lead to a deterioration in the control quality.

☞ On the following axis types the fine positioner of the slave axes is automatically deactivated as soon as power of the synchronization axis is switched on. When the power supply to the synchronization axis is switched off, the fine positioner of the slave axes is re-activated.

- Central hydraulic controller axes (HDS)

☞ The proportional component of the position branch is usually not utilized and should remain deactivated. In conjunction with the Kv of the slave axes, it tends to cause the system to oscillate.

The integration component can be limited by "P-0-2862.x.3, Synchronization position limitation integrator". An excessive integration component "P-0-2862.x.11, Correction value: synchronization position integrator" in the case of brief blocking of a slave axis can lead, for example, to undesirably strong overshoots.

With the help of parameter "P-0-2860.0.6, Synchronization down ramp integrator position" the current integration component is reduced when the slave axis has switched to force limitation.

Pertinent parameters

- P-0-2862.0.1, Synchronization position P-gain
- P-0-2862.0.2, Synchronization position integral time
- P-0-2862.0.3, Synchronization position limitation integrator
- P-0-2862.0.10, Correction value: synchronization position P-gain
- P-0-2862.011, Correction value: synchronization position integrator
- P-0-2862.0.12, Output of synchronization position

Synchronization velocity controller

Description

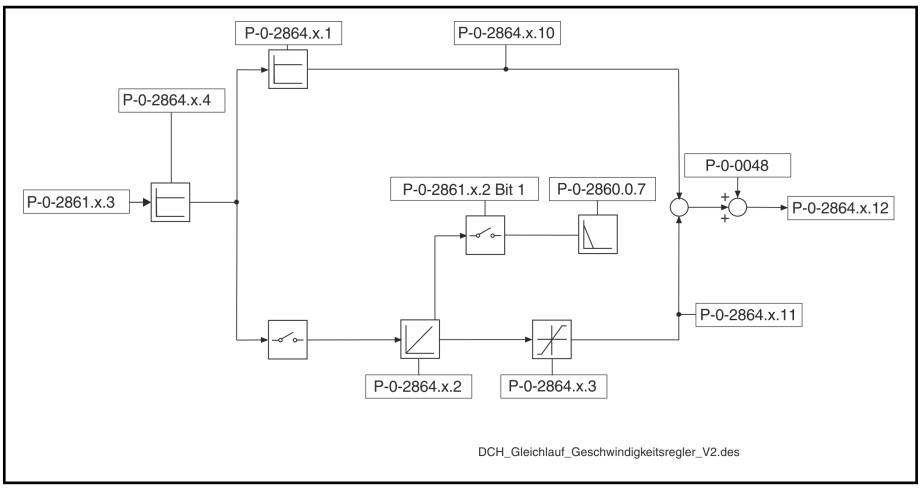


Fig. 7-40: Velocity branch

It is possible to run synchronization in the operation mode"ContinuousMotion" . This can be commanded using commands "MC_MoveVelocity" or "MH_MoveAbsPDB" or directly via the cyclic provision of velocity.

In the "ContinuousMotion" operation mode the positions of the axes in relation to each other are controlled. The command velocity of the slave axis is

increased or reduced in dependence on the position difference from the master axis.

Like the position branch the velocity branch uses a PI-controller for correcting the synchronization difference. Parameter "P-0-2864.x.4, Synchronization velocity factor conversion position velocity" is used to convert the established position deviation into a velocity deviation. All subsequent controller components are represented in the configured velocity scaling.

The integrator is active as long as the deviation from the master axis is greater than the set integration window "P-0-2860.0.5, Synchronization integration window". When the deviation is within the integration window, the integrator is stopped and the current integration component is maintained.

The integration component "P-0-2864.x.11, Correction value: synchronization velocity integrator" can be limited by "P-0-2864.x.3, Synchronization velocity limitation integrator".

With the help of parameter "P-0-2860.0.7, Synchronization down ramp integrator velocity" the current integration component is reduced as soon as the slave axis switched to "force limitation".

Synchronization force controller

Description

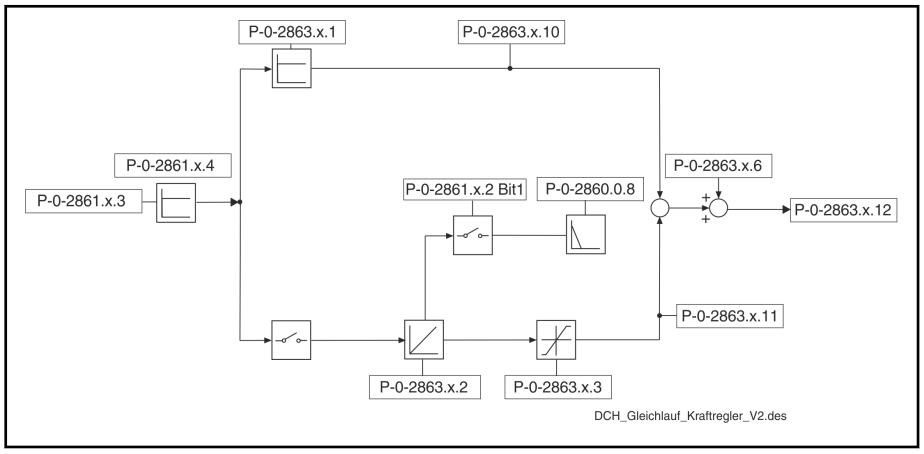


Fig. 7-41: Force controller

During force limitation, synchronous operation controls the positions in relation to each other, thus allowing the slave axes to be held in parallel also under load. Depending on the selected synchronous operation mode, the force branch operates in parallel to the selected operation mode "cyclic position" or "cyclic velocity". If a slave axis switches to force limitation, the command value generation of the synchronization axis is stopped. Parameter "P-0-2860.0.1, Synchronization control word" bit 5 can be used to make a setting which ensures that command values continue to be generated although one or several axes are in force limitation.

Like the force branch the position branch utilizes a PI-controller for correcting the synchronization difference. Parameter "P-0-2864.x.4, Synchronization force factor conversion position force" is used to convert the established position deviation into a force deviation. All subsequent controller components are represented in the configured scaling.

The force command values "P-0-2863.x.12, Output of synchronization force" of the slave axes are influenced in a manner that the positions are kept constant in relation to each other. In order that the slave axes will not receive a force command value that is smaller than the required holding force, a mini-

mum force value can be set, ("P-0-2863.x.5, Synchronization force minimum force value").

The integrator is active as long as the deviation from the master axis is greater than the set integration window "P-0-2860.0.5, Synchronization integration window". When the deviation is within the integration window, the integrator is stopped and the current integration component is maintained.

The integration component "P-0-2863.x.11, Correction value: synchronization force integrator" can be limited by "P-0-2863.x.3, Synchronization force limitation integrator".

By means of parameter "P-0-2860.0.8, Synchronization down ramp integrator force" the current integration component is reduced as soon as the axis switched to force limitation.

The following axis types support force synchronization:

- HYDRCONTROL
- HMC
- IAC
- PFC_V2
- IndraDrive

All the other axis types only support position synchronization (synchronization mode 0-4).

Target integrator

Description

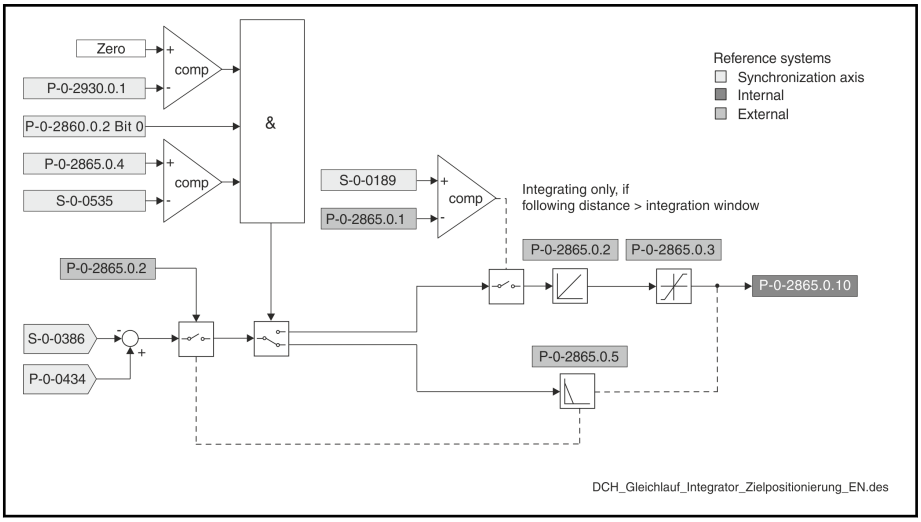


Fig. 7-42: Target integrator

The target integrator works only in cyclic position!

The synchronization function includes an integrator for target positioning. When it is activated, it positions "S-0-0386, Active position feedback value" to "P-0-0434, Position command value of controller" irrespective of the selected synchronization mode. The integrator is only active as long as the command velocity "P-0-2930.0.1, Feedforward control setpoint velocity" of synchronization is zero, no command value break "P-0-2860.0.2 bit 0, Synchronization status word, break monitoring active" is present, and "S-0-0535, Active velocity feedback value" of the synchronization axis is within "P-0-2865.0.4, Synchronization target integrator enable speed".

During the movement, "P-0-2865.0.10, Correction value: synchronization target integrator" of the integrator is reduced via an adjustable ramp "P-0-2865.0.5, Synchronization target integrator down ramp". When P-0-2865.0.5 = 0, P-0-2865.0.10 is abruptly set to 0 without a ramp. The target integrator is activated by entering "P-0-2865.0.2, Synchronization target integrator integral time". P-0-2865.0.10 can be limited by "P-0-2865.0.3, Synchronization target integrator limitation". P-0-2865.0.10 is added to the command value for every slave axis when command values are provided for the slave axes.

Pertinent parameters

- S-0-0189, Following distance
- S-0-0386, Active position feedback value
- S-0-0535, Active velocity feedback value
- P-0-0434, Position command value of controller
- P-0-2860.0.2, Synchronization status word
- P-0-2865.0.1, Synchronization target integrator integration window
- P-0-2865.0.2, Synchronization target integrator integral time
- P-0-2865.0.3, Synchronization target integrator limitation
- P-0-2865.0.4, Synchronization target integrator enable speed
- P-0-2865.0.5, Synchronization target integrator down ramp
- P-0-2865.0.10, Correction value: synchronization target integrator
- P-0-2930.0.1, Feedforward control setpoint velocity

7.3.5 Special functions

Model error calculation

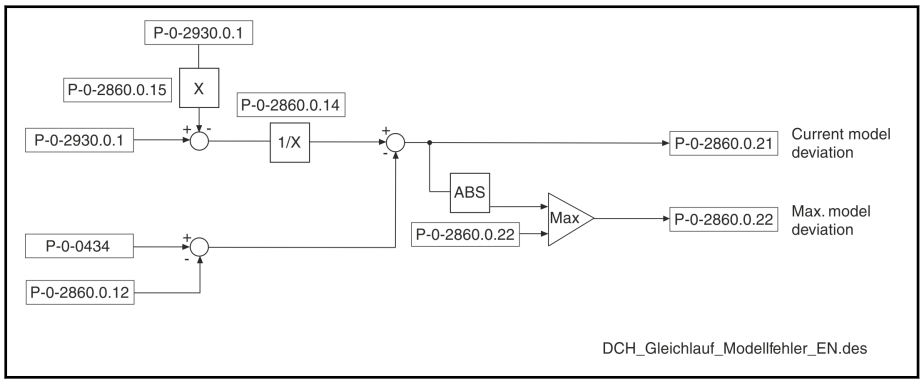


Fig. 7-43: Model errors

The given Kv and command velocity result in a model following error. To map the model more exactly, velocity feedforward control is included in the calculation. Given a feedforward control of 100 % the resulting theoretical following error is 0 mm.

Since the synchronization axis has no Kv (S-0-0104) and no velocity feedforward (P-0-0040), parameters "P-0-2860.0.15, Synchronization model scaling velocity feedforward control“ and "P-0-2860.0.14, Synchronization model loop gain" are employed instead for model calculation. These parameters are used exclusively for model calculations and have no influence on the command value provision for the slave axes.

The command velocity "P-0-2930.0.1, Feedforward control setpoint velocity" is multiplied by "P-0-2860.0.15, Synchronization model scaling velocity

feedforward control" and adjusted by means of "P-0-2860.0.12, Synchronization actual reference position" to obtain a following error in “position”.

Then the theoretical model following error is processed together with the actual following error in a calculation and a model deviation is obtained. The actual following error is calculated between the values "P-0-0434, Position command value of controller" and "P-0-2860.0.12, Synchronization actual reference position".

The current model deviation is shown as absolute value in parameter "P-0-2860.0.21, Synchronization model deviation". The maximum model deviation is shown in parameter "P-0-2860.0.22, Synchronization maximum model deviation". This is a "saving" value, which is only reset when the user sets the value to 0 or the control is restarted.

Model error monitoring will not cause a shutdown. This is used for the break mechanism of synchronization.

Pertinent parameters

- P-0-0434, Position command value of controller
- P-0-2860.0.12, Synchronization actual reference position
- P-0-2860.0.14, Synchronization model loop gain
- P-0-2860.0.15, Synchronization model scaling velocity feedforward control
- P-0-2860.0.21, Synchronization model deviation
- P-0-2860.0.22, Synchronization maximum model deviation
- P-0-2930.0.1, Feedforward control setpoint velocity

Break mechanism/command value correction

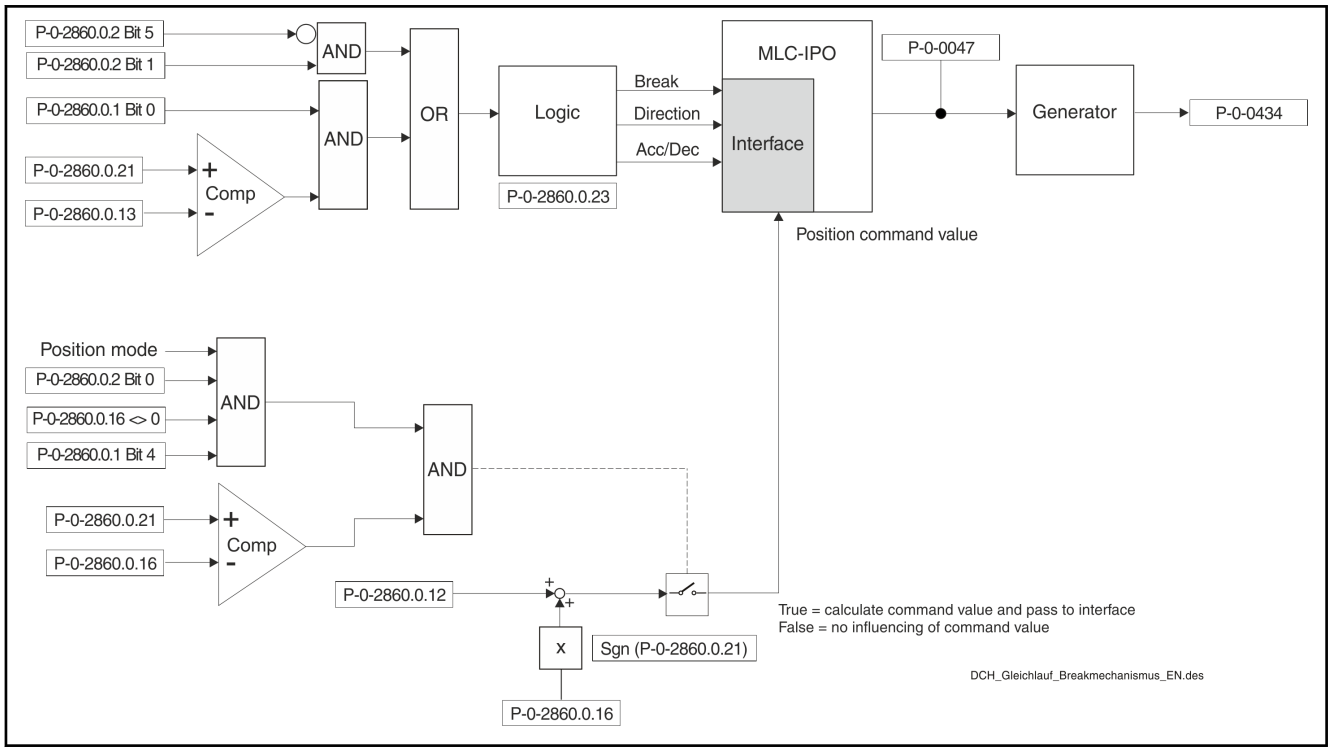


Fig. 7-44: Break mechanism and command value correction

Break monitoring and command value correction only work in the operation mode of closed-loop position control.

Break mechanism

The break mechanism is used to stop command value calculation of the synchronization axis as soon as an axis can no longer follow the command value input of the synchronization axis. One reason may be that the axis cannot move very fast or alternating control changes over to force limitation.

The break mechanism becomes active when the slave axes change over to force limitation, "P-0-2860.0.2 bit 1, Synchronization status word" **or** "P-0-2860.0.21, Synchronization model deviation" is greater than "P-0-2860.0.13, Synchronization break distance" and, in addition, "P-0-2860.0.1 bit 1, Synchronization control word, Break monitoring activated“ is set.

The command value provision for forward or backward movements is stopped in dependence on "P-0-2930.0.1, Feedforward control setpoint velocity".

- P-0-2930.0.1 ≥ 0, then break in positive direction
- P-0-2930.0.1 < 0, then break in negative direction (break in negative direction is supported only with the central controller axis, since this axis supports alternating contol in both positive and negative direction)

Command value correction

If command value correction is activated in addition to break monitoring, "P-0-2860.0.1, bit 4, Synchronization control word, command value follow-up activated" and "P-0-2860.0.16, Synchronization threshold command value follow-up" are greater than 0 and break monitoring active, the command value of the synchronization axis is corrected.

The new command value is calculated from "P-0-2860.0.12, Synchronization actual reference position" and "P-0-2860.0.16, Synchronization threshold command value follow-up" taking account of the sign of the current following error (command value - actual reference value).

When command value provision is resumed by the interpolator, it starts from the current command position of the synchronization axis.

Pertinent parameters

- P-0-2860.0.1, Synchronization control word
- P-0-2860.0.2, Synchronization status word
- P-0-2860.0.12, Synchronization actual reference position
- P-0-2860.0.13, Synchronization break distance
- P-0-2860.0.16, Synchronization threshold command value follow-up
- P-0-2860.0.21, Synchronization model deviation
- P-0-2860.0.23, Synchronization break delay ramp

7.4 Pressure/swivel angle controller (pump controller)

7.4.1 Controller structures

The pump control is provided with two different controller structures that can be switched over using the pump controller control word "P-0-2950, Pump controller control word", bit 15. With the setting of bit 15 = 0, the parallel structure is used, with bit 15 = 1, the cascade structure. Both structures are suitable for correcting pressure and swivel angle. Depending on the system characteristics of the machine, the two structures offer different advantages.

When switching from the parallel structure to the cascade structure, the cascade controller is always initialized in swivel angle control. Switching to pressure control, if necessary, would then be carried out by the changeover logic. When switching back to the parallel structure, no special initialization needs to be taken into account.

The pump control distinguishes between open and closed circuit. The selection is made by means of parameter "P-0-2989, Configuration of pump

controller". The closed circuit allows 4-quadrant operation, which requires two pressure sensors on the pump.



The current drive speed has to be indicated in parameter "P-0-2993, Current drive speed". If this value is not cyclically written, e.g. by variable-speed operation, the user has to enter the drive speed here.

7.4.2 Description of parallel structure

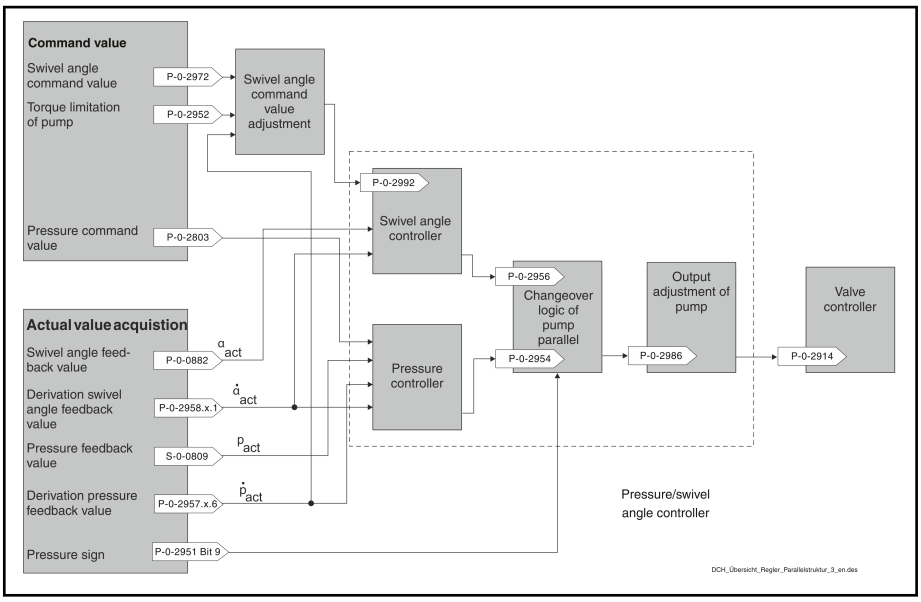


Fig. 7-45: Pump controller - overview of parallel structure

The parallel structure with pressure controller and swivel angle controller is called in the operation mode "pressure/swivel angle control" or "pressure/flow control".

The swivel angle command value is adjusted in swivel angle command value processing, before it is fed to the actual swivel angle controller.

In pump control the pressure and the swivel angle controller are simultaneously active and both generate an actuating value. In standard cases, the changeover logic of the pump passes on the smallest control variable of both controllers (minimum value comparator function). This minimum value comparator ensures that always only one of the two variables of pressure or swivel angle is used for controlling and that it is possible to switch dynamically between the two control types. The output variable of the pump changeover logic can be modified using various characteristic curves and functions in output adjustment of the pump before the variable is handed over to the valve controller as valve command value.

7.4.3 Description of cascade structure

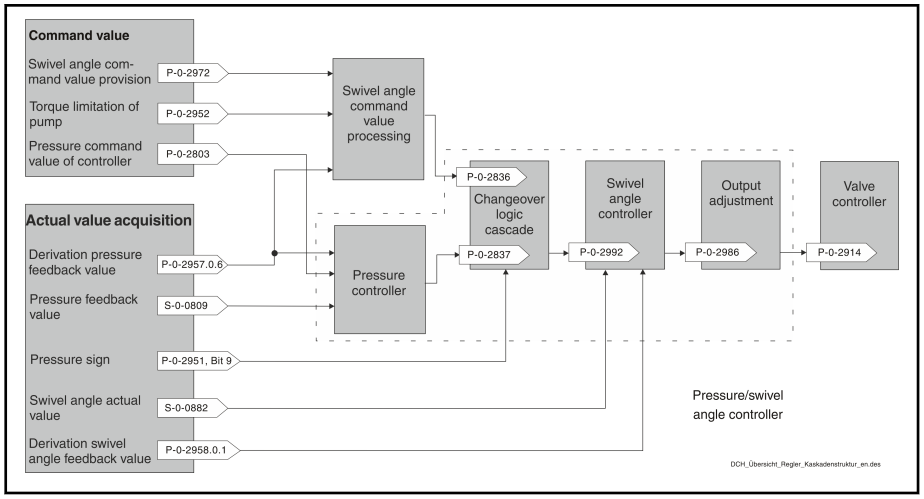


Fig. 7-46: Overview of cascade structure

The cascade structure with pressure controller and swivel angle controller is called in the operation mode “pressure/swivel angle control” or “pressure/flow control”. The swivel angle command value is adjusted by means of various variables in swivel angle command value processing, before it is fed to the actual swivel angle controller. The outputs of swivel angle command value processing and of the pressure controller are passed on to the changeover logic. The changeover logic generates the swivel angle command value valid for the control. In the actual pressure value acquisition feature, the various actual pressure values are compared and the resulting sign is generated for the changeover logic. The output of the swivel angle controller is passed on to output adjustment.

7.4.4 Common functions

Swivel angle command value processing

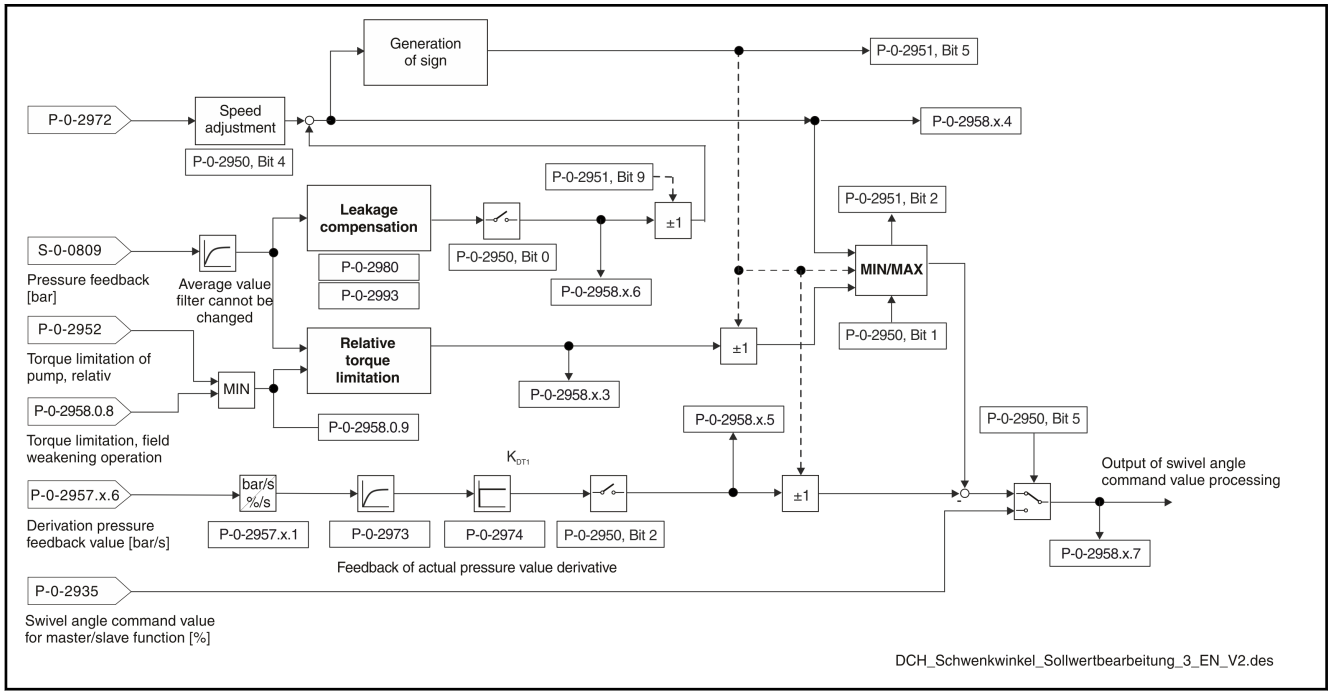


Fig. 7-47: Swivel angle command value processing for cascade and parallel structure

Speed adjustment

Speed adjustment of the swivel angle command value is required, when the pump controller is operated at variable drive speed, and the "S-0-0880, Swivel angle command value" provided by the control refers to the maximum drive speed. In this case, the adjustment can be activated via "P-0-2950, Pump controller control word, bit 4" so that the swivel angle command value is converted in relation to the current drive speed.

☞ For the operation mode of closed-loop pressure control/(open/closed-loop) flow control, this conversion is not necessary, since the flow generator takes account of the current drive speed.

Leakage compensation

Leakage compensation can be used to compensate for pressure-related leakage of the pump or the system. For this, the controller computes a leakage compensation value from a linear characteristic curve and the current pressure. Support points for this characteristic curve are the reference pressure of pump controller calibration (P-0-2947.0.16, Reference pressure for pump controller calibration, factory setting 20 bar) and 0 % swivel angle as well as the pressure for "P-0-2957.0.15, Pressure normalization" with the leakage compensation value.

Leakage compensation is active when "S-0-0809, Pressure feedback value" is greater than the reference pressure of pump controller calibration.

The leakage offset value is shown in parameter "P-0-2958.0.6, Correction value: leakage compensation offset value".

Calculation example with factory setting of 20 bar for the reference pressure:

Offset value = $((p_{act} - 20\ bar) * C_{leak}) / (p_{norm} - 20\ bar)$

C_{leak}: Leakage compensation value (is determined from "P-0-2980, Leakage compensation calibration value" and "P-0-2993, Current drive speed")

Relative torque limitation

To protect the drive motor against overloading, the maximum torque of the pump can be limited. Parameter "(P-0-2952, Torque limitation of pump,

relative" is a relative variable in percent and refers to the maximum torque of the pump at standard pressure (P-0-2957.0.1).

In addition, a further torque limitation of the motor may be necessary in field-weakening operation. For this purpose, a further parameter is available, P-0-2958.0.8, Torque limitation, field weakening operation. In swivel angle command value processing the parameters P-0-2952 and P-0-2958.0.8 are compared to each other and the smaller of these values is passed on as effective torque limitation P-0-2958.0.9 for calculation.

The permissible maximum swivel angle command value for the pump is calculated from the current pressure feedback value p_{act} and the effective torque limitation according to the following calculation rule:

Max. permissible swivel angle command value = effective torque limitation of pump, relative (P-0-2952) * p_{norm} / p_{act}

The max. permissible swivel angle command value is shown in parameter "P-0-2958.0.3, Correction value: torque limitation".

A min/max value comparator switches between the permissible maximum swivel angle that results from torque limitation and "P-0-2958.0.4, Swivel angle command value after leakage compensation". By means of the pump controller control word "P-0-2950, Pump controller control word", bit 6, 7, the min/max value comparator can be firmly set to the swivel angle command value, which deactivates the torque limitation function.

☞ Relative torque limitation protects the drive motor against overloading. In mooring operation (pulling load), torque limitation is not effective.

Feedback of derivative of actual pressure value

The derivative of the actual pressure value is added to the swivel angle command value via the feedback function to stabilize the swivel angle controller. The derivative of the actual pressure value can be smoothed via "P-0-2973, Filter time for feedback of actual pressure value derivative", a low-pass filter of 1st order, and multiplied by a factor "P-0-2974, Time constant for feedback of act. pressure value derivative".

Swivel angle controller

In both, the parallel and the cascade structure, the swivel angle controller consists of a PD-controller:

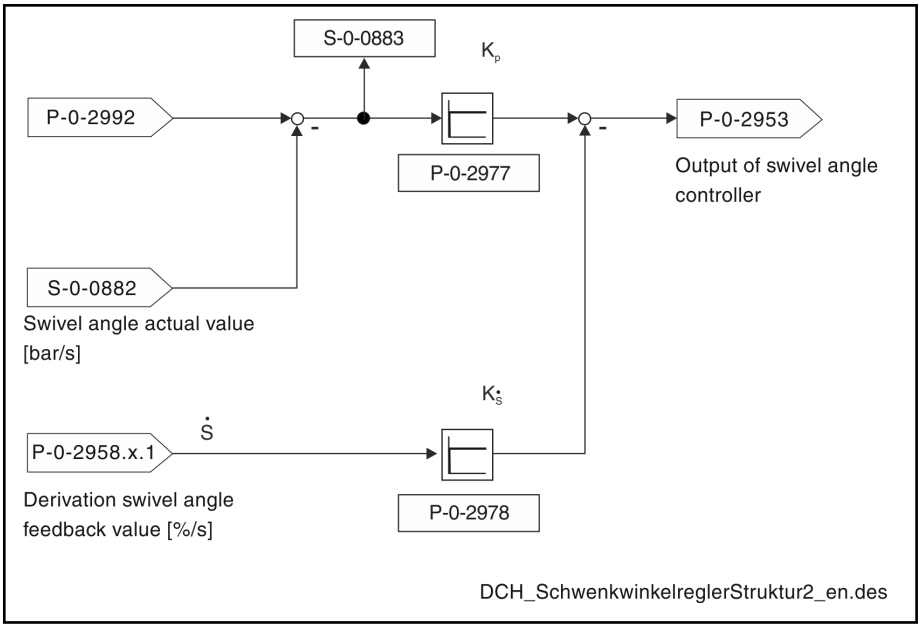


Fig. 7-48: Swivel angle controller (cascade and parallel structure)

Pump output adjustment

In pump output adjustment, various values can be added to the valve command value as feedforward values. Moreover, it is possible to limit the negative swivel angle to a fixed value, "P-0-2988, Control variable adjustment, swivel angle minimum value". For this, a simplified controller structure of the swivel angle controller is used. This negative swivel angle limitation can be deactivated by means of parameter "P-0-2950, Pump controller control word", bit 9. When negative swivel angle limitation is active, a maximum value comparator is used to switch between the controller output of swivel angle limitation and parameter "P-0-2959.0.1, Correction value: output adjustment after feedforward".

To compensate for zero point deviations of the pilot valve, an offset value is generated for the valve command value from a pressure-related characteristic curve with several calibration values. At the end of pump output adjustment, the valve command value can be limited to a bipolar maximum value or directly to a positive or negative maximum value.



The parameters of direct valve signal 1 and 2 are used only as command value input in direct valve control. Switching between direct valve signal 1 and 2 is accomplished by means of "P-0-2828.0.1, Pressure feedback value A (applicative)".

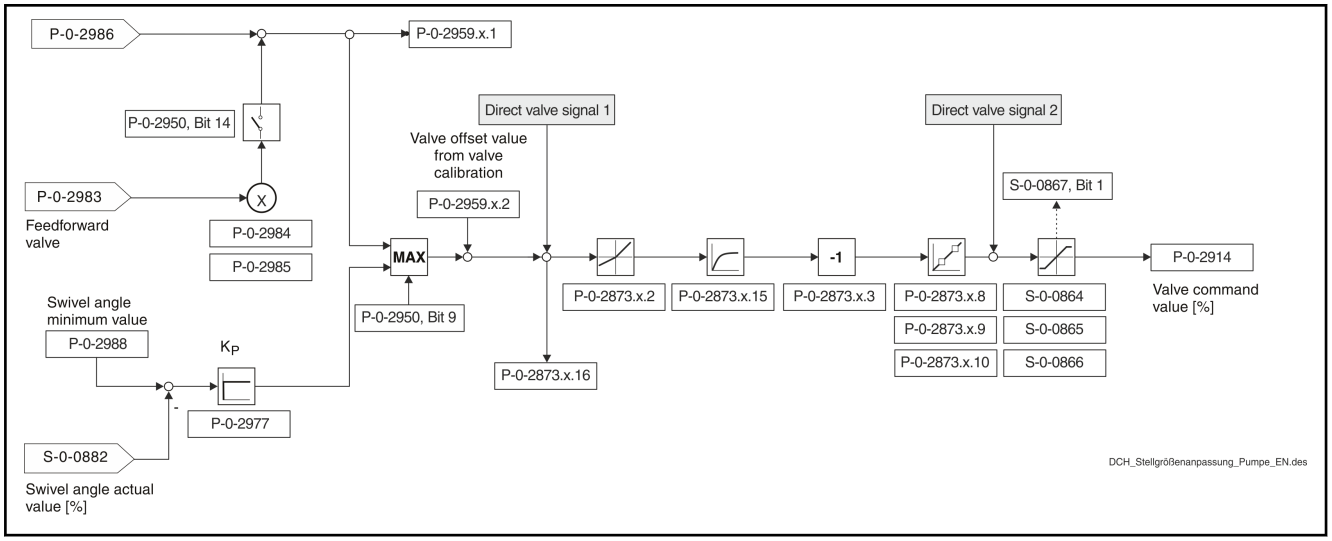


Fig. 7-49: Pump output adjustment

Master/slave function

In pump control, a master/slave function can be activated for controlling a multiple-pump system. "P-0-2950, bit 5, Pump controller control word" can be used to switch between the master and the slave function. P-0-2950, bit 5 = 1 configures the controller as slave. If bit 5 = 0, the controller is configured as master.

In master operation, pressure and swivel angle controller are active. Feedforward control of the valve command value is deactivated by default. In slave operation, merely the swivel angle controller is active. The swivel angle command value for the slave is set by the master via "P-0-2935, Swivel angle command value for master/slave function". In the parallel structure, the actual swivel angle value of the master pump is written to P-0-2935. To improve dynamics, the valve command value of the master (P-0-2914) is provided to the slave as feedforward value for the valve command value (see fig. 7-50 "Circuitry of the master/slave function (parallel structure)" on page 439).

In the cascade structure, "P-0-2992, Swivel angle command value, internal" of the master pump is written to P-0-2935. The feedforward control of the valve command value is not required in the cascade structure.

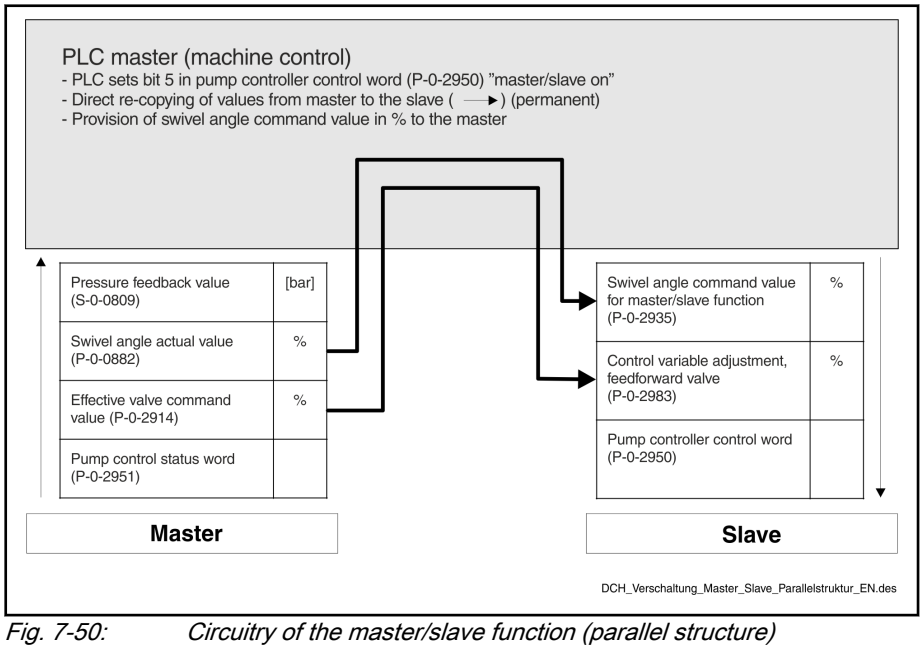


Fig. 7-50: Circuitry of the master/slave function (parallel structure)

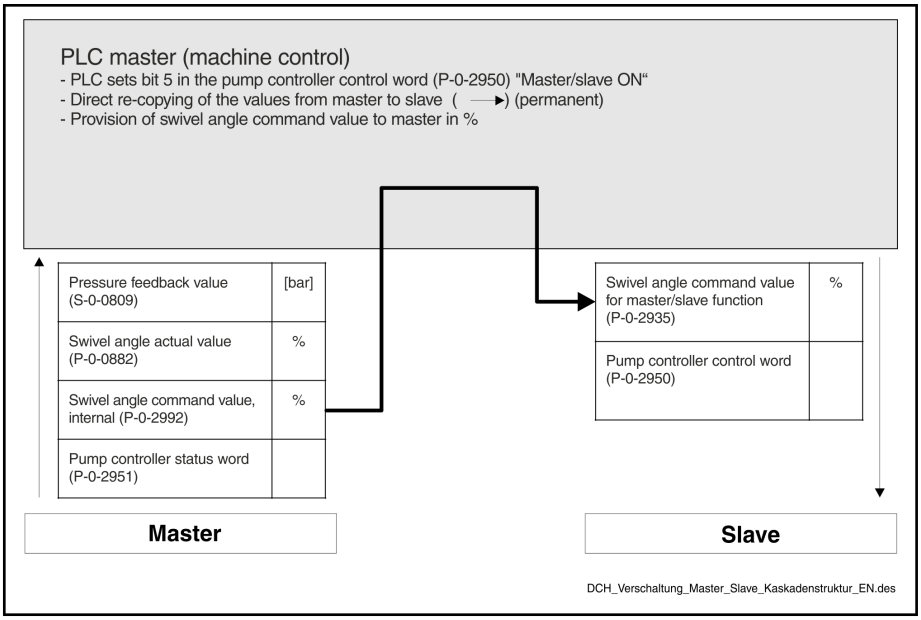


Fig. 7-51: Circuitry of the master/slave function (cascade structure)

7.4.5 Functions of the parallel structure

Pressure controller (parallel structure)

In the parallel structure, the pressure controller consists of a PD-controller with additional feedback of the actual swivel angle value. In addition, an inflected characteristic curve can be activated for the P-gain, "P-0-2950, bit 3, Pump controller control word". The inflected characteristic curve provides a second KP gain for the positive and negative control difference as well as the associated activation threshold for this second KP gain. With the help of parameters "P-0-2806.0.18, Pressure controller adaptation, P-term" and "P-0-2806.0.19, Pressure controller adaptation, D-term" the pressure controller can be adapted to changes in speed. A disturbance feedforward can be set up by means of parameter "P-0-2806.0.20, Pressure controller disturbance feedforward".

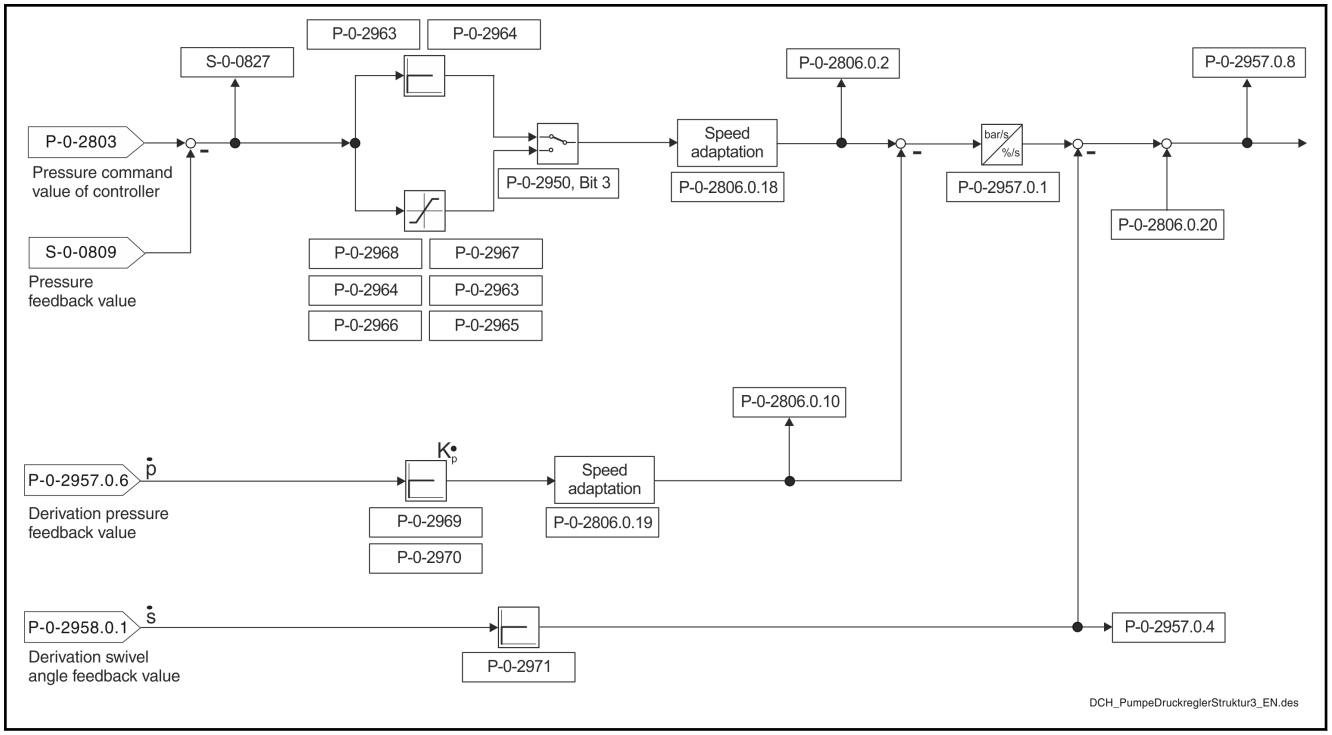


Fig. 7-52: Pressure controller structure of the pump (parallel structure)

The settings of the controller parameters depend on the connected oil volume. The following table lists various settings as guideline for the controller parameters of the SY(H)DFED system in conjunction with different oil volumes:

Controller parameters	Universal (default setting)	0 l	1 l	2.5 l	5 l	7.5 l	10 l
Pressure controller P-gain 1 positive (P-0-2963)	2.8	2.8	4.3	4.3	4.7	5	4.3
Pressure controller P-gain 1 negative (P-0-2964)	2.8	2.8	4.3	4.3	4.7	5	4.3
Pressure controller time constant D-component positive (P-0-2969)	0.19 s	0.04 s	0.2 s	0.2 s	0.41 s	0.44 s	0.45 s
Pressure controller time constant D-component negative (P-0-2970)	0.23 s	0.04 s	0.2 s	0.2 s	0.41 s	0.44 s	0.45 s
Pressure controller time constant swivel angle feedback (P-0-2971)	0.07 s	0.04 s	0.07 s	0.07 s	0.075 s	0.05 s	0.06 s
Gate time derivation actual pressure value 1 (P-0-2960)	22.5 ms	13.5 ms	13.5 ms	22.5 ms	22.5 ms	22.5 ms	22.5 ms

Tab. 7-6: Settings for controller parameters for different oil volumes

Controller parameters	12.5 l	15 l	20 l	25 l	30 l	40 l
Pressure controller P-gain 1 positive (P-0-2963)	4.4	4.4	3.8	3.6	3.6	3.5
Pressure controller P-gain 1 negative (P-0-2964)	4.4	4.4	3.8	3.6	3.6	3.5
Pressure controller time constant D-component positive (P-0-2969)	0.52 s	0.535 s	0.59 s	0.68 s	0.7 s	0.72 s
Pressure controller time constant D-component negative (P-0-2970)	0.52 s	0.535 s	0.59 s	0.68 s	0.7 s	0.72 s
Pressure controller time constant swivel angle feedback (P-0-2971)	0.07 s	0.07 s	0.07 s	0.07 s	0.07 s	0.07 s
Gate time derivation actual pressure value 1 (P-0-2960)	22.5 ms	22.5 ms	22.5 ms	22.5 ms	22.5 ms	22.5 ms

Tab. 7-7: Settings for controller parameters for different oil volumes

Adaptation characteristic curve for the speed-related adaptation of the pressure controller in the parallel structure

At reduced speed, the control behavior of the pressure control of a control pump differs from that at nominal speed. By adapting the pressure controller in the parallel structure, a largely similar control behavior can be achieved over an extended speed range in dependence on the current speed. The adaptation characteristic curve can be activated via the pump controller control word P-0-2950, bit 11. With the factory setting, the adaptation characteristic curve is not activated. If the adaption characteristic curve is switched off, both multiplication factors are set once to the value “1.0”.

The adaptation characteristic curve can be configured for the P-term and the D-term. To this end, one parameter each is provided for the upper and the lower speed limit value for the P-term and the D-term. (One parameter each for the gain factor of P- and D-term at the lower speed limit). The speed limit values are checked for plausibility. The values for the lower speed limit always have to be smaller than the values for the upper speed limit. If this condition is not fulfilled, the multiplication factors are set to the value “1.0”. The following figure shows the adaptation for the P-term:

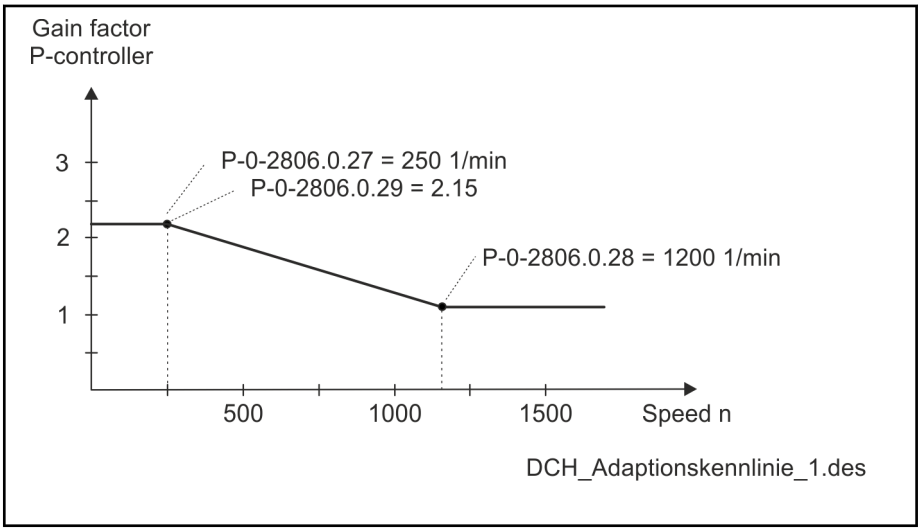


Fig. 7-53: Adaptation characteristic curve of the pressure controller in the parallel structure

The current multiplication factor from the adaptation characteristic curve is displayed in parameters "P-0-2806.0.18, Pressure controller adaptation, P-term" and "P-0-2806.0.19, Pressure controller adaptation, D-term".

Pump changeover logic (parallel structure)

A minimum value comparator in the pump changeover logic compares the control variables of the pressure controller and the swivel angle controller. The smallest of these values is passed on to the controller output. The minimum value comparator can be switched off by means of parameter "P-0-2950, bit 6 and 7, Pump controller control word" and operation can be firmly set to the pressure controller or swivel angle controller:

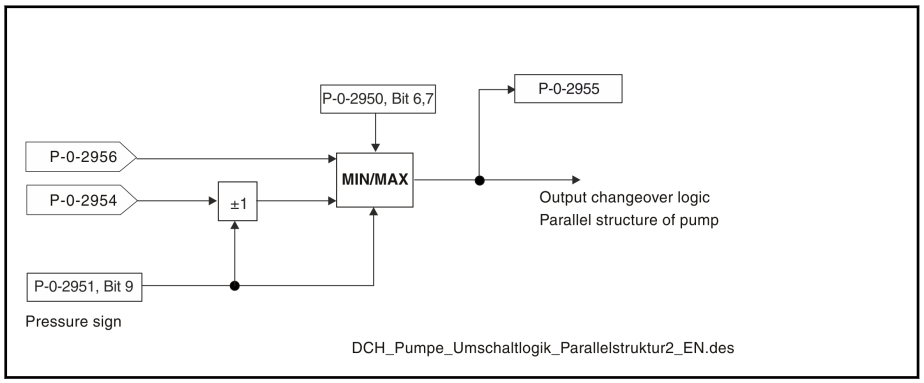


Fig. 7-54: Pump changeover logic in parallel structure

Torque limitation is only effective when swivel angle control is active as well.

7.4.6 Functions of the cascade structure

Pressure controller (cascade structure)

The pressure controller in the cascade structure, see fig. 7-55 "Pressure controller for the cascade" on page 444 and fig. 7-56 "Pressure controller in the cascade, switching integrator" on page 445, consists of a PID-controller with feedback of the change of the actual pressure value to the I-component (feedforward). At the output of the pressure controller, the output variable is converted into the unit "percent of swivel angle". The integrator is a switching integrator. The integrator is calculated when all of the conditions below are fulfilled:

- The pressure control error is outside the accuracy window
- The output signal is not limited
- The integration value is not limited by the given limit values

The limitation of the integrator depends on the selection of the switching conditions (from swivel angle to pressure).

The following is valid in the case of "min/max value principle" with active integrator of the changeover logic:

If, in the changeover logic, merely the **min/max value principle with active integrator (from swivel angle to pressure)** is selected, the integrator in the pressure controller is always calculated. The various switching conditions are valid as well! The integrator is limited to the smaller of the two values, that is, either "P-0-2818, Pressure controller upper integrator limit, cascade" or the amount of the flow value calculated from the internal swivel angle command value. Only the positive limit value of the integrator is influenced. The negative limitation is created in dependence on "P-0-2950, bit 10, Pump controller control word".

The calculated flow command value is used to initialize the integrator if either the "min/max value principle with active integrator" (from swivel angle to pressure) was activated or switching to this operation mode took place.

In the case of "min/max value principle" or "switch-on threshold" or "min/max value principle and switch-on threshold" of the changeover logic, the following is valid:

The integrator is cleared (reset to zero), when the pressure controller is not active. When switching to the pressure controller takes place, the integrator is "initialized", see "Initialization of the I-component when the pressure controller is activated" on page 445.

The integrator value of the pressure controller can be limited in two ways:

- P-0-2950, bit 10 = 0: The integrator value of the pressure controller is limited to the maximum displacement of the pump
- P-0-2950, bit 10 = 1: The values of parameters "P-0-2818, Pressure controller upper integrator limit, cascade" and "P-0-2838, Pressure controller lower integrator limit, cascade" are used for limiting the integrator value.

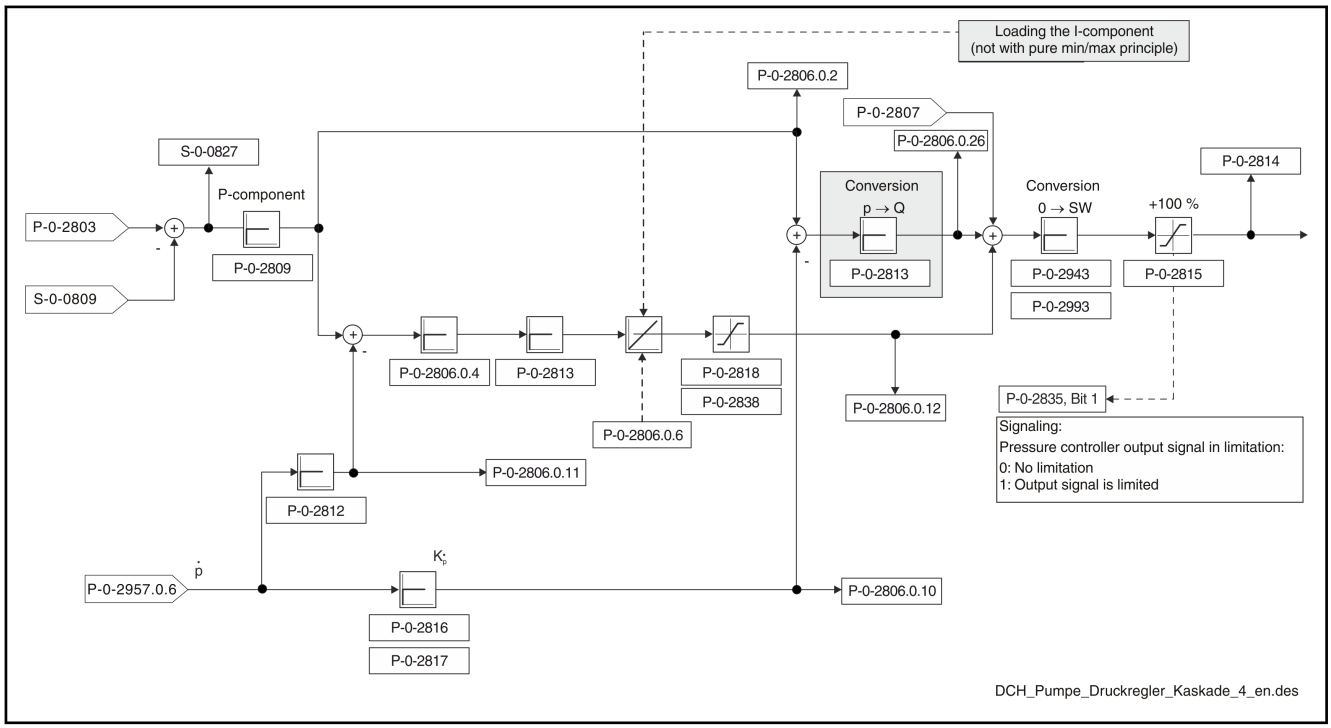


Fig. 7-55: Pressure controller for the cascade

Due to the different structural setup of the controllers for the parallel and the cascade structure, different parameter settings are required for the proportional gain and the gain factor for the D-component.

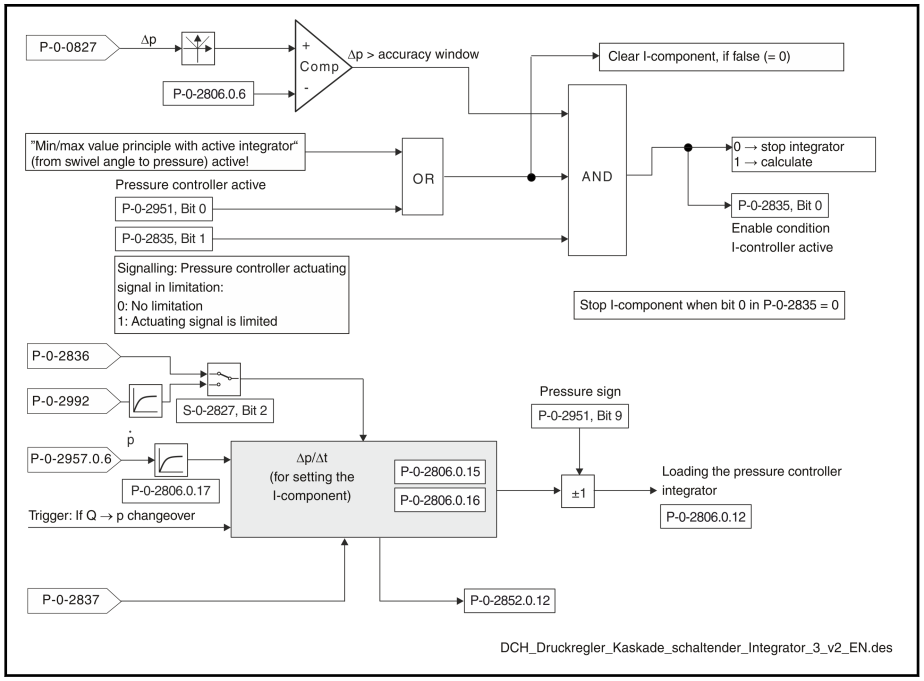


Fig. 7-56: Pressure controller in the cascade, switching integrator

Initialization of the I-component when the pressure controller is activated

If the "min/max value principle with active integrator" (from swivel angle to pressure) is selected in the changeover logic, the integrator in the pressure controller also always carries out calculations. Initializing the integrator when switching over to the pressure controller is then not required and will not take place.

With the other changeover modes, the initialization is utilized as described in the following.

When the pressure controller is not active, the I-term is set to zero (cleared), whereas, when the pressure controller is active, the integrator has to generate the corresponding actuating signal in order to produce the currently required flow (i.e. swivel angle). This means that when changing over to the pressure controller takes place, the integrator has to be initialized with a useful value. This initialization value is calculated in dependence on the pressure change and the dead volume. For this, the pressure change can be filtered. The filter time has to be set by means of parameter "P-0-2806.0.17, Pressure controller preload, pressure change filter time".

The initialization of the I-component of the pressure controller is calculated according to the following formula:

P-0-2827, bit 2 = 0

$$I-component = (swivelangle_{comm_modelfilter} - p_{actuating}) * KB_{i-sum}$$

I-component I-term of the pressure controller (P-0-2806.0.9)

Swivel angle$_{comm_modelfilter}$ Swivel angle command value after model filter

Changeover logic $p_{actuating}$ Internal pressure control value as input for the changeover logic (P-0-2837)

KB_{i-sum} Scaling factor depending on the pressure change, see fig. 7-59 "Initialization of the pressure controller integrator in dependence on the pressure change" on page 446.

Fig. 7-57:

P-0-2827, bit 2 = 1

$$I-component=(swivelangle_{set}-p_{actuating})*KB_{i-sum}$$

I-component	I-term of the pressure controller (P-0-2806.0.9)
Swivel angle$_{set}$	Internal swivel angle command value as input for the changeover logic (P-0-2836)
Changeover logic $p_{actuating}$	Internal pressure control value as input for the changeover logic (P-0-2837)
KB_{i-sum}	Scaling factor depending on the pressure change, see fig. 7-59 "Initialization of the pressure controller integrator in dependence on the pressure change" on page 446.

Fig. 7-58: I-term of the pressure controller

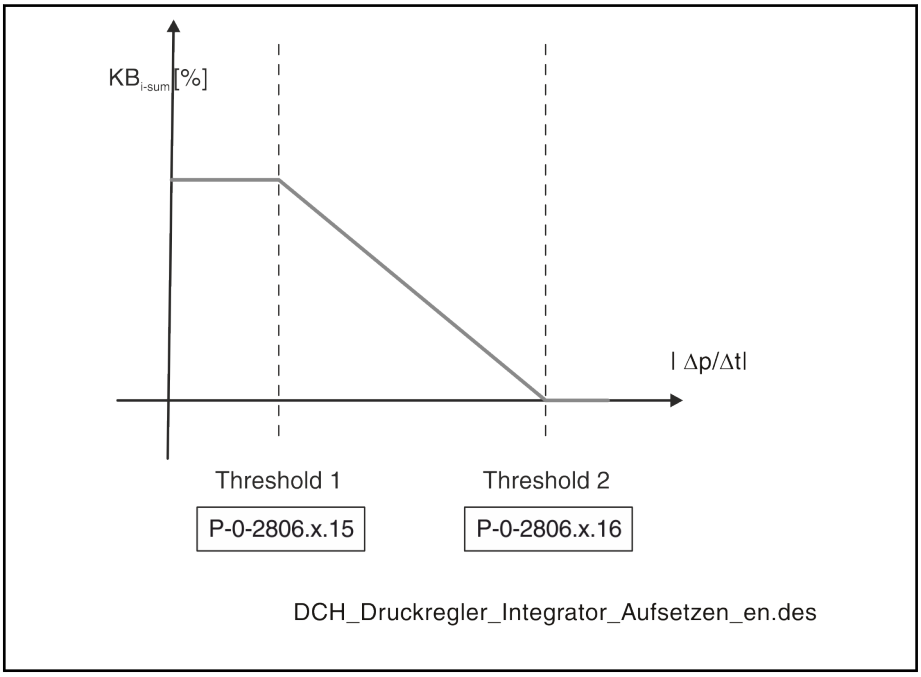


Fig. 7-59: Initialization of the pressure controller integrator in dependence on the pressure change

For initializing the integrator, the thresholds should be set according to the following rule of thumb:

P-0-2806.0.15 threshold 1 = compression module [bar] / (3 [s/l] * dead volume [in l])

P-0-2806.0.16 threshold 2 = compression module [bar] / (1 [s/l] * dead volume [in l])

For the compression module, a value of about 12000 - 14000 [bar] can be assumed for oil grade HLP, for example.

Changeover logic for the cascade structure

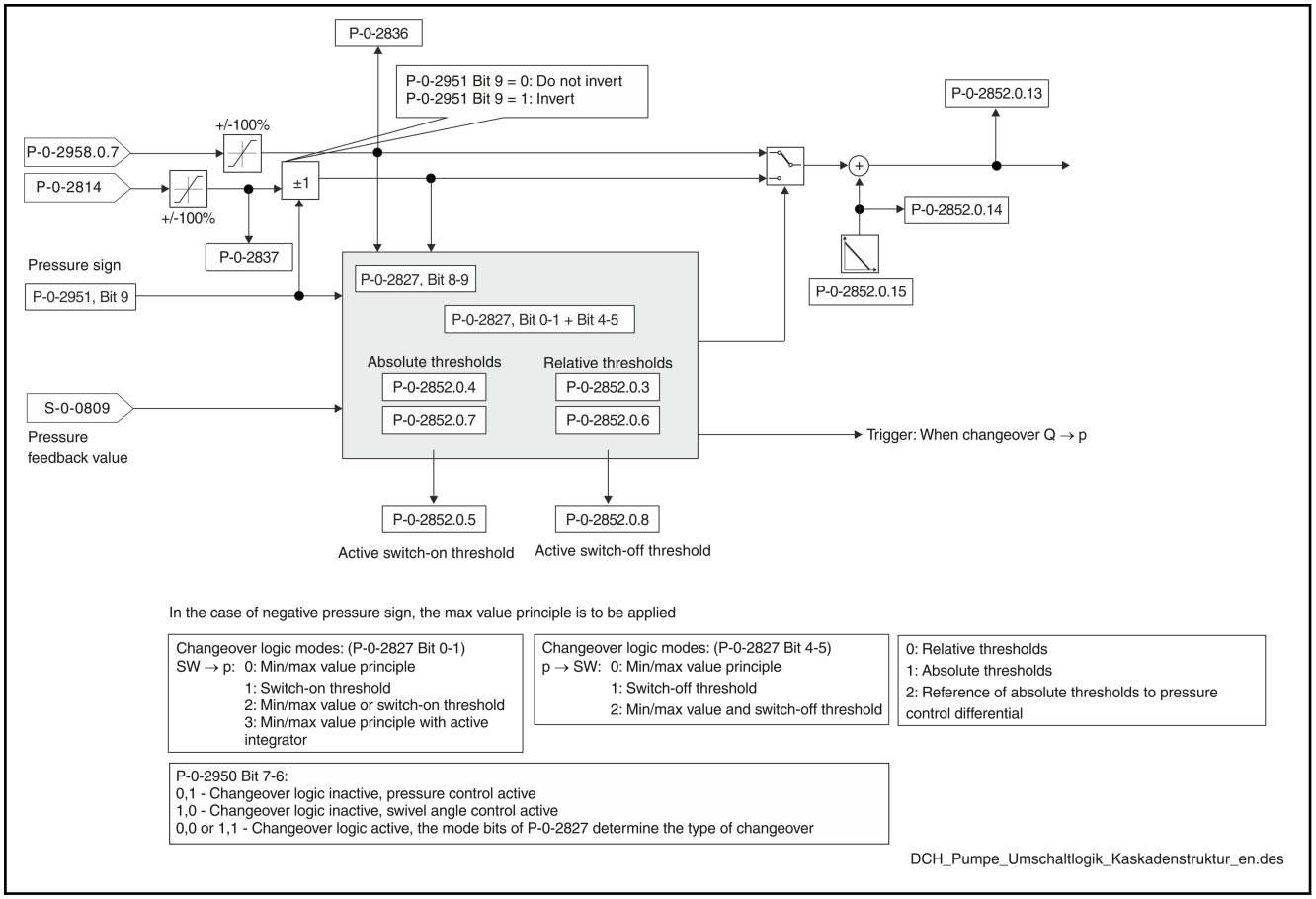


Fig. 7-60: Pump changeover logic, cascade structure

The changeover logic switches between swivel angle control and pressure control, see fig. 7-60 "Pump changeover logic, cascade structure" on page 447.

Via bits 7/6 in parameter "P-0-2950, Pump controller control word" the changeover logic can be activated/deactivated. For changing to the pressure controller, several modes are provided: These modes have to be configured by means of "P-0-2827, Pump changeover logic control word":

- "Min/max value"
- "Pressure switch-on threshold": The changeover logic switches over to the pressure controller depending on a defined relative or absolute threshold
- "Min/max value and pressure switch-on threshold": Both criteria have to be fulfilled in order that switching to pressure control takes place

The following setting options are available for changing over from the pressure controller to the swivel angle controller:

- "Min/max value"
- "Pressure switch-off threshold": The changeover logic switches over to the swivel angle controller depending on a defined relative or absolute threshold
- "Pressure switch-off threshold or min/max value": The criterion that is fulfilled first switches over to the swivel angle controller

If the pressure sign is negative (P-0-2951, bit 9 = 1), the max value principle is applied, otherwise the min value principle.

☞ In the hydraulic variant "closed circuit" with pulling loads, the following special case is valid for the changeover logic. A precondition for this is a positive swivel angle command value and a pressure feedback value A active for the control, or a negative swivel command value and a pressure feedback value B active for this control. In this case, the changeover condition between swivel angle control and pressure control is changed to "min/max value or pressure switch-on threshold".

The relative threshold refers to the internal pressure command value. Since, depending on the setting, the internal pressure command value may change via a ramp, this ramp also has an effect on the relative threshold. In case of problems, it may be helpful to also consider "P-0-2852.0.5, Pressure controller active switch-on threshold" or "P-0-2852.0.8, Pressure controller active switch-off threshold".

☞ Torque limitation is only effective when swivel angle control is active as well.

7.4.7 Parameters/diagnostic and status messages

P-0-2950, Pump controller control word

Structure (additionally):

Bit 11	**Activate/deactivate pressure controller adaptation in parallel structure** **0:** Adaptation not active. The adaptation factors are set to 1. **1:** Adaptation active. The adaptation factors are calculated via the speed characteristic curve.

Tab. 7-8: P-0-2950, Structure

Lower speed limit of P-term adaptation, P-0-2806.0.27

This parameter is used for setting the lower limit value of the speed characteristic curve. Below this speed limit the P-term of the pressure controller is no longer adapted.

Lower speed limit of D-term adaptation, P-0-2806.0.30

This parameter is used for setting the lower limit value of the speed characteristic curve. Below this speed limit the D-term of the pressure controller is no longer adapted.

Upper speed limit of P-term adaptation, P-0-2806.0.28

This parameter is used for setting the upper limit value of the speed characteristic curve. Above this speed limit the P-term of the pressure controller is no longer adapted. From this limit value on the adaptation factor remains at 1.

P-term gain factor for lower speed limit, P-0-2806.0.29:

By means of P-0-2806.0.29 the P-term gain factor can be set for the lower speed limit. The gain factor for the upper limit speed is firmly set to 1.0. Between the upper and the lower speed limit the gain factor is linearly increased depending on the speed.

D-term gain factor for lower speed limit, P-0-2806.0.32:

By means of P-0-2806.0.32 the D-term gain factor can be set for the lower speed limit. The gain factor for the upper limit speed is firmly set to 1.0. Be-

tween the upper and the lower speed limit the gain factor is linearly increased depending on the speed.

Pertinent parameters

- P-0-2802, Flow command value internal
- P-0-2803, Pressure command value of controller
- P-0-2806.0.2, Output pressure controller P-gain
- P-0-2806.0.4, Pressure controller integration time constant
- P-0-2806.0.6, Pressure controller integrator accuracy window
- P-0-2806.0.10, Correction value: pressure controller D-component
- P-0-2806.0.11, Pressure controller feedback to integrator
- P-0-2806.0.12, Output pump pressure controller I-part
- P-0-2806.0.15, Pressure controller preload integrator, threshold 1
- P-0-2806.0.16, Pressure controller preload integrator, threshold 2
- P-0-2806.0.17, Pressure controller preload, pressure change filter time
- P-0-2806.0.18, Pressure controller adaptation, P-term
- P-0-2806.0.19, Pressure controller adaptation, D-term
- P-0-2806.0.20, Pressure controller disturbance feedforward
- P-0-2806.0.26, Output pressure controller in PD branch
- P-0-2806.0.27, Lower speed limit of P-term adaptation
- P-0-2806.0.28, Upper speed limit of P-term adaptation
- P-0-2806.0.29, P-term gain factor for lower speed limit
- P-0-2806.0.30, Lower speed limit of D-term adaptation
- P-0-2806.0.31, Upper speed limit of D-term adaptation
- P-0-2806.0.32, D-term gain factor for lower speed limit
- P-0-2807, Pressure controller pilot flow control command value
- P-0-2809, Pressure controller P-gain, cascade structure
- P-0-2812, Feedback of actual pressure value derivative to integrator
- P-0-2813, Pressure controller dead volume
- P-0-2814, Output of pump pressure controller, cascade structure
- P-0-2815, Pressure controller output signal, negative limit, cascade
- P-0-2816, Pressure controller positive factor for D-component, cascade
- P-0-2817, Pressure controller negative factor for D-component, cascade
- P-0-2818, Pressure controller upper integrator limit, cascade
- P-0-2827, Pump changeover logic control word
- P-0-2835, Pump pressure controller status word
- P-0-2836, Pump changeover logic swivel angle, cascade
- P-0-2837, Pump changeover logic output pressure controller, cascade
- P-0-2838, Pressure controller lower integrator limit, cascade
- P-0-2852.0.3, Pressure controller switch-on threshold, relative
- P-0-2852.0.4, Pressure controller switch-on threshold, absolute
- P-0-2852.0.5, Pressure controller active switch-on threshold
- P-0-2852.0.6, Pressure controller switch-off threshold, relative
- P-0-2852.0.7, Pressure controller switch-off threshold, absolute
- P-0-2852.0.8, Pressure controller active switch-off threshold

- P-0-2852.0.12, Pressure change at changeover time
- P-0-2852.0.13, Output of pump changeover logic, cascade structure
- P-0-2852.0.14, Output ramp of pump changeover logic, cascade structure
- P-0-2852.0.15, Pump changeover logic ramp time, cascade
- P-0-2914, Effective valve command value
- P-0-2935, Swivel angle command value for master/slave function
- P-0-2940, Pressure feedback value 1
- P-0-2941, Pressure feedback value 2
- P-0-2942, Calibration history
- P-0-2943, Pump displacement volume
- P-0-2944, Motor nominal speed
- P-0-2947.0.1, Max. allowed pressure sensor offset calibration value
- P-0-2947.0.2, Max. allowed valve offset calibration value (amount)
- P-0-2947.0.3, Max. allowed pressure ctrl. diff. for valve offset calibr.
- P-0-2947.0.4, Max. swivel angle sensor zero point corrective value
- P-0-2947.0.5, Max. allowed pressure ctrl. diff. for SWA offset calibration
- P-0-2947.0.6, Valve comm. value for swivel angle factor calibration
- P-0-2947.0.7, Min. allowed swivel angle sensor factor
- P-0-2947.0.8, Max. allowed swivel angle sensor factor
- P-0-2947.0.9, Max. allowed act. pressure value for SWA factor calibration
- P-0-2947.0.10, Max. allowed leakage offset
- P-0-2947.0.11, Max. allowed pressure differential for leakage calibration
- P-0-2947.0.12, Calibration time
- P-0-2947.0.13, Min. time for control error detection
- P-0-2947.0.14, Threshold value controller deviation detection
- P-0-2947.0.15, Valve error detection time
- P-0-2947.0.16, Reference pressure for pump controller calibration
- P-0-2948, Selection of swivel angle sensor type
- P-0-2949.0.1, Swivel angle sensor configuration
- P-0-2949.0.2, Swivel angle sensor, lower working point
- P-0-2949.0.3, Swivel angle sensor, upper working point
- P-0-2949.0.4, Swivel angle sensor wire rupture, lower threshold
- P-0-2949.0.5, Swivel angle sensor wire rupture, upper threshold
- P-0-2949.0.6, Swivel angle sensor wire rupture, timeout
- P-0-2950, Pump controller control word
- P-0-2951, Pump controller status word
- P-0-2952, Torque limitation of pump, relative
- P-0-2953, Output of swivel angle controller
- P-0-2954, Pump changeover logic output pressure controller, parallel
- P-0-2955, Output of pump changeover logic, parallel structure
- P-0-2956, Pump changeover logic swivel angle, parallel

- P-0-2957.0.1, Pressure normalization
- P-0-2957.0.2, Output pressure controller P-gain
- P-0-2957.0.3, Correction value: pressure controller D-component
- P-0-2957.0.4, Correction value: swivel angle feedback
- P-0-2957.0.6, Derivation pressure feedback value
- P-0-2957.0.7, Pressure feedback value, delayed
- P-0-2957.0.8, Output of pump pressure controller, parallel structure
- P-0-2958.0.1, Derivation swivel angle feedback value
- P-0-2958.0.3, Correction value: torque limitation
- P-0-2958.0.4, Swivel angle command value after leakage compensation
- P-0-2958.0.5, Feedback of actual pressure value derivative
- P-0-2958.0.6, Correction value: leakage compensation offset value
- P-0-2958.0.7, Output of swivel angle command value processing
- P-0-2958.0.8, Torque limitation, field weakening operation
- P-0-2958.0.9, Effective torque limitation

Pertinent diagnostic messages

- E2280 Warning: Wire rupture of swivel angle sensor
- E2282 Warning: Control deviation pump controller
- F2280 Error wire rupture of swivel angle sensor
- F2281 Valve error pump controller
- F8285 Error: Output stage

7.5 Limitations

7.5.1 Overview of limitations

To protect the mechanical system of the axis, HydraulicDrives feature various limitation options:

- Torque/force limitation
  - Sign-dependent, axis-side torque/force limit values
- Velocity limitation
  - Drive-side velocity limit values
  - Axis-side velocity limit values
- Position limitation
  - Evaluation of axis-side travel range limit switches
  - Firmware-side travel range limit values

7.5.2 Velocity limitation

Brief description

Velocity limits are implemented in the drive, which allow the velocity command value to be limited to a freely defined amount or to different positive and negative values.

Features of velocity limitation

- Unipolar velocity limit values ("S-0-0038, Positive velocity limit value", "S-0-0039, Negative velocity limit value"), scaled, with reference to load where applicable
- Cyclically configurable, bipolar velocity limit value ("S-0-0091, Bipolar velocity limit value"), scaled, with reference to load, if necessary

- Bipolar velocity limit value (P-0-0113) of the motor, unscaled, with reference to the motor only

With the value “0”, the limitation is switched off by "S-0-0038, Positive velocity limit value", "S-0-0039, Negative velocity limit value" and "S-0-0113, Maximum velocity of the drive".

The limitation parameters act on the effective velocity command value.

Moreover, the actual velocity is monitored. If the actual velocity value is greater than the 1.125-fold of the parameterized velocity limit value, the drive enable is immediately switched off. Error “F8079, Velocity limit value exceeded“ is output. Possible causes are:

- Velocity controller oscillates
- Torque settings without sufficient counter-torque
- Commutation offset incorrect
- Motor output frequency >600 Hz in open-loop operation

"S-0-0113, Maximum velocity of the drive" forms the basis for calculating the maximum value for all the other velocity limit values. The maximum value = S-0-0113 +100 rpm.

7.5.3 Position limitation/travel range limit switches

Brief description

To avoid accidents and damage to the machine, comprehensive preventive safety precautions are provided. Part of these safety precautions is the limitation of the allowed working range (travel range) by the drive. For this purpose, position monitoring functions and position limitations have been implemented in the drive.

⚠ CAUTION	**The travel range monitoring function (travel range limit switches or software limit switches) only fulfills the requirements for protecting machinery, but is not sufficient for personal protection!**

Variants of travel range monitoring

The drive provides two possibilities of determining and monitoring a limitation of the working range (travel range):

- Monitoring of **position limit values (software limit switches)**

  Monitoring the actual position value for exceeding one of the two position limit values ("S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value") by the actual position value ("S-0-0403, Position feedback value status"), which is homed, i.e. related to the machine zero point.

- Monitoring of **travel range limit switches**

  Monitoring for activation of one of the two travel range limit switches (Limit+, Limit-) that are connected to the digital inputs of the drive

☞ The functionality of the travel range limit switches is only guaranteed, if the corresponding digital inputs have been configured for this purpose!

See "Digital inputs/outputs"

Features of travel range limit switches

- Monitoring of 2 travel range limit switches (Limit+, Limit-) at the drive is possible
- Signal behavior of travel range limit switches can be set (N/C-N/O)
- Activation of travel range limit switches via parameter
- Reaction (error/warning) when exceeding travel range can be set
- Status display of the travel range limit switches
- Command values monitored for validity when limit switch activated
- Travel range limit switches evaluated and position limit value monitor activated in 2-ms clock cycle

Features of position limit values

- Available with functional package Axis Controller CL
- 2 position limit values ("software limit switches") can be parameterized; only operational when axis has been homed
- Reaction (warning/error) to exceeded values can be set
- Activation of position limit values via parameter
- Automatic reference to measuring system that has been homed
- Command values monitored for validity when position limit values exceeded

Pertinent parameters

- S-0-0012, Class 2 diagnostics
- S-0-0049, Positive position limit value
- S-0-0050, Negative position limit value
- S-0-0055, Position polarities
- S-0-0147, Homing parameter
- S-0-0403, Position feedback value status
- S-0-0478, Position/travel range limit status
  (Alias: P-0-0091, Position/travel range limit status)
- S-0-0532, Travel range limit parameter
  (Alias: P-0-0090, Travel range limit parameter)
- P-0-0222, Travel range limit switch inputs

Pertinent diagnostic messages

- E2053, Target position out of travel range
- E8029, Positive position limit exceeded
- E8030, Negative position limit exceeded
- E8042, Both travel range limit switches activated
- E8043, Positive travel range limit switch activated
- E8044, Negative travel range limit switch activated
- F6028, Position limit value exceeded (overflow)
- F6029, Positive position limit exceeded
- F6030, Negative position limit exceeded
- F6042, Both travel range limit switches activated
- F6043, Positive travel range limit switch activated
- F6044, Negative travel range limit switch activated

Travel range limit switches

It is possible to connect and monitor 2 travel range limit switches (Limit+, Limit-) at the digital inputs of the drive.

☞ The travel range limit switch inputs are polled every 2 ms so that the assigned error reaction is started at the earliest approx. 3 ms after the limit switch has been activated.

Activating monitoring

Monitoring for exceeding the travel range limit switches is only carried out when the monitor was activated by bit 1 of "S-0-0532, Travel range limit parameter".

Reaction when exceeding travel range

The drive reaction to exceeding the travel range can be determined via bit 2 of "S-0-0532, Travel range limit parameter".

Exceeding travel range as an error

When "0" is entered in bit 2 of "S-0-0532, Travel range limit parameter", exceeding the travel range is handled as an error with the reaction set for a travel range error (F6xx). After having carried out the error reaction, the drive switches off the internal controller enable. See also "Error reactions"

Exceeding travel range as a warning

When "0" is entered in bit 2 of "S-0-0532, Travel range limit parameter", exceeding the travel range is handled as a warning with the reaction "Emergency Halt".

Drive behavior:

- The drive does not switch off the internal drive enable.
- As long as the warning condition is present, i.e. the limit switch is activated, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode.

See also "Error reactions"

Position limit values (software limit switches)

Parameters for position limit values

To define the travel range via position limit values, the following parameters are available:

- S-0-0049, Positive position limit value
- S-0-0050, Negative position limit value

☞ The position limit values are polled every 2 ms so that the assigned error reaction is started at the earliest approx. 3 ms after the position limit has been exceeded.

Prerequisite for activating the function

Prerequisite for using (activating) the position limit value monitor:

- The position data reference of the drive must have been established (i.e. the encoder system of the active operation mode has to be in reference). The status bit in "S-0-0403, Position feedback value status" then is "1".
- Monitoring of the position limit values was activated in parameter "S-0-0055, Position polarities" (bit 4 = 1).

Dedicated point for position limit value monitoring

When 2 measuring systems are used, the drive, for position limit value monitoring, automatically refers to the measuring system that has been homed.

☞ When two measuring systems are used and both systems are in reference, the encoder selected in parameter "S-0-0147, Homing parameter" (bit 3) is used.

Exceeding the position limit values

Exceeding the position limit values is detected when the actual position value of the active operation mode is outside the travel range defined by the position limit values.

Reaction when exceeding position limit values

The drive reaction to exceeding the position limit value can be determined via bit 2 of "S-0-0532, Travel range limit parameter".

Exceeding position limit values as an error

When "0" is entered in bit 2 of "S-0-0532, Travel range limit parameter", exceeding the travel range is handled as an error with the reaction set for a travel range error (F6xx). After having carried out the error reaction, the drive switches off the internal controller enable. See also "Error reactions"

Exceeding position limit values as a warning

When "1" is entered in bit 2 of "S-0-0532, Travel range limit parameter", exceeding the position limit value is handled as a warning with the reaction "Emergency Halt".

Drive behavior:

- The drive does not switch off the internal drive enable.
- As long as the warning condition is present, i.e. the limit switch is activated, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode. See also "Error reactions"

Leaving the inadmissible travel range

After the allowed travel range has been exceeded, the command values are checked for validity and only such command values are accepted that lead back to the allowed travel range.

☞ Moving into the allowed travel range is also possible in the case of error!

Notes on commissioning

When parameterizing the position limit values, take the positions of the travel range limit switches into account. The working range defined with the two position limit values "S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value" should be within the working range defined with the travel range limit switches. As long as the position data reference has not been established yet (axis not homed), the function of the software limit switches (position limit values) is not yet guaranteed. Independent thereof is the function of the travel range limit switches that always causes the drive to be switched off when the defined limit is exceeded to avoid collisions (machine protection).

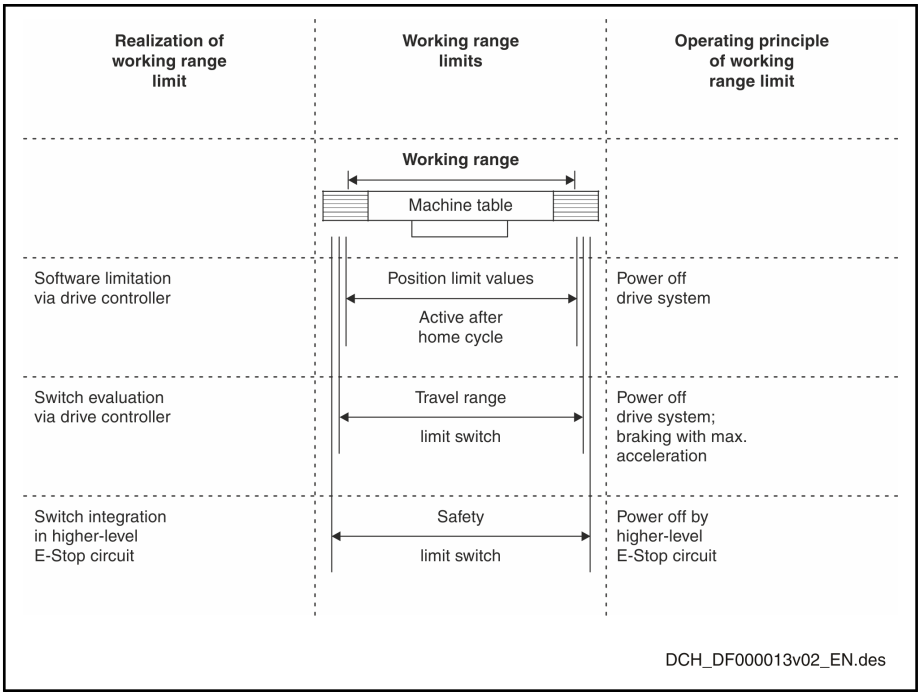


Fig. 7-61: Variants and operating principles of working range limitations

The safety limit switches that can be included in the E-Stop circuit are the last safeguard by the drive. In addition, the control master can monitor the position limit values.

Activating the position limit value monitor

The monitor of the position limit values is activated by setting bit 4 in parameter "S-0-0055, Position polarities".

Before activating position limit value monitoring, it is necessary to establish the drive's position data reference, because position limit values are only useful and operational when the axis has been homed.

Activating the travel range limit switches

The travel range limit switches are activated by setting bit 1 in "S-0-0532, Travel range limit parameter".

To this end, 2 digital inputs have to be configured to "P-0-0222, Travel range limit switch inputs" bit 0 and 1.

See "Digital inputs/outputs"

Signal behavior of travel range limit switches (N/O and N/C)

Via bit 0 of "S-0-0532, Travel range limit parameter", it is possible to determine whether the connected travel range limit switches are to be evaluated as N/O or N/C. This allows activating an inversion of the signal.

Recommissioning in case of error

After a limit switch error or a limit value error occurred (diagnostic messages "F6043, Positive travel range limit switch activated" / "F6044, Negative travel range limit switch activated" or "F6029, Positive position limit exceeded" / "F6030, """" Negative position limit exceeded"), the following steps are required for recommissioning:

- The error message has to be cleared by means of command "S-0-0099, C0500 Reset class 1 diagnostics".
- Activate the drive with a positive edge of the drive enable signal.

If the error condition is still present, i.e. if the limit switch is still activated or if the position limit values are still exceeded, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode.

The following applies:

Operation mode	Command value check
Direct valve control	Polarity of valve opening
Torque control	Polarity of "S-0-0080, Torque/force command value (2 bytes)"
All operation modes with drive-internal velocity control	Polarity of the internal velocity command value
All operation modes with drive-internal position control	Polarity of the velocity resulting from the preset position command value

Tab. 7-9: Checking the command values in the case of error

If command values leading out of the allowed travel range continue to be preset, the error message (or warning) for travel range limit switch errors/position limit value errors will be generated again!

Diagnostic and status messages

Diagnostic messages when travel range limit values exceeded

In case the position limit values are exceeded, the corresponding diagnostic message depends on the handling set in "S-0-0532, Travel range limit parameter" (bit 2):

Handling	Display	Diagnostics
As error (bit 2 = 0)	F6029	F6029, Positive position limit exceeded
	F6030	F6030, Negative position limit exceeded
As warning (bit 2 = 1)	E8029	E8029, Positive position limit exceeded
	E8030	E8030, Negative position limit exceeded

Tab. 7-10: Diagnostic messages when position limit values exceeded

E2053, Target position out of travel range

When "drive-internal interpolation" is used as active operation mode, the drive checks whether the target position is outside the position limit values "S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value". If this is the case, the drive does not move. It generates the warning "E2053, Target position out of travel range" and additionally sets bit 13 in parameter "S-0-0012, Class 2 diagnostics".

Diagnostic messages when travel range limit switch activated

Exceeding the travel range limit switches is detected when these switches are activated. When this monitor reacts, the corresponding diagnostic message depends on the handling set in "S-0-0532, Travel range limit parameter" (bit 2):

Handling	Display	Diagnostics
	F6028	F6028, Position limit value exceeded (overflow)
As error (bit 2 = 0)	F6042	F6042, Both travel range limit switches activated
	F6043	F6043, Positive travel range limit switch activated
	F6044	F6044, Negative travel range limit switch activated
As warning (bit 2 = 1)	E8042	E8042, Both travel range limit switches activated
	E8043	E8043, Positive travel range limit switch activated
	E8044	E8044, Negative travel range limit switch activated

Tab. 7-11: Diagnostic messages when travel range limit switches exceeded

Status of travel range limit switches

The states of the connected travel range limit switches are displayed in parameter "P-0-0222, Travel range limit switch inputs":

- Bit 0 → status of positive limit switch (Limit+)
- Bit 1 → status of negative limit switch (Limit-)

7.6 Power supply

7.6.1 General

The drive can be switched between "drive ready (Ab)" and "ready for operation (bb)" via the enable of the power supply.

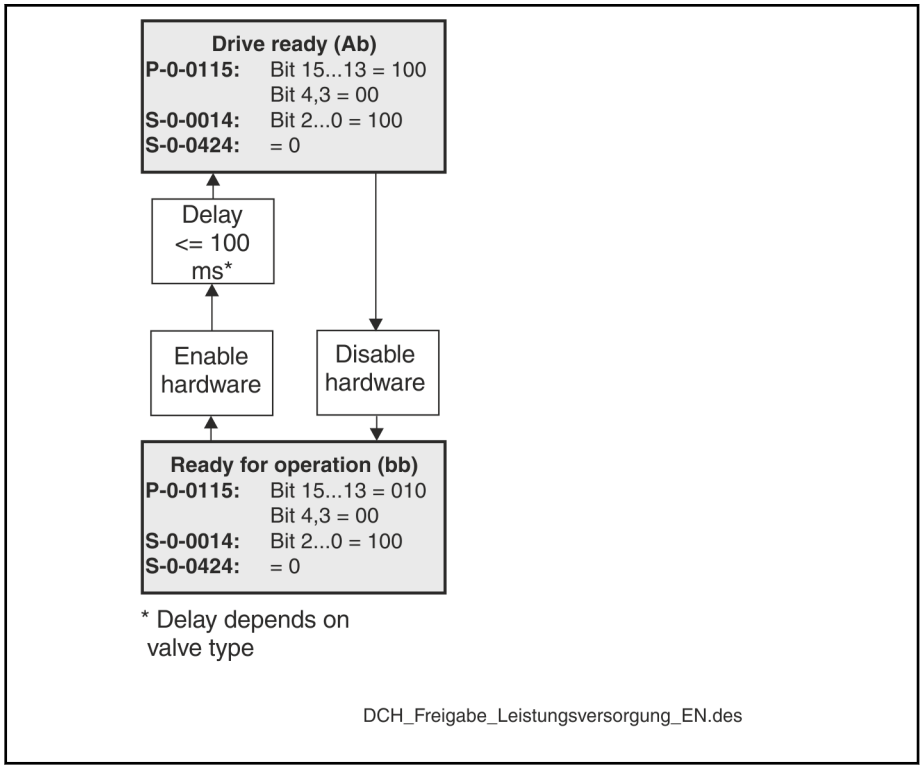


Fig. 7-62: Enable of power supply

With regard to the transition "bb" ↔ "Ab" there are 3 different hardware characteristics:

- Wired to dedicated enable inputs, see "P-0-2946, Enable signal" (e.g. WRxD, WRxQ, WRxF)
- Automatically (e.g. SY(H)DFED)
- Configurable to digital input through assignment of "P-0-0861, Power supply status word, bit 0" (e.g. HMC / HPC)

If the **power supply is disabled** while the controller enable is active, error "F8282, Error: Hardware enable" is triggered.

☞ Error "F8282, Error: Hardware enable" can be switched off by means of "P-0-2819, Error suppression control word, bit 5".

In this case, merely information message "A0521, Power loss, switching back to bb" is generated. The state machine is then directly switched back to "ready for operation (bb)".

7.6.2 Enable acknowledgement

Valves may have an enable acknowledgement as digital output. It signals by means of its level whether the valve is in a safe state or whether it is active. The output behaves inversely to the enable input in logical terms.

With the various valve types the enable acknowledgement behaves as follows:

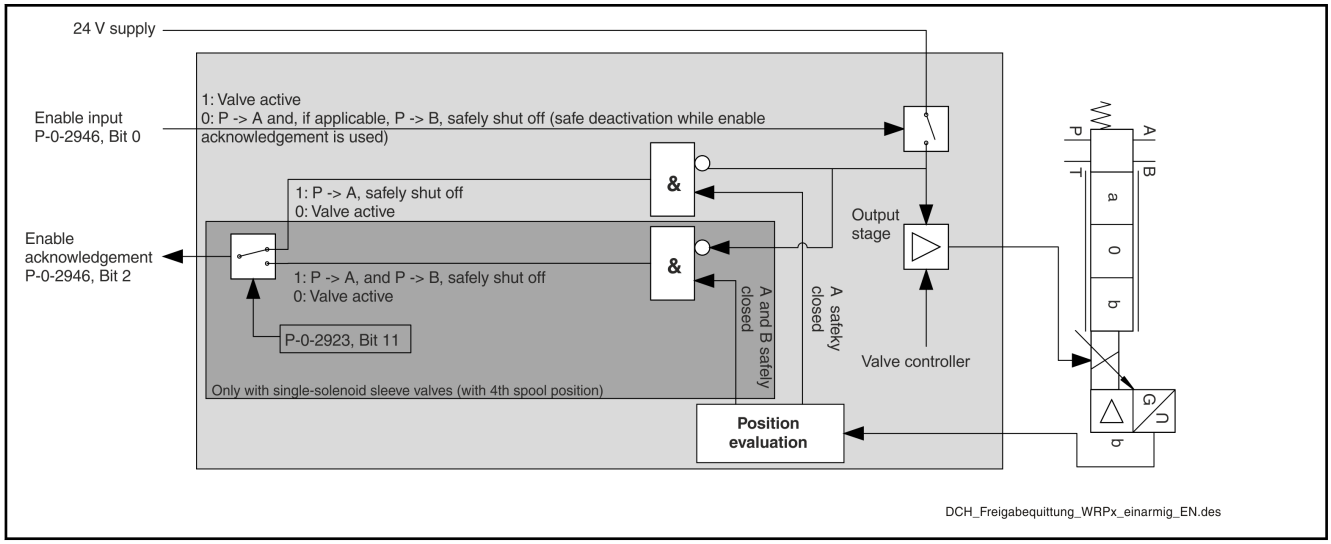


Fig. 7-63: Valve type WRPx (one solenoid)

Enable acknowledgement A: is set as soon as the valve disconnected port A reliably from the pump.

In the case of single-solenoid valves with 4th spool position, "P-0-2923, Configuration of system data, bit 11" can be used to select whether the enable acknowledgement is to be set only when both, port A and port B were reliably disconnected from the pump.

See also "data sheet 29391 (type 4WRPDH, sizes 6 and 10)".

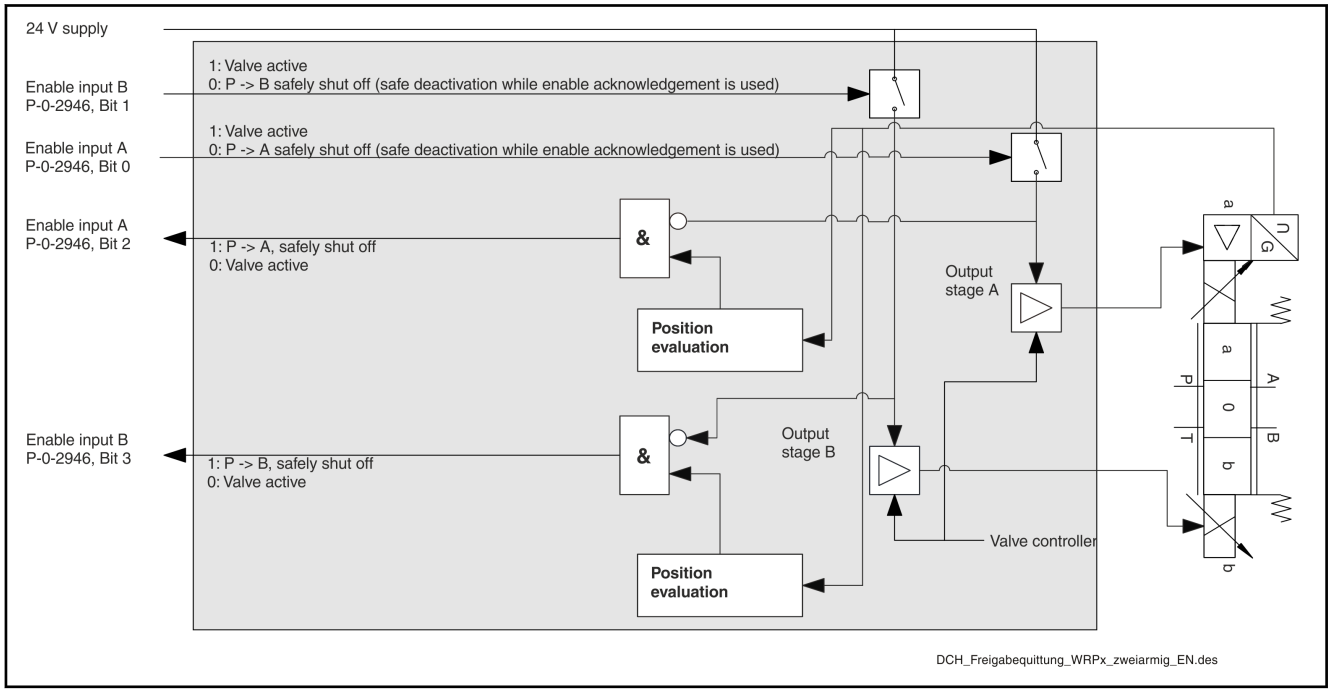


Fig. 7-64: Valve type WRPx (two solenoids)

In the case of two-solenoid valves, there is an enable acknowledgement A and an enable acknowledgement B:

- Enable acknowledgement A: is set as soon as the valve disconnected port A reliably from the pump.
- Enable acknowledgement B: is set as soon as the valve disconnected port B reliably from the pump.

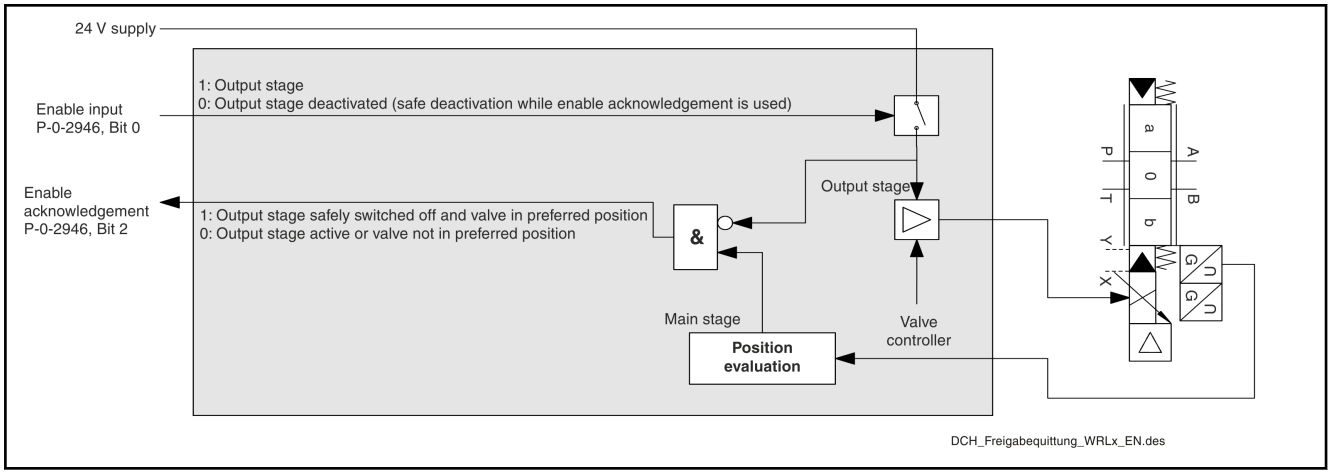


Fig. 7-65: Valve type WRLx (pilot operated, with spool types E, W and Q)

The enable acknowledgement is set as soon as the valve is in its "failsafe position".

See also "data sheet 29289 (type 4WRLD, from size 10 on)".



The type of the current solenoid (-> one solenoid, two solenoids, pilot operated, …) can be established by means of parameter "P-0-2946.0.1, Valve type".

7.6.3 Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-2946, Enable signal
- P-0-2946, Valve type
- P-0-0861, Power supply status word

Pertinent diagnostic messages

- F8282, Error: Hardware enable

8 Device functions

8.1 Availability of device functions

The following overview shows, in which functional packages the individual device functions are available (valid for the firmware derivatives HDB und HDC, unless specified otherwise).

Device function	In functional package ...							
	Base package					Extension package		
	IFB	p/Q	DFE	Axis controller OL	Axis controller CL	Servo [1]	Sync [1]	MLD
Drive Halt					■			
Emergency halt	■	■		■	■			
Output stage shutdown	■	■	■	■	■			
Quick stop					■			
Return motion						■		
Reaction on error	■	■	■	■	■			
NC reaction on error	■	■	■	■	■			
MLD reaction on error								■
Quadrant error correction						■		
Positive stop drive procedure					■			
Axis error precision correction						■		
Parameter set switching	■	■	■	■	■			
Set/shift coordinate system						■	■	
Parking axis				■	■			

Tab. 8-1: Availability of device functions

[1] Only in conjunction with axis controller CL

To use a functional package, it must have been activated (enabled). The currently enabled functional packages are displayed in parameter "P-0-2004, Active functional packages", see also Functional package enabling.

8.2 Digital inputs/outputs

8.2.1 Configurable digital I/O

General information

HydraulicDrive controllers are provided with digital on-board I/Os in dependence on the device type.

These can be used directly in the drive or by a higher-level control unit through transmission over a cyclic data channel.

Availability of digital inputs/outputs

The number of available digital inputs and outputs and the assignment of digital inputs and outputs to the device connectors depend on the device type of HydraulicDrive (on-board electronics in the valve or control cabinet electronics). These details can be found in the technical data sheet of the respective device.

For an overview of technical data sheets, please refer to "Reference documentations".

Processing of digital inputs

- Each of the digital inputs is read in over the I/O interface within the position clock cycle and mapped to "P-0-0303, Digital inputs, input image of device".
- The assignment of digital inputs to the respective connector and pin is described by parameter "P-0-0305, Digital inputs, indication of connector and pin".
- The digital inputs can be assigned to a parameter via parameters "P-0-0300, Digital inputs, assignment list" and "P-0-0301, Digital inputs, bit numbers". Possible parameters are listed in S-0-0399.



Each device-side digital input can be evaluated in every subdevice (multiple evaluation).

Processing of digital outputs

- The digital outputs can be assigned to a parameter using parameters "P-0-0310, Digital outputs, assignment list" and "P-0-0311, Digital outputs, bit numbers". Possible parameters are listed in S-0-0398.
- The assignment of digital inputs to the respective connector and pin is described by parameter "P-0-0315, Digital outputs, indication of connector and pin".
- Only one assignment to a digital output can be made from a drive parameter. Multiple assignments to a digital output from the individual subdevices are therefore not possible.

Assignment and relation to hardware

Inputs The digital inputs can be assigned via parameters "P-0-0300, Digital inputs, assignment list" and "P-0-0301, Digital inputs, bit numbers". There is no separate image of the subdevice. Hence, every physical input in every subdevice can be assigned and used. The HydraulicDrive firmware, however, prevents the same bit of a device parameter (parameter that is available only once in the device) from being written by two inputs or by one input via the assignment of two subdevices. In this case, "C0203, Parameter conversion error (->S-0-0423)" is issued when changing over from PM to OM takes place.

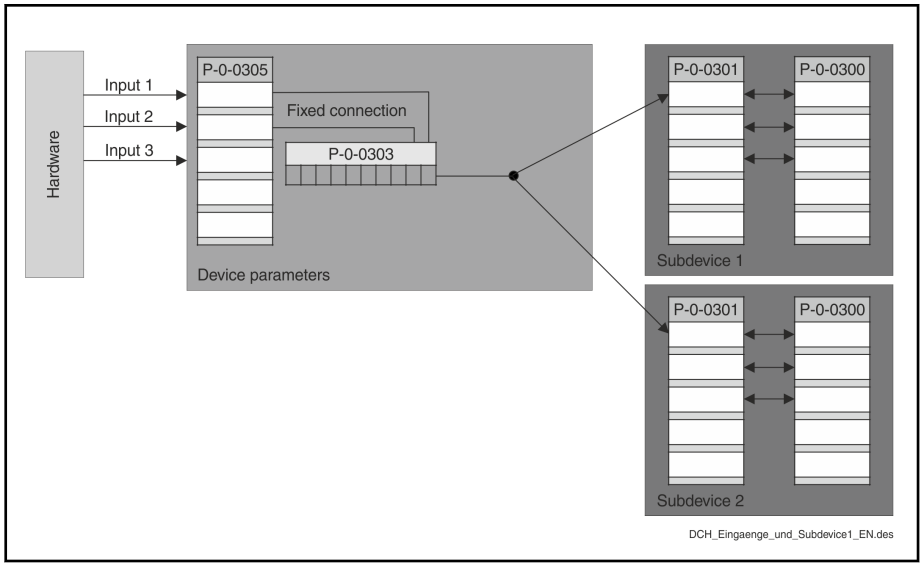


Fig. 8-1: Interrelationship between physical inputs and assignment in the subdevice

Outputs

The digital outputs can be assigned via parameters "P-0-0310, Digital outputs, assignment list" and "P-0-0311, Digital outputs, bit numbers". There is no separate image of the subdevice. The outputs have, however, to be assigned to the relevant subdevice. The allocation is made directly by the assignment; this means, by setting a target parameter other than "S-0-0000, Dummy parameter" the assignment is activated. Every physical output can therefore be assigned from every subdevice. The HydraulicDrive firmware runs a check to prevent the same bit from several subdevices from being used. In this case, "C0203, Parameter conversion error (->S-0-0423)" is issued when changing over from PM to OM takes place.

If a digital output is not used by any of the subdevices, the HydraulicDrive firmware sets this output to the "low“ state.

The digital outputs can be written (set) by a master through inclusion in the master data telegram (Sercos) or in the cyclic command value data channel of master communication. The HydraulicDrive firmware supports this only, if it does not utilize the digital outputs itself ("P-0-0310, Digital outputs, assignment list" equal to "S-0-0000, Dummy parameter").

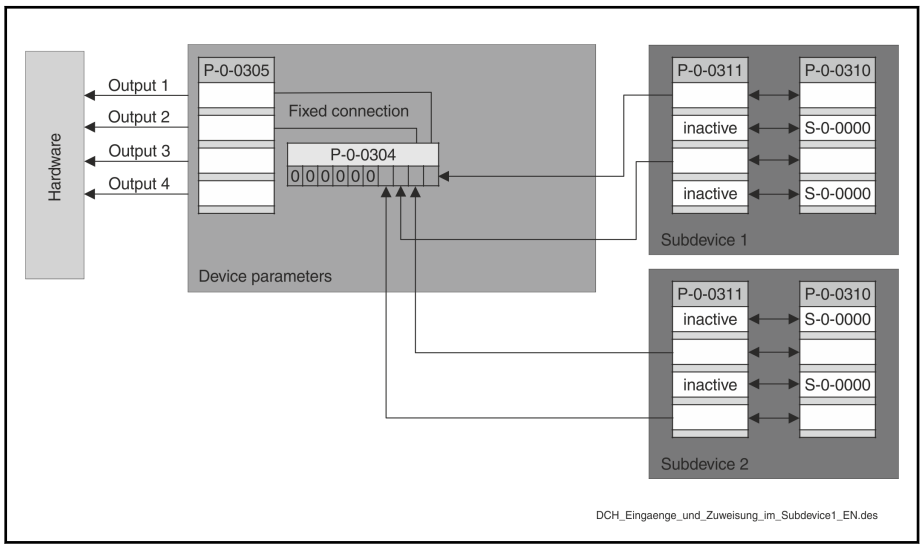


Fig. 8-2: Interrelationship between physical inputs and assignment in the subdevice

Utilization of the digital outputs of the HPC and HMC for sensor supply

The 4 digital outputs of the HPC or the 2 digital outputs and the outputs Vencoder_SSI and Vencoder_ANA of the HMC can make available a total current of 500 mA.

One or several digital outputs can therefore also be used for furnishing the supply voltage (→ input voltage $+U_B$ = 24 V) for a sensor (e.g. pressure transducer), if the summation current of 500 mA is not exceeded.

In order that the digital output, which is used as supply voltage, is always set irrespective of the operational state of the HPC or HMC, an optional bit of parameter "P-0-2918.0.3, Sensor supply via digital outputs" has to be assigned to the digital output.

If the digital outputs are overloaded due to an excessive amount of current output, error "F8283, Overload" is triggered.

The current load current at the digital outputs is shown in parameter "P-0-2885.0.6, Load current, actual value".

Pertinent parameters and diagnostic messages

Parameters

- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device
- P-0-0305, Digital inputs, indication of connector and pin
- P-0-0310, Digital outputs, assignment list
- P-0-0311, Digital outputs, bit numbers
- P-0-0315, Digital outputs, indication of connector and pin
- P-0-2918.0.3, Sensor supply via digital outputs
- P-0-2885.0.6, Load current, actual value

Diagnostic messages

- C0203, Parameter conversion error (->S-0-0423)
- F8283, Overload

8.3 Analog inputs/outputs

8.3.1 Hardware variants of analog peripherals

Availability of analog inputs and outputs

The number of available inputs and outputs, the configuration options (voltage, current) for and the assignment of digital inputs and outputs to the device connectors depend on the HydraulicDrive device type (on-board electronics in the valve or control cabinet electronics). These details are contained in the technical data sheet of the respective device. You can find them in the "Reference documentations".

Configuration of analog inputs and outputs for voltage and current

The following parameters determine whether the individual analog inputs and outputs are to work in voltage or current operation.

Parameters for configuring inputs and outputs	Firmware derivative				
	HDB	HDC	HDE	HDM	HDP
P-0-2918.0.1	■				■
P-0-2918.0.2		■		■	
P-0-2918.0.4			■		

Tab. 8-2: Configuring the analog inputs and outputs for voltage or current

Monitoring of analog outputs on device types VT-HMC and VT-HPC

- In the case of device types VT-HMC and VT-HPC the hardware automatically monitors analog outputs for overloading, temperature and short-circuit.
- When hardware monitoring responds, error "F8284, Error Analog output (controller)" is triggered on the hardware, if the analog output is used as controller output. Otherwise, warning "E2302, Analog output overload" is triggered.

Pertinent parameters and diagnostic messages

Parameters

- P-0-2918.0.1, Hardware control word of analog inputs and outputs
- P-0-2918.0.2, Hardware control word of analog inputs and outputs
- P-0-2918.0.4, Hardware control word of analog inputs and outputs
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6
- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0221, Analog input 7
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0256, Analog input 8
- P-0-0139, Analog output 1
- P-0-0140, Analog output 2
- P-0-0414, Analog output 3
- P-0-0415, Analog output 4

Diagnostic messages

- E2302, Analog output overload
- F8284, Error Analog output (controller)

8.3.2 Assignments of analog inputs

Functional description

Over the analog inputs, it is possible to read in, for example, analog sensors, but also any other optional voltage and current signals can be reassigned to various drive parameters. The number of analog inputs and outputs depends on the type of HydraulicDrive. The number of analog inputs that are available on the various types of the HydraulicDrive is explained in more detail in "Analog inputs/outputs".

General features of analog inputs

- Depending on the type of HydraulicDrive up to 8 analog inputs are available
- Updating of analog inputs within the base clock cycle
- Reading in from various analog sensors
- Reading in of optional voltage and current signals (within defined ranges)
- Filtering of analog input signals
- Wire break monitoring
- Parameterizable signal transformation through offset and nominal value for assignment to internal drive parameters
- Monitoring for double assignment of a drive parameter (e.g. when master communication and an analog input are to write to the same drive parameter)

Use of analog inputs

The analog inputs of the HydraulicDrive can be used in the following two ways:

1. **Use for pressure/force acquisition for the controller**

   In this case, the value from an analog output is output to the respective actual pressure or force value in a scaled form.

2. **Free configuration of analog inputs and assignment to drive parameters**

   In this case, the value from an analog output is output to any drive parameter in a scaled form (selection restricted to "P-0-0212, Analog input, list of assignable parameters").

Assignment of a read-in analog value to a drive parameter

Assigning an analog input works according to the following principle:

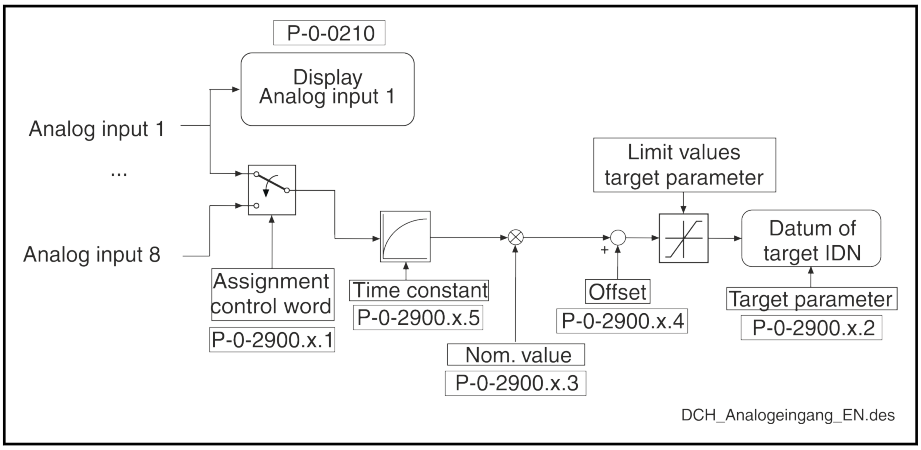


Fig. 8-3: Assignment of a read-in analog value to a drive parameter

Meaning of nominal value and offset in the assignment of the analog input

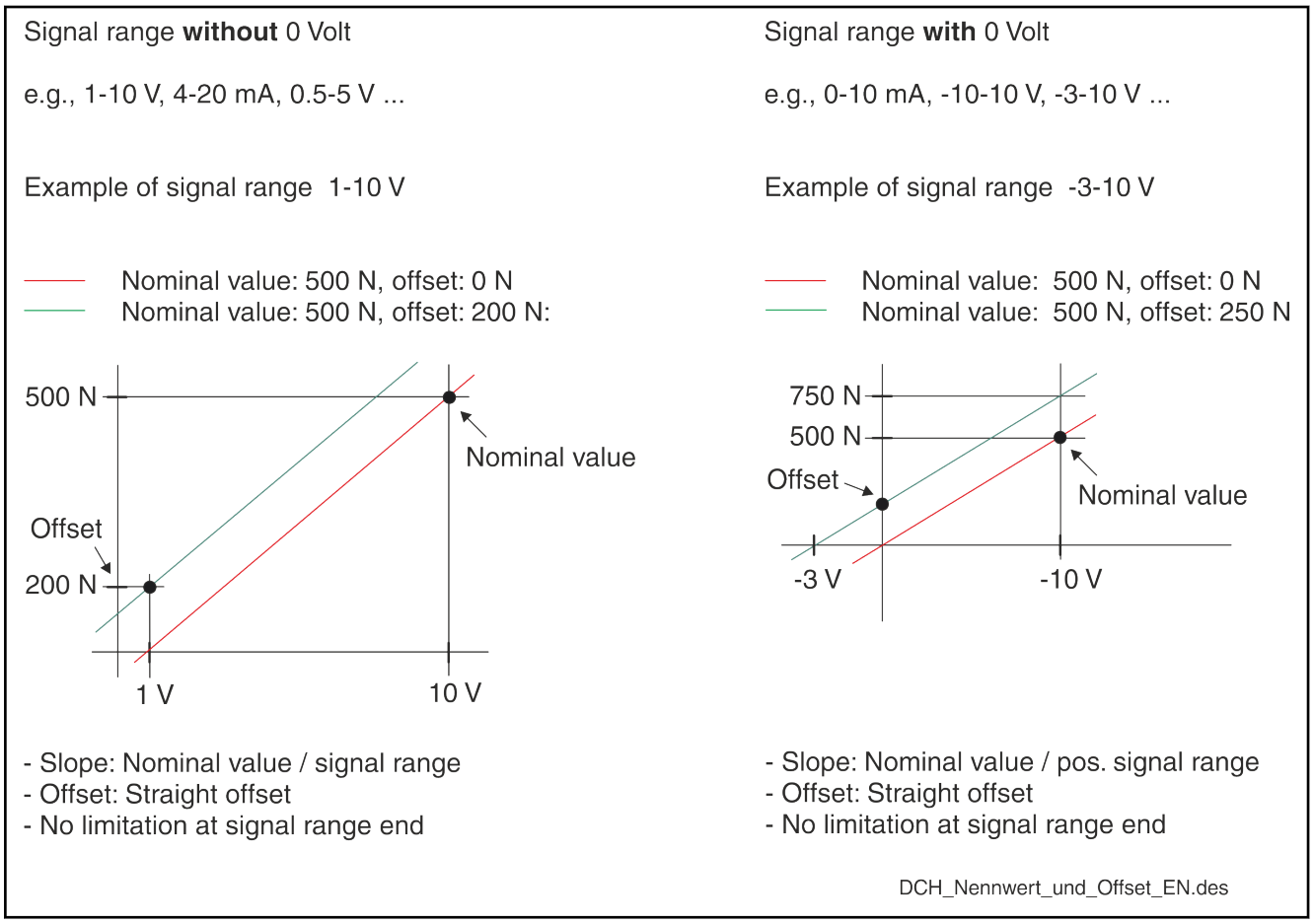


Fig. 8-4: Nominal value and offset in the assignment

Number of assignments to drive parameters

The number of assignments of analog inputs to drive parameters is limited. The same analog input may be assigned to several drive parameters, but for performance reasons, only a maximum of 5 assignments can be used per subdevice.

List of assignable drive parameters

An analog input is assigned to drive parameters on the basis of a predefined selection list that is contained in parameter "P-0-0212, Analog input, list of assignable parameters". This parameter contains the IDN list of status variables and signals of the axis that can be written via an analog input.

Assignment clock cycle

For the assignments you can define, in which clock cycle these are to be calculated. You can select the valve controller clock cycle, the velocity controller clock cycle and the position controller clock cycle.

Wire break monitoring

Wire break monitoring is available separately for each assignment, as soon as a signal range was selected, the lower limit of which is greater than 0. By means of "P-0-02900.x.7, Analog input, assignment, extended control word" you can configure whether a wire break message is to be output as warning, as error or not at all (no monitoring).

The status word "P-0-2900.x.6, Analog input, assignment, status word" displays the wire break error or warning.

To prevent false messages, the wire break has to be present for at least 5 ms.

Monitoring responds when the analog input is below half the value of the lower limit.

Example: Signal range 4...20 mA → wire break message in the case of signals of less than 2 mA.

Pertinent parameters and diagnostic messages

Parameters

- P-0-0208, Analog input 5
- P-0-0209, Analog input 6
- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0212, Analog input, list of assignable parameters
- P-0-0221, Analog input 7
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0256, Analog input 8
- P-0-2900.x.1, Analog input, assignment, control word
- P-0-2900.x.2, Analog input, assignment, target parameter
- P-0-2900.x.3, Analog input, assignment, nominal value
- P-0-2900.x.4, Analoger input, assignment, offset
- P-0-2900.x.5, Analog input, assignment, filter time
- P-0-2900.x.6, Analog input, assignment, status word
- P-0-2900.x.7, Analog input, assignment, extended control word
- P-0-2900.x.8, Analog input, assignment, signal range lower limit
- P-0-2900.x.9, Analog input, assignment, signal range upper limit

Diagnostic messages

- C0242, Multiple configuration of a parameter (->S-0-0423)
- E2270, Analog input, wire break
- F2270, Analog input, wire break

8.3.3 Assignment of analog outputs

Functional description

HydraulicDrives are provided with analog outputs. The number of analog outputs depends on the type of HydraulicDrive. The number of analog outputs that are available on the various types of the HydraulicDrive is explained in more detail in the chapter "Analog inputs/outputs".

General features of analog outputs

- Depending on the type of HydraulicDrive up to 4 analog outputs are available
- Updating of analog outputs in the position controller clock cycle
- The analog outputs can be written via master communication (cyclic and acyclic channel)
- The analog outputs can be written via IndraMotion MLD
- The analog outputs can be written via IndraWorks

- Provision of drive parameters to analog outputs
- Parameterizable output offset and scaling per V/mA for the output of drive parameters
- Monitoring for double provision to an analog output (e.g., cyclic writing via master communication and simultaneous output of a drive parameter)

Operating principle of output to analog outputs

The analog inputs of the HydraulicDrive can be used in the following two ways:

1. **Direct output of voltages and currents**

   In this case, the output parameter of analog outputs is written directly via master communication by accessing the parameters in IndraWorks or via IndraMotion MLD.

2. **Output of drive parameters**

   In this case, the value from an analog output is provided to the respective actual pressure or force value in a scaled form.

Direct output of voltage and current values

Voltage and current values are output directly by writing the corresponding output parameters of the analog outputs. The individual analog outputs are assigned the following output parameters, which serve to display the current output value:

- P-0-0139, Analog output 1
- P-0-0140, Analog output 2
- P-0-0414, Analog output 3
- P-0-0415, Analog output 4

By writing the output parameters listed above via master communication or IndraMotion MLD, it is possible to directly influence the analog value to be output.

Output of drive parameter values

The figure below illustrates, how the drive parameters are made available to analog outputs.

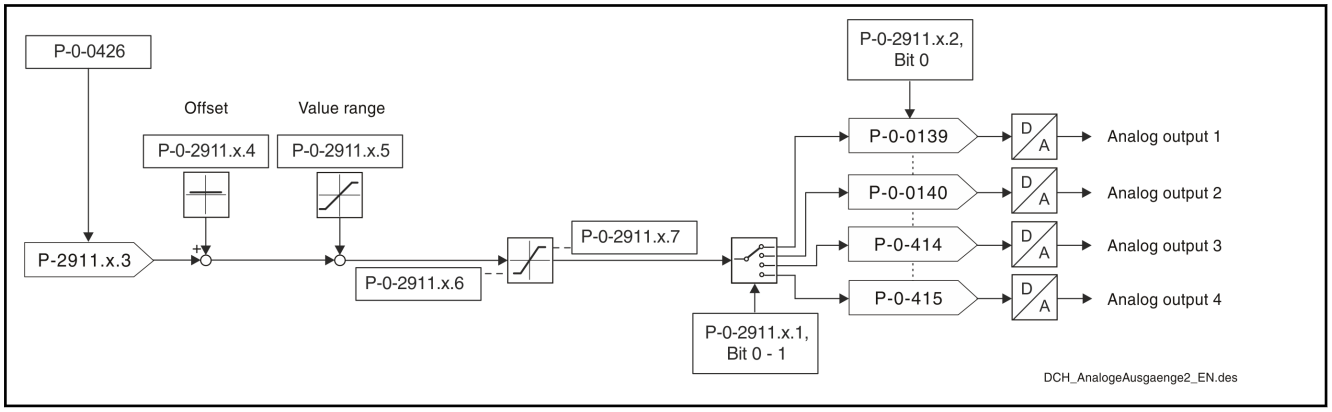


Fig. 8-5: Output of drive parameter values

Number of drive parameters that can be output

The number of drive parameters that can be output simultaneously to the analog outputs depends on the number of analog outputs available on the HydraulicDrive. If, for example, two analog outputs are available on the HydraulicDrive, up to two drive parameters can be assigned to these analog outputs.

Pertinent parameters in assignments of drive parameters

Assignment 1:

The following parameters have to be configured for the assignment of a drive parameter to an analog output:

- P-0-2911.x.1, Analog output, assignment, control word
- P-0-2911.x.2, Analog output, assignment, status word
- P-0-2911.x.3, Analog output, assignment, source parameter
- P-0-2911.x.4, Analog output, assignment, offset
- P-0-2911.x.5, Analog output, assignment, value range
- P-0-2911.x.6, Analog output, assignment, signal range, lower limit
- P-0-2911.x.7, Analog output, assignment, signal range, upper limit

The following assignment applies:

- Assignment 1: x = 0
- Assignment 2: x = 1
- Assignment 3: x = 2
- Assignment 4: x = 3



The parameters for parameterizing the individual assignments are available only, if the HydraulicDrive actually features the corresponding number of analog outputs. The parameters for the 2nd assignment can only be used, if at least 2 analog outputs are actually available.

List of parameters that can be assigned to the analog output

Values of drive parameters are output on the basis of a predefined selection list which is stored in parameter "P-0-0426, Analog output IDN list of assignable parameters". This parameter contains the IDN list of parameters of status variables and signals of the axis that can be made available via an analog output.

Assignment of a drive parameter

The assignment is made by entering the IDN of the drive parameter in parameter "P-0-2911.x.3, Analog output, assignment, source parameter" of the relevant assignment.

Definition of the analog output

To which analog output a drive parameter is to be output is determined via control parameter "P-0-2911.x.1, Analog output, assignment, control word" of the relevant assignment via bits 0 - 1. The following assignment applies:

Status bit 0-1	Analog output for output
00	Analog output 1
01	Analog output 2
10	Analog output 3
11	Analog output 4

Tab. 8-3: Definition of the analog output

Mapping of the signal range of a drive parameter to the value range of the analog output

By means of the two parameters "P-0-2911.x.6, Analog output, assignment, signal range, lower limit" and "P-0-2911.x.7, Analog output, assignment, signal range, upper limit" the value range of the analog output can be defined by entering the lower and upper limit.

The signal of the drive parameter is to be mapped in this value range. The provision of the signal to the analog output is limited by these two limit values, i.e., the smallest voltage or the smallest current that can be output is de-

termined by parameter P-0-2911.x.6. Parameter P-0-2911.x.7 determines the highest voltage or highest current that can be output.

By means of parameter "P-0-2911.x.4, Analog output, assignment, offset" the offset can be set, which is to be added to the current signal value of the drive parameter when it is output. Parameter "P-0-2911.x.5, Analog output, assignment, value range" is used for scaling the signal range of the drive parameter to the value range of the analog output. This parameter determines, which value range of the drive parameter is to be mapped to the analog output.

Example of drive parameter output

Parameter "S-0-0386, Active position feedback value" is to be provided at analog output 1 via assignment 1. Analog output 1 is set as current output (4 - 20 mA). The actual position value is to be mapped to the analog output within the range from -50 mm to 110. At the analog output, a value of 4 mA is to be provided, if the actual position value is -50 mm, and a value of 20 mA, if the actual position value is 100 mm. In this example, the parameters for assignment 1 have to be set as follows:

Parameter selection	P-0-2911.0.3	S-0-0386
Control parameters	P-0-2911.0.1, bit 0-1	00 (→ provision to analog output 1)
Range of values	P-0-2911.0.5	160 mm (-50 mm to 110 mm)
Offset	P-0-2911.0.4	90 mm
Lower limit	P-0-2911.0.6	4 mA
Upper limit	P-0-2911.0.7	20 mA

Tab. 8-4: Example of drive parameter output

"P-0-2911.0.4, Analog output, assignment, offset" results from the following formula:

$$P-0-2911.0.4 = \frac{\text{Range of values to be output } (P\text{–}0\text{–}2911.0.5)}{\text{Range of values of output } (P\text{–}0\text{–}2911.0.7 - P\text{–}0\text{–}2911.0.6)} * \text{Lower limit } (P\text{–}0\text{–}2911.0.6) - \text{signal value at lower limit}$$

Fig. 8-6: Example of drive parameter output

Example:

$$P-0-2911.0.4 = \frac{160\ mm}{16\ mA} * 4\ mA - (-50mm) = 90\ mm$$

Fig. 8-7: Example of drive parameter output

The figure below illustrates how the actual position value could be issued at the analog output as a function of time:

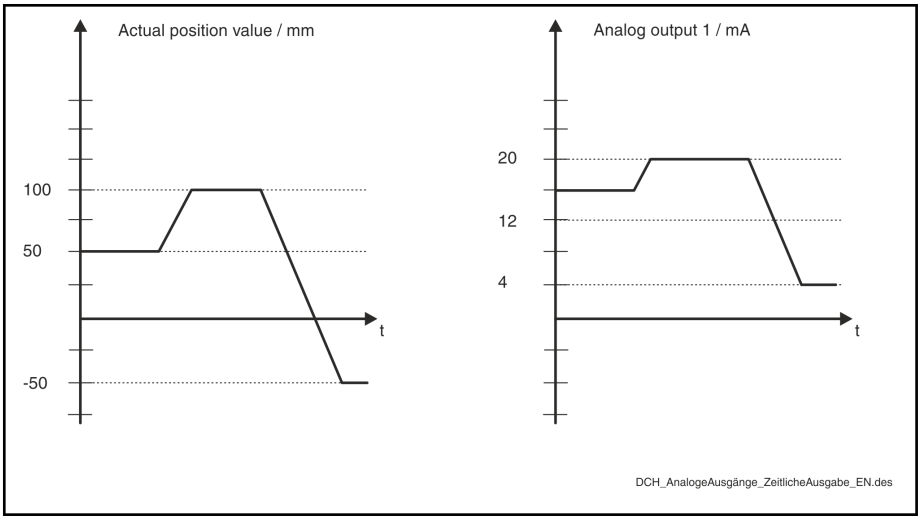


Fig. 8-8: Output of the actual position value as a function of time

Limitation

If the actual position value is greater or less than the mapping range determined in this example (-50 mm to 110 mm), the provision to analog output 1 is restricted to the lower limit ("P-0-2911.0.6, Analog output, assignment, signal range, lower limit") or to the upper limit ("P-0-2911.0.7, Analog output, assignment, signal range, upper limit"). The figure below shows this limitation.

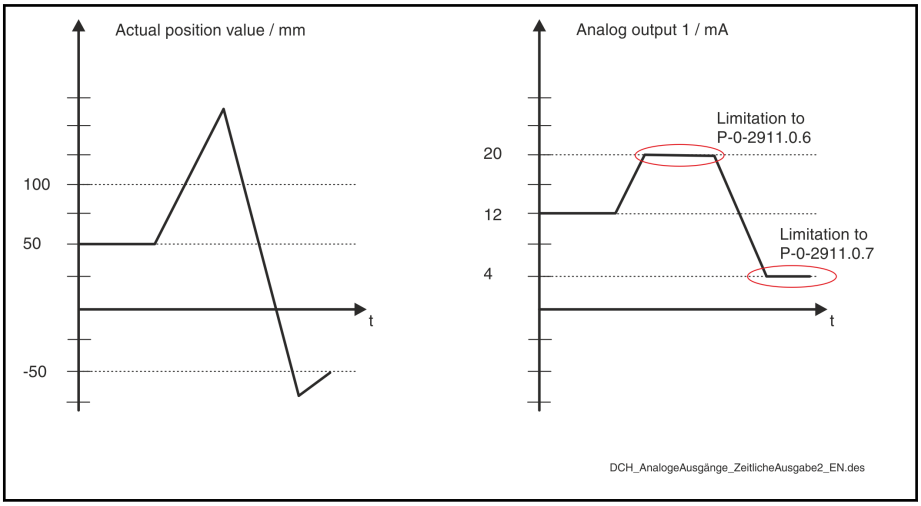


Fig. 8-9: Output of actual position value 2 as a function of time

Bit output of drive parameters

If a drive parameter is selected in parameter "P-0-2911.0.3, Analog output, assignment, source parameter" for output, the value of which is represented in binary format (bit string), the status is provided by a single bit of the parameter to the analog output. In this case, the number of the bit to be output has be set in control parameter "P-0-2911.0.1, Analog output, assignment, control word" in bits 4 - 8. The following assignment applies:

Status bit 4-8	Number of the drive parameter bit to be output
00000	Bit 0
00001	Bit 1
00010	Bit 2

Status bit 4-8	Number of the drive parameter bit to be output
...	....
11110	Bit 30
11111	Bit 31

Tab. 8-5: Bit output of drive parameters

If the status of the outputting bit is 0, the value that is contained in parameter "P-0-2911.0.6, Analog output, assignment, signal range, lower limit" is provided to the analog output. If the status of the bit is 0, the value that is contained in parameter "P-0-2911.0.7, Analog output, assignment, signal range, upper limit" is provided to the analog output.

Monitoring for double provision to an analog output

When changing from PM to OM, a check is run to see that there is no double provision set to an analog output (e.g., cyclic writing via master communication and simultaneous output of a drive parameter). In this case, diagnostic message "C0242, Multiple configuration of a parameter (->S-0-0423)" appears.

Deactivation of an assignment of an analog output

When the assignment of a drive parameter of an analog output is deactivated, the default value of 0 V in the case of a voltage output, and 0 mA in the case of a current output, is provided to the analog output (P-0-0139, P-0-0140, P-0-0414 and P-0-0415), to which the assignment was made.

Pertinent parameters and diagnostic messages

Parameters

- P-0-0426, Analog output IDN list of assignable parameters
- P-0-2911.0.1, Analog output, assignment, control word
- P-0-2911.0.2, Analog output, assignment, status word
- P-0-2911.0.3, Analog output, assignment, source parameter
- P-0-2911.0.4, Analog output, assignment, offset
- P-0-2911.0.5, Analog output, assignment, value range
- P-0-2911.0.6, Analog output, assignment, signal range, lower limit
- P-0-2911.0.7, Analog output, assignment, signal range, upper limit
- P-0-2911.1.1, Analog output, assignment, control word
- P-0-2911.1.2, Analog output, assignment, status word
- P-0-2911.1.3, Analog output, assignment, source parameter
- P-0-2911.1.4, Analog output, assignment, offset
- P-0-2911.1.5, Analog output, assignment, value range
- P-0-2911.1.6, Analog output, assignment, signal range, lower limit
- P-0-2911.1.7, Analog output, assignment, signal range, upper limit
- P-0-2911.2.1, Analog output, assignment, control word
- P-0-2911.2.2, Analog output, assignment, status word
- P-0-2911.2.3, Analog output, assignment, source parameter
- P-0-2911.2.4, Analog output, assignment, offset
- P-0-2911.2.5, Analog output, assignment, value range
- P-0-2911.2.6, Analog output, assignment, signal range, lower limit
- P-0-2911.2.7, Analog output, assignment, signal range, upper limit
- P-0-2911.3.1, Analog output, assignment, control word

- P-0-2911.3.2, Analog output, assignment, status word
- P-0-2911.3.3, Analog output, assignment, source parameter
- P-0-2911.3.4, Analog output, assignment, offset
- P-0-2911.3.5, Analog output, assignment, value range
- P-0-2911.3.6, Analog output, assignment, signal range, lower limit
- P-0-2911.3.7, Analog output, assignment, signal range, upper limit

Diagnostic messages

- C0242, Multiple configuration of a parameter (->S-0-0423)

8.4 Drive Halt

8.4.1 Functional description

The function "Drive Halt" is used for deceleration of an axis by a higher-level control unit. The drive no longer follows the command values of the active operation mode, but decelerates on its own. The procedure depends on the activated functional package.

Activating the function "Drive Halt"

Drive Halt is triggered by:

- Withdrawing the Drive Halt bit in the control word of master communication (e.g.: master control word, S-0-0134, bit 13).
- Interrupting a drive control command (e.g., drive-controlled homing procedure)

Return to the operation mode active before

The operation mode active before and still selected is reactivated, when the Drive Halt bit is set again in the control word of master communication.

With "Drive Halt", the kind of deceleration depends on the operation mode active before.

8.4.2 Drive Halt with functional package OL, IFB, or p/Q

Decelerating is accomplished by setting "P-0-2914 Effective valve command value" to "0" via the ramp function set in the operation mode “direct valve control”.

For acknowledgement of "Drive Halt", see "Drive Halt with functional package CL". The actual velocity is calculated from the valve command value with the help of valve standard velocity.

8.4.3 Drive Halt with functional package DFE

In the case of pump control, the drive is not stopped, but special command values for swivel angle and pressure become effective:

- Swivel angle "P-0-2976 Swivel angle command value (without controller enable)"
- Pressure: "P-0-2975 Pressure command value (without controller enable)"

Drive Halt is acknowledged immediately.

8.4.4 Drive Halt with functional package CL

Stopping takes place with defined acceleration and defined jerk.

Drive Halt is carried out as quick stop in closed-loop position control without velocity controller. Position control is activated, if one of the operation modes with position control (S-0-0032...) has been defined (incl. internal PLC operation modes). Otherwise, the “velocity” control mode is active.

Quick stop in position control

In closed-loop position control stopping takes place applying the deceleration in "S-0-0372, Drive Halt acceleration bipolar" and jerk in "S-0-0349, Bipolar jerk limit".

☞ If the content of "S-0-0372, Drive Halt acceleration bipolar" is equal to "0", decelerating is based on the value in "S-0-0138, Bipolar acceleration limit value".

☞ If alternating control (see "Alternating control") is active, torque/force is limited on the basis of S-0-0092.

If Drive Halt is started from an operation mode with position command value delay, then the delay is also activated for Drive Halt. Downstream of the fine interpolator, the position command value can be delayed by a maximum of 32 position cycles, before it is fed to the position controller. This allows a master axis to be controlled synchronously with the activated slave axis. The number of position cycles is set in the position command value delay (P-0-0456). The undelayed position command value generator (P-0-0457) is entered in a ring buffer, the delayed position command value is then taken over to the position command value controller (P-0-0434).

Position-controlled stopping is carried out in position control with following distance, if an operation mode that also contained position control with following distance was active before. Otherwise, the function is executed with lagless position control.

Model monitoring is active, ssee "closed-loop position control".

Quick stop in velocity control

If the “velocity” control type is selected, stopping takes place in closed-loop velocity control using the value in parameter "S-0-0372, Drive Halt acceleration bipolar" and jerk in "S-0-0349, Bipolar jerk limit".

☞ If the content of "S-0-0372, Drive Halt acceleration bipolar" is equal to "0", decelerating is based on the value in "S-0-0138, Bipolar acceleration limit value".

☞ If alternating control (see Alternating control) is active, torque/force is limited on the basis of S-0-0092.

Acknowledging Drive Halt

At standstill, i.e. the actual velocity is within the standstill window (S-0-0124), Drive Halt is acknowledged.

- Bit 4 (Drive Halt acknowledgement) in parameter "P-0-0115, Device control: Status word" is set.
- "A0010 Drive Halt" is output in diagnostics (S-0-0095).
- In the diagnostic message number (S-0-0390), "0x000A0010" is output.

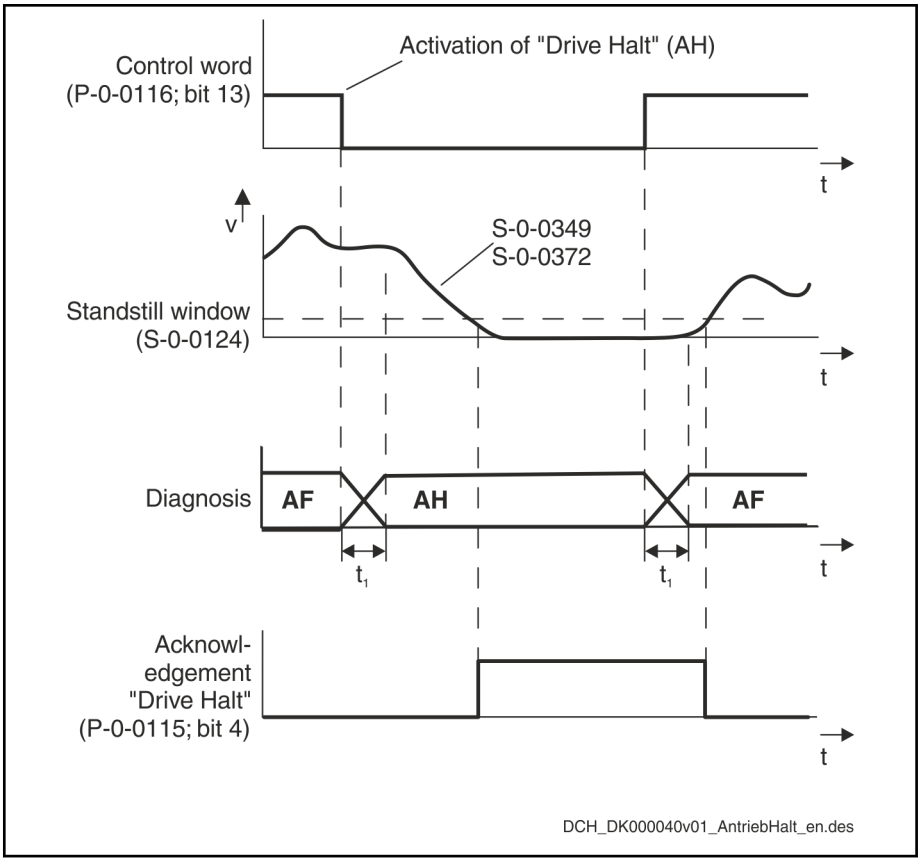


Fig. 8-10: Principle of “Drive Halt” with quick stop in CL

8.4.5 Pertinent parameters and diagnostic messages

Parameters

- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- S-0-0095, Diagnostic message
- S-0-0390, Diagnostic message number
- S-0-0124, Standstill window
- P-0-0115, Device control: Status word
- P-0-0116, Device control: Control word

Diagnostic messages

- A0010, Drive halt active

8.5 Error reactions

8.5.1 Overview of warning and error classes and reactions

Functional description

Depending on the operation mode used and certain parameter settings, the drive controller carries out monitoring functions. An error or warning message is generated by the drive controller, if a state is detected that no longer allows

correct operation. These messages are subdivided into classes, which are defined by the first two digits of the diagnostic message number.

Warning classes and warning reactions

Warnings are classified in different warning classes which determine whether or not the drive carries out an automatic reaction when the warning is generated.

Diagnostic message number	Warning class	Warning reaction
E2xxx	Non-fatal warning	Prewarning only, no reaction, operation possible without any restrictions
E4xxx	Warning of master communication	Master communication disturbed in part or in whole; operation possible to a restricted extent only
E8xxx	Fatal warning	The drive is decelerated via the reaction "emergency halt" Exception of functional package DFE: The reaction is: "Changeover to internal command values"

Tab. 8-6: Warning classes and warning reactions

Error classes and error reactions

Errors are categorized into different error classes depending on their criticality.

When this axis is in closed-loop control (the controller enable is set) and an error occurs, a drive error reaction is started automatically. This drive error reaction depends on:

- the error class of the error occurred and
- the setting of the following parameters:
  - P-0-0117, Activation of control unit reaction on error
  - P-0-0119, Best possible deceleration

Diagnostic message number	Error class	Error reaction
F2xxx	Non-fatal error	• Control reaction according to "P-0-0117, Activation of control unit reaction on error" • Drive-side error reaction according to "P-0-0119, Best possible deceleration, bits 0...3"
F4xxx	Error of master communication	• Drive-side error reaction according to "P-0-0119, Best possible deceleration, bits 0...3"

Diagnostic message number	Error class	Error reaction
F6xxx	Travel range error	• Drive-side error reaction according to "P-0-0119, Best possible deceleration, bits 4...7"
F8xxx	Fatal error	• Drive-side error reaction: Immediate shutdown and switching off of the output stage (if possible)

Tab. 8-7: Error classes and error reactions

Fatal system errors

Apart from the above error classes that result from drive-side monitors of the control, communication, peripherals, etc., there is also a class of fatal system errors. These are based on errors in drive-internal signal processing with the result that a manageable reaction is hardly possible.

Diagnostics and reaction are shown in the following:

Diagnostic message number	Error class	Error reaction
F9xxx	Fatal system error or "processor exception"	• Immediate shutdown and switching off of the output stage (if possible) • Deactivation of all local digital outputs • Deactivation of all analog outputs

Tab. 8-8: Fatal system errors

☞ A fatal system error can at present only be signaled by red permanent lighting of the module status LED.

See Diagnostic LED.

Best possible deceleration

The reaction "best possible deceleration" is carried out automatically in the case of the following states:

- Deactivating the drive enable by resetting of "Drive ON": "P-0-0116, Device control: Control word", bit 15,14: 11 → 01
- Non-fatal errors (F2xxx)
- Interface errors (F4xxx)
- Travel range errors (F6xxx)

The reaction can be set in "P-0-0119, Best possible deceleration":

Reaction	Intended use	Parameterizable deceleration as a reaction to		
		- Deactivating the drive enable - Non-fatal errors (F2xxx) - Interface errors (F4xxx) - Fatal warnings (E8xxx)	Travel range errors (F6xxx)	Fatal errors (F8xxx)
Immediate shutdown	Best possible deceleration	1_{hex}	1_{hex}	Immediate shutdown independently of the setting in P-0-0119
Emergency stop	Deceleration that spares the mechanical system through controlled closing of the proportional/high-response valve	0_{hex}	0_{hex}	Not possible
Quick stop	Deceleration that spares the mechanical system through open- or closed-loop controlled stopping	2_{hex}	2_{hex}	Not possible
Return motion	For deliberate return movement in the event of an error	3_{hex}	3_{hex}	Not possible
Changeover to internal command values	For pump controls	5_{hex}	5_{hex}	Not possible

Tab. 8-9: Best possible deceleration

Possible reactions for "best possible deceleration"

Immediate shutdown

Is used, if best possible deceleration is to be carried out in the event of an error. "P-0-2914, Effective valve command value" = 0 is set; in the case of drive controllers with integrated valve output stage, the latter is additionally switched off. This ensures the high-response or proportional valve’s moving to the failsafe position.

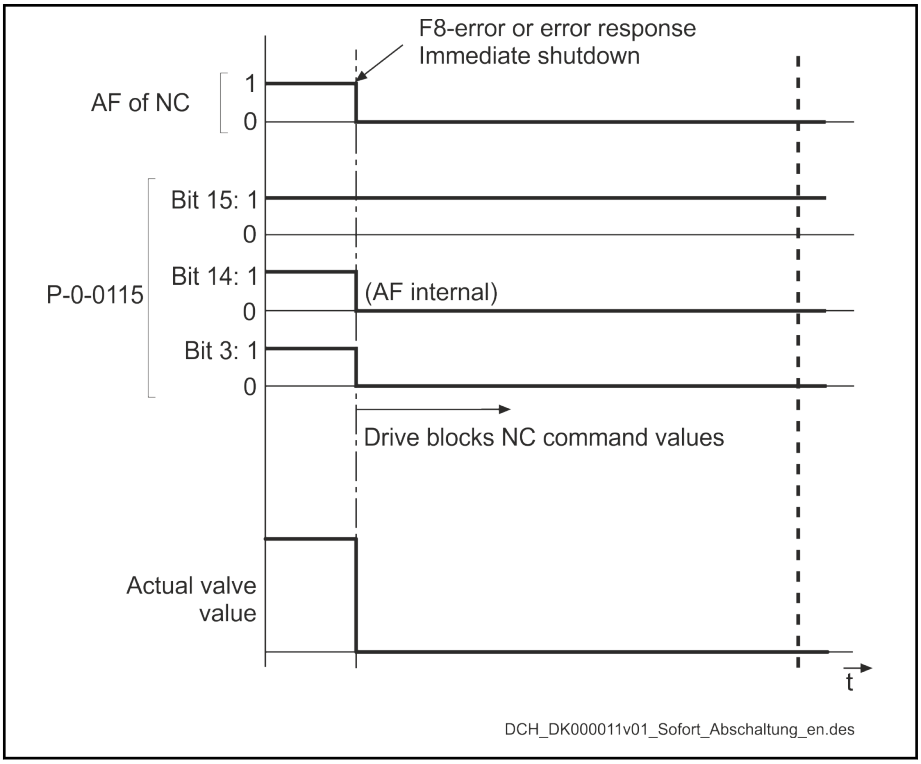


Fig. 8-11: Immediate shutdown

☞ The deceleration reaction can result in additional loads to the mechanical drive system and should be used in exceptional cases only.

Emergency stop

Irrespective of the active operation mode, "P-0-2914, Effective valve command value" is ramped to "P-0-2873.0.14, Control disabled offset" by means of "P-0-2928.0.8, Valve command value emergency ramp".

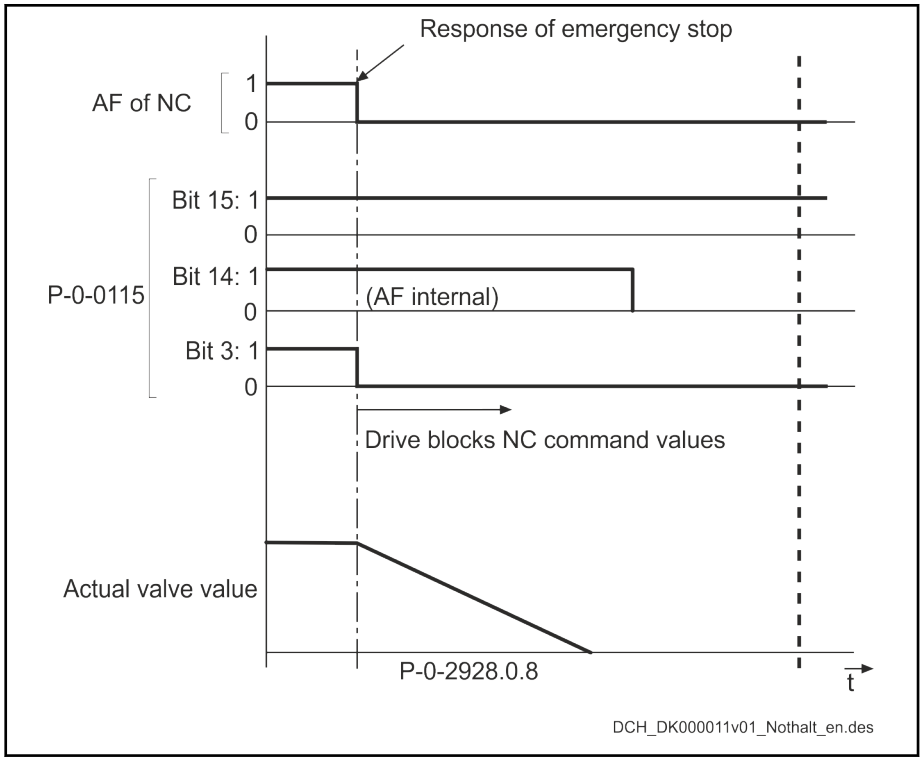


Fig. 8-12: Emergency stop

Quick stop

Deceleration via "S-0-0372, Drive Halt acceleration bipolar" that spares the mechanical system of the drive. In the event of an error, the drive is decelerated applying a command value ramp, which is determined by "S-0-0372, Drive Halt acceleration bipolar" and the jerk limit value "S-0-0349, Bipolar jerk limit". If the value of S-0-0372 = "0", the value in "S-0-0138, Bipolar acceleration limit value" is effective.

Torque/force limitation is possible by means of alternating control.

The drive is decelerated in closed-loop velocity control. After having performed a quick stop, "P-0-2914, Effective valve command value" is set to "P-0-2873.0.14, Control disabled offset".

☞ The quick stop is available only with functional package Axis Controller CL.

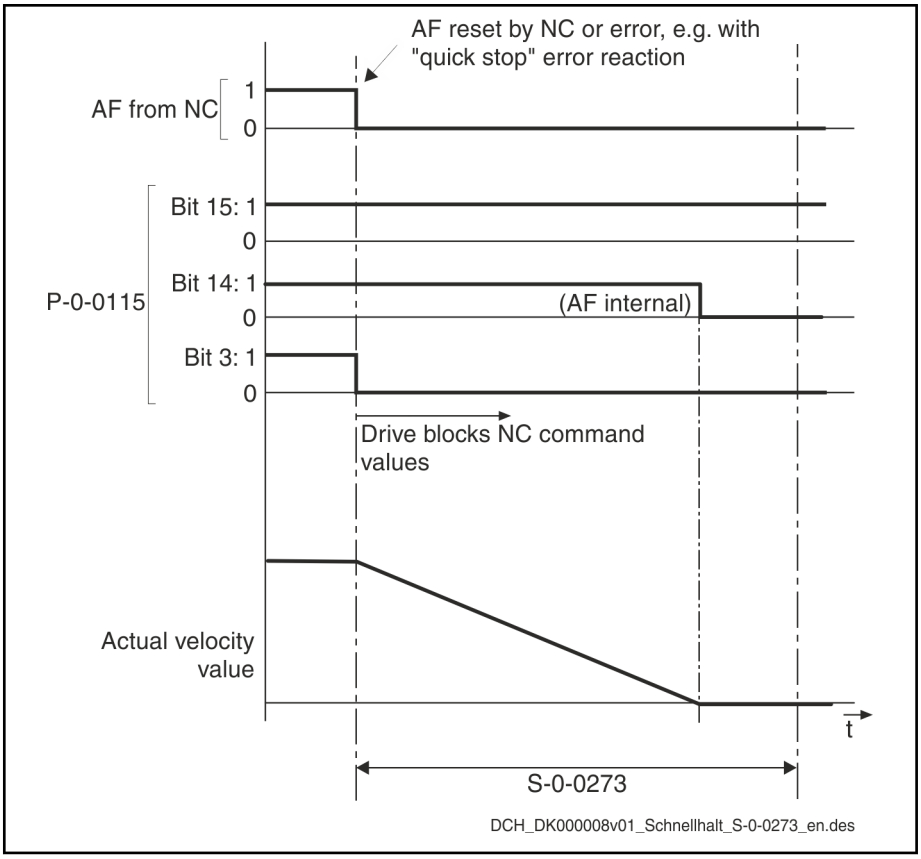


Fig. 8-13: Quick stop with deceleration time < S-0-0273

If "S-0-0273, Maximum drive off delay time" has elapsed, before the quick stop deceleration has resulted in a standstill of the drive, "P-0-2914, Effective valve command value" is set immediately to "P-0-2873.0.14, Control disabled offset".

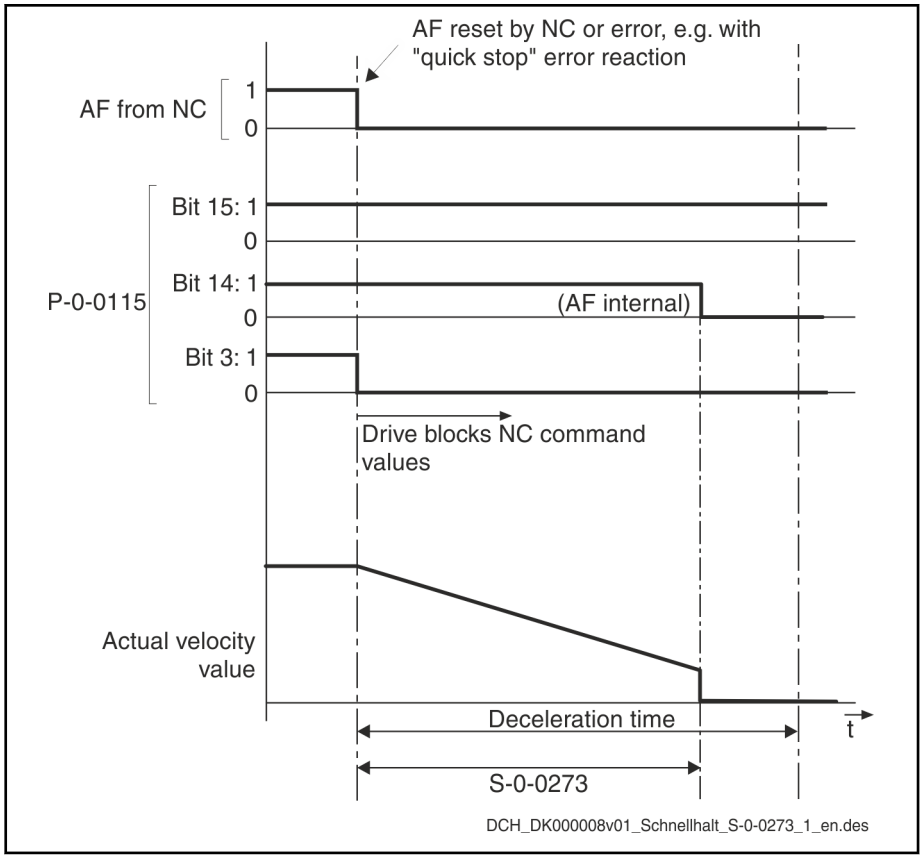


Fig. 8-14: Quick stop with deceleration time > S-0-0273

Return motion

Return motion is used, if, in the event of an error, the axis needs deliberately to be returned from the machining zone.



When the enable is removed no return movement is performed.

With alternating control, force limitation is impossible.

The return motion starts at the setpoint position last valid. The position command value profile is generated internally by means of predefined travel block data (velocity, acceleration, jerk). The value of parameter "P-0-0055, Return distance" depends on the sign, i.e. a positive return value causes a positive motion with reference to the coordinate system selected. The value of "P-0-0055, Return distance" can also be configured and transmitted in the cyclic telegram (MDT). The velocity profile is generated using the parameters "P-0-0056, Return velocity", "P-0-0057, Return acceleration", and "P-0-0058, Return jerk". After having completed the return movement, "P-0-2914, Effective valve command value" is set to "P-0-2873.0.14, Control disabled offset". If "S-0-0273, Maximum drive off delay time" has elapsed before the return motion has been completed, "P-0-2914, Effective valve command value" is set immediately to "P-0-2873.0.14, Control disabled offset".

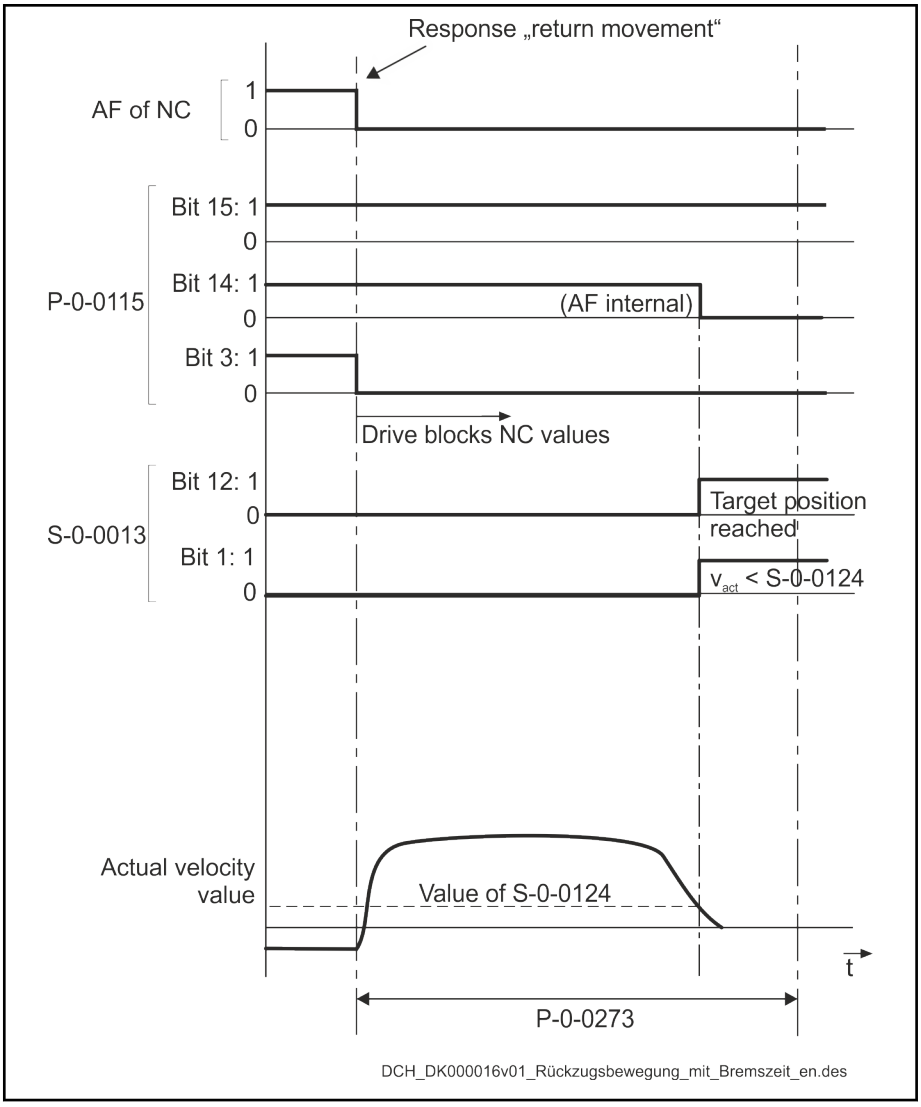


Fig. 8-15: Return motion with deceleration time < S-0-0273

If "S-0-0273, Maximum drive off delay time" has elapsed before the return motion has been completed, "P-0-2914, Effective valve command value" is set immediately to "P-0-2873.0.14, Control disabled offset".

Changeover to internal command values

Internal command values are used in order to switch to defined command values required for pump controls (functional package DFE) in the operation modes "pressure/swivel angle control" or "closed-loop pressure control/ (open/closed-loop) flow control". Instead of the command values from the generators, the internal command values "P-0-2975, Pressure command value (without controller enable)" and "P-0-2976, Swivel angle command value (without controller enable)" are used. The transition takes place without a ramp.

Availability of the reaction for best possible deceleration

The availability of the individual reactions for best possible deceleration depends on the activated function package.

	IFB	p/Q	DFE	Axis controller OL	Axis controller CL	Axis controller CL + SRV
Immediate shutdown	■	■	■	■	■	■
Emergency stop	■	■	-	■	■	■

Quick stop	-	-	-	-	■	■
Return motion	-	-	-	-	-	■
Changeover to internal command values	-	-	■	-	-	-

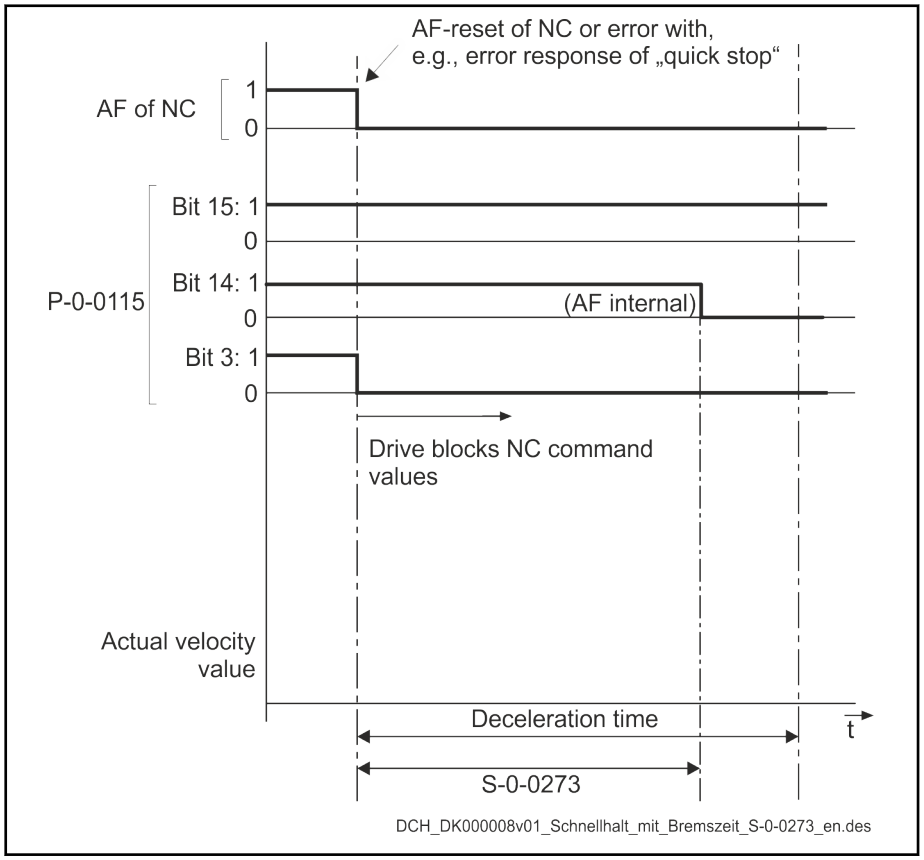


Fig. 8-16: Quick stop with deceleration time > S-0-0273

Pertinent parameters

- S-0-0138, Bipolar acceleration limit value
- S-0-0273, Maximum drive off delay time
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- P-0-0055, Return distance
- P-0-0056, Return velocity
- P-0-0057, Return acceleration
- P-0-0058, Return jerk
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration
- P-0-02928.0.8, Valve command value emergency ramp
- P-0-2975, Pressure command value (without controller enable)
- P-0-2976, Swivel angle command value (without controller enable)

Pertinent diagnostic messages

- F6024, Maximum braking time exceeded

8.5.2 Best possible deceleration

Functional description

Setting of drive-side reaction

The sequence of the drive-side error reaction, this is, the way of command value generation and operation mode, is set in "P-0-0119, Best possible deceleration".

The reaction to F2...F4 errors is set in bits 0...3:

- "0" - valve ramp
- "1" - output stage shutdown
- "2" - velocity command value reset with ramp and filter (quick stop)
- "3" - return motion
- "4" - valve ramp
- "5" - internal command values

The reaction to F6 errors is set in bits 4...7:

- "0" - valve ramp
- "1"- output stage switch-off
- "4" - valve ramp
- "5" - internal command values

Limit value parameters during drive-side error reaction

Type of deceleration	Acceleration limit values			Jerk limit value	Calculation from filter constant from
	S-0-0138	S-0-0429	S-0-0372	S-0-0349	
Emergency stop Velocity command value reset	X				No filter active
Emergency stop Velocity command value reset with ramp and filter	X	X		X	S-0-0349 & S-0-0372
Quick stop Velocity command value reset with ramp and filter	X		X	X	S-0-0349 & S-0-0372

Tab. 8-10: Limit value parameters during drive-side error reaction

Fatal system errors

Apart from the above error classes that result from drive-side monitors of the control, communication, peripherals, etc., there is also a class of fatal system errors. These are based on errors in drive-internal signal processing with the result that a manageable reaction is hardly possible. Diagnostics and reaction are shown in the following:

Diagnostic message number	Error class	Error reaction
F9xxx / E-xxxx	Fatal system error or "processor exception"	• Immediate switch-off of the output stage • Deactivation of all local digital outputs • Deactivation of all analog outputs

Tab. 8-11: Fatal system error

Time sequence when switching off the drive enable

After withdrawing the controller enable, the following actions can or have to be carried out:

- Activating the non-return valve with "S-0-0207, Drive off delay time". During this time the axis is protected against drifting away by a velocity command value reset.

In parameter "S-0-0207, Drive off delay time" you have to enter the time that the non-return valve takes for closing, i.e. the time between the activation of the valve and its actual being closed. During this time, the drive prevents the axis from drifting away by resetting the velocity command value.

When the controller enable is switched off, bit 3 of the drive status changes to 0 ("drive ignores command value input"), and at the end of the delay time S-0-0207, bit 14 and 15 of the drive status (P-0-0115) change to "Ab" = 10b.

A typical switch-off sequence of the drive is shown in the following graphic:

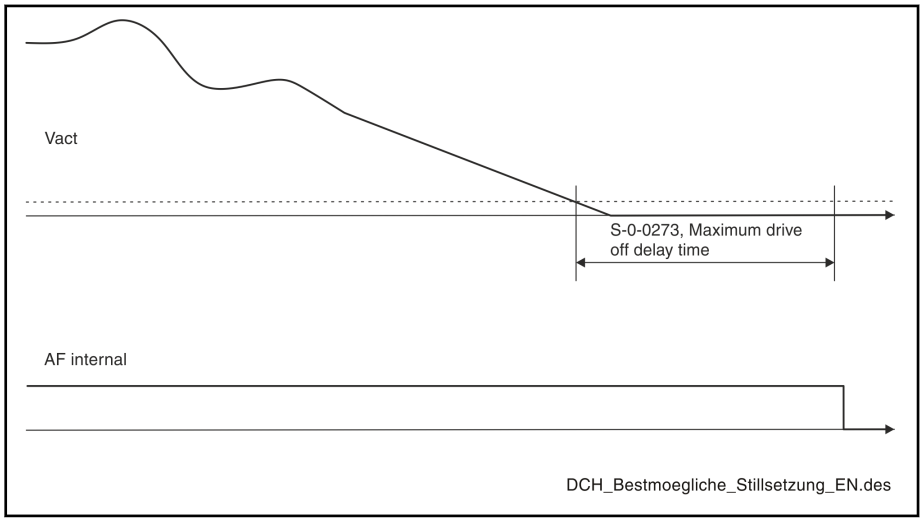


Fig. 8-17: Operating principle of S-0-0207, Drive off delay time.

Deceleration time < S-0-0273

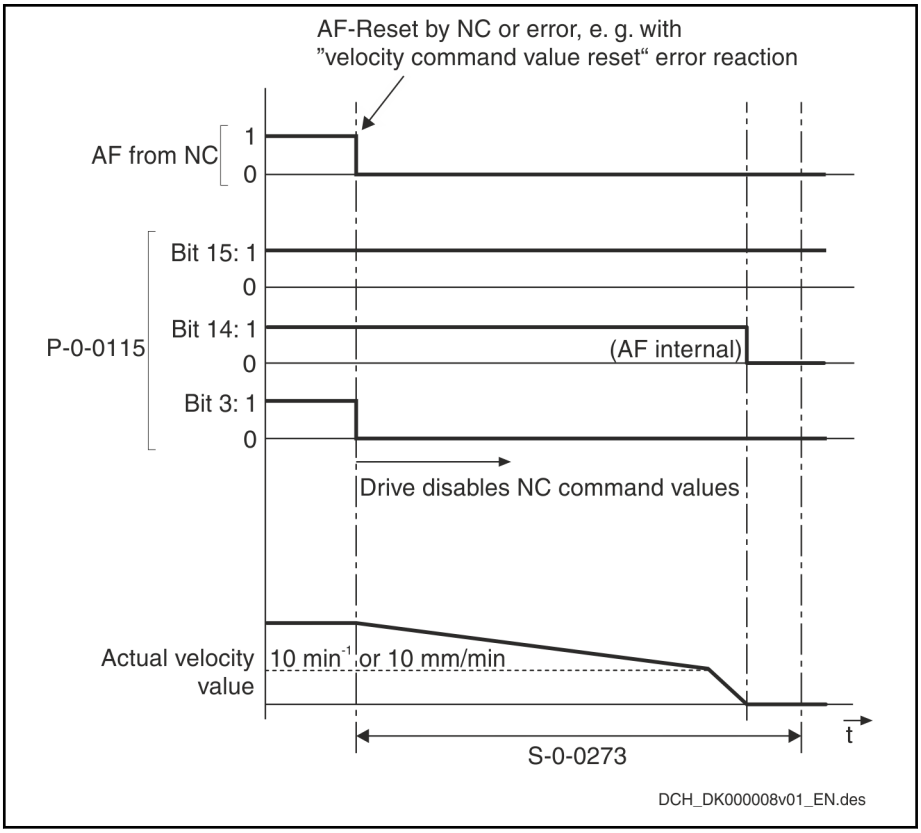


Fig. 8-18: Deceleration time < S-0-0273

Deceleration time > S-0-0273

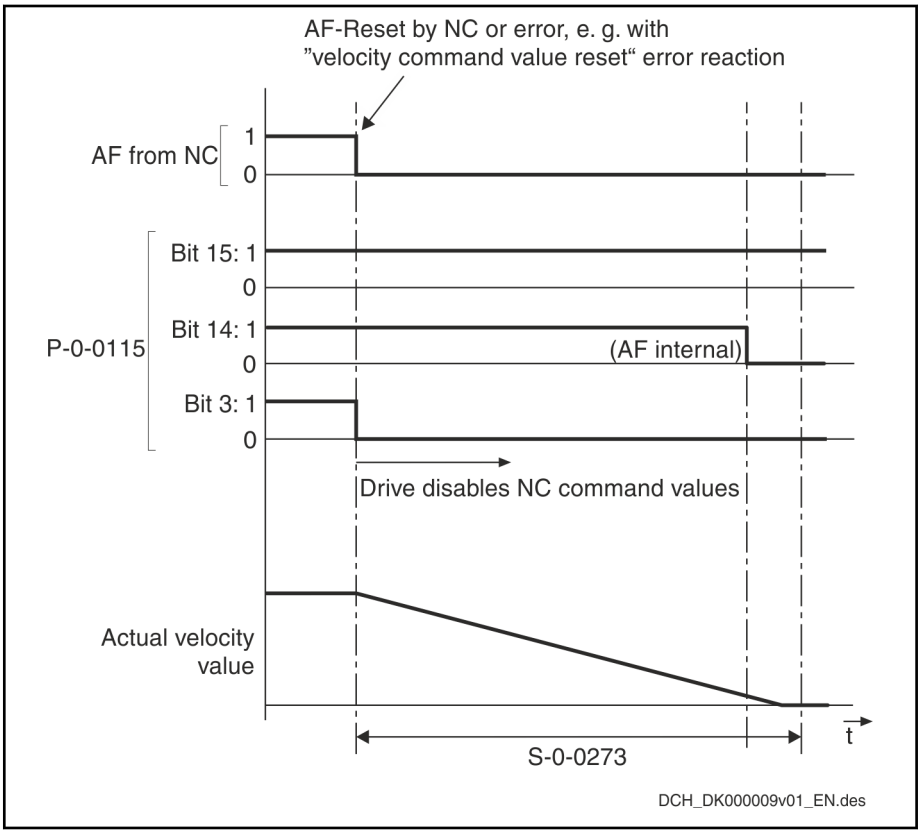


Fig. 8-19: Deceleration time > S-0-0273

Velocity command value reset ("Emergency Stop")

Velocity command value reset ("Emergency Stop") is used, if best possible deceleration is to be carried out in the event of an error in the closed-loop control mode.

P-0-0119, bit 0...3 = 0; P-0-0119, bit 4...7 = 0

In the event of an error, the controlled drive in closed-loop velocity control is stopped with command value = "0". Parameter "S-0-0138, Bipolar acceleration limit value" is used as acceleration limit value.

Velocity command value reset with ramp and filter ("Emergency Stop")

Velocity command value reset with ramp and filter (Emergency Stop) is used, if the stopping process is to spare the mechanical system and the quick stop characteristics are to be adhered to.

P-0-0119, bit 0...3 = 4; P-0-0119, bit 4...7 = 4

In the event of an error, the servo-drive in closed-loop velocity control is stopped using a command value ramp, which is determined by "S-0-0429, Emergency halt deceleration" and the jerk limit value "S-0-0349, Bipolar jerk limit". If the value of S-0-0429 = "0", the value in "S-0-0138, Bipolar acceleration limit value" is effective.

Velocity command value reset with filter and ramp ("Quick Stop")

Velocity command value reset with filter and ramp ("Quick Stop") is used, if the stopping process is to spare the mechanical system and the quick stop characteristics are to be adhered to.

P-0-0119, bit 0...3 = 2

In the case of an error, the closed-loop-controlled servo drive in velocity control, or the open-loop-controlled drive in V/Hz (U/f) operation is decelerated with a command value ramp, determined by "S-0-0372 Drive Halt acceleration bipolar" and the jerk limit value "S-0-0349 Bipolar jerk limit". If the value of S-0-0327 = "0", the value in "S-0-0138, Bipolar acceleration limit value" is effective. A torque/force limitation is derived from parameter P-0-0109.

In open-loop-controlled U/f operation, stopping is carried out taking account of "P-0-0569, Maximum stator frequency slope".

After "S-0-0273, Maximum drive off delay time" has elapsed, the servo-brake is applied; after the drive off delay time from S-0-0207 has elapsed, the drive enable is switched off internally. In the case of a main spindle brake, the brake is applied at a velocity of less than 10 rev/min.

Output stage shutdown

Output stage shutdown is used, if an axis is to move to the failsafe position of the valve.

P-0-0119, bit 0...3 = 1; P-0-0119, bit 4...7 = 1 or Fatal Errors

In the event of an error, the valve is brought to the failsafe position as quickly as possible. In this process, the drive may be exposed to some mechanical stress.

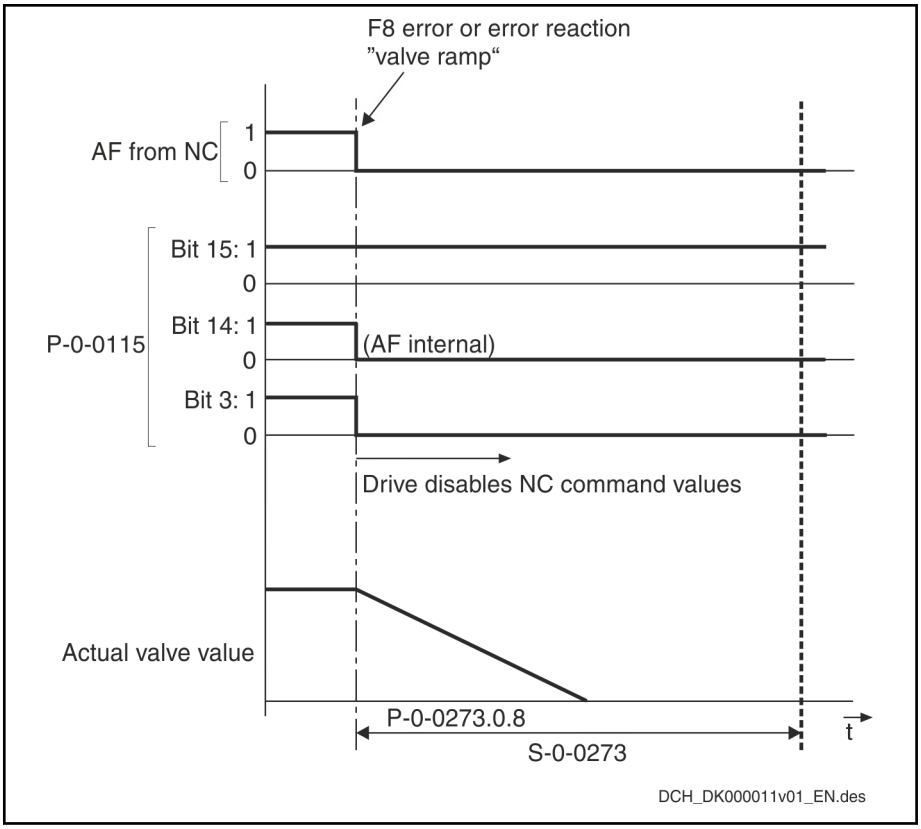


Fig. 8-20: Output stage shutdown

Return motion

Return motion is used, if, in the event of an error, the axis needs deliberately to be returned from the machining zone. The return motion starts at the set-point position last valid.

P-0-0119, bit 0...3 = 3

If "return motion" is set for best possible deceleration, the drive generates a position command value profile to run the desired travel distance in the event of an error. In the case of error, a relative travel distance is therefore activated.

Generating the position command value profile

With the "drive-internal interpolation" mode the position command value profile is generated internally by means of predefined travel block data (velocity, acceleration, jerk), see Drive-internal interpolation. See Drive-internal interpolation

The value of parameter "P-0-0055, Return distance" is sign-related, i.e. a positive return value causes a positive motion with reference to the coordinate system selected.

The value of "P-0-0055, Return distance" can be configured and transmitted in the cyclic telegram (MDT).

The velocity profile is generated using the parameters:

- "P-0-0056, Return velocity" and
- "P-0-0057, Return acceleration".

In addition, the position command values can be smoothed by the position command value average value filter, with the order of the average value filter ("P-0-0042, Current position command average value filter order") being calculated from "P-0-0057, Return acceleration" and "P-0-0058, Return jerk".

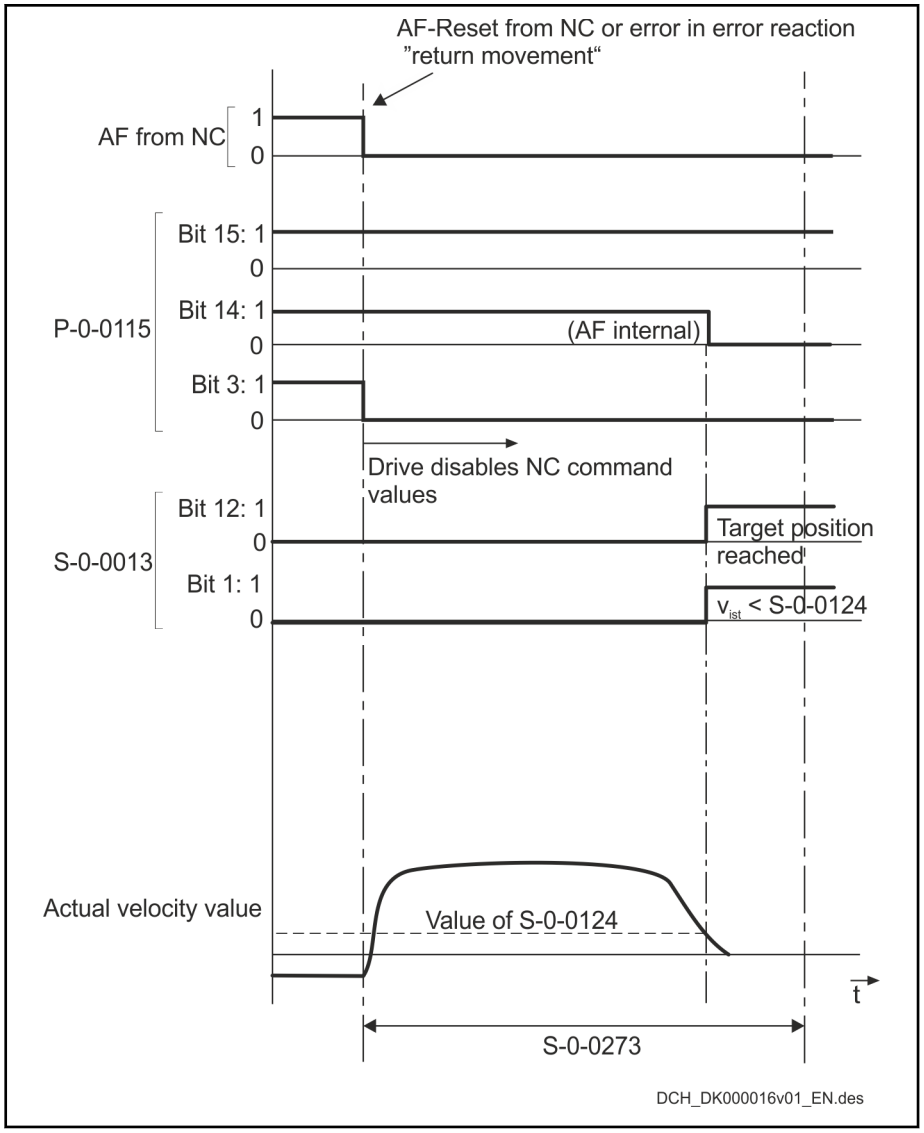


Fig. 8-21: Return motion

Internal command values

Internal command values are used for a pump to switch over to defined command values in the operation mode "closed-loop pressure/swivel angle control" or "closed-loop pressure control / (open-loop/closed-loop) flow control". In the event of a fault, the drive enable is withdrawn and the command value generators are switched off. Instead of the command values from the generators, internal command values are used.

Internal command values:

- P-0-2975, Pressure command value (without controller enable)
- P-0-2976, Swivel angle command value (without controller enable)

Pertinent parameters and diagnostic messages

Parameters

- P-0-0055, Return distance
- P-0-0056, Return velocity
- P-0-0057, Return acceleration
- P-0-0058, Return jerk
- P-0-0109, Torque/force peak limit

- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration
- P-0-0569, Maximum stator frequency slope
- P-0-2975, Pressure command value (without controller enable)
- P-0-2976, Swivel angle command value (without controller enable)
- S-0-0138, Bipolar acceleration limit value
- S-0-0273, Maximum drive off delay time
- S-0-0429, Emergency halt deceleration
- P-0-0372, Drive Halt acceleration bipolar
- P-0-0193, Positioning jerk

Diagnostic messages

- F6024, Maximum braking time exceeded

8.5.3 Control reaction on error

NC reaction on error

Brief description

To avoid damage to the machine, some applications require that the master (e.g. NC) also retains control over the travel profile of the axes in the case of error and shuts down the machine axes in a coordinated way. For this case, the "NC reaction on error" option was implemented; it can be activated via parameter P-0-0117.

An error in the drive controller is signaled to the master via the drive status word (see S-0-0135) so that the master can shut down the machine axes in a coordinated way and therefore avoid possible damage.

☞ An NC reaction on error is only possible with non-fatal errors (diagnostic message F2xxx), otherwise the drive always reacts with an immediate error reaction on the drive side.

Pertinent parameters

- S-0-0135, Drive status word
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration

Functional description

In the case of NC reaction on error, the axis reporting the error still is provided with the command values preset by the master and follows them, even in the case of error, for another 30 s. To achieve this, the function has to be activated so that the defined time delay of 30 s becomes effective between the detection of the error and the drive-side reaction.

Activating the NC reaction

The NC reaction in the event of an error is set in "P-0-0117, Activation of control unit reaction on error".

P-0-0117, bit 0:

- Bit 0 = "0" → The drive carries out its error reaction **without delay** according to the setting in "P-0-0119, Best possible deceleration" after recognizing the error.
- Bit 0 = "1" → The drive carries out its error reaction according to the setting in parameter P-0-0119 **only 30 s after recognizing the error**. The drive continues following the command values of the master for the du-

ration of 30 s after detection of the error, thus allowing an **NC error reaction**.

Note: In case that after the recognition of the error the error message is deleted within this wait time, **no** drive reaction as set in parameter P-0-0119 will be executed.

☞ The activation of "NC reaction on error" (P-0-0117, bit 0 = "1") only makes sense for masters that have the respective procedure for the case of error.

8.5.4 Error suppression

Selected axis errors can be converted into a warning.

☞ Configuring an error as warning results in the fact that responding of the monitoring function will no longer cause an error reaction.

It is therefore the user's responsibility to react to the monitoring function (error) in an appropriate way that suits the individual system requirements. If the user fails to react, the plant/machine may be damaged or destroyed!

This mechanism has been implemented for the following errors:

Number	Text
F2028	Excessive deviation
F2037	Excessive position command difference
F8022	Enc. 1: Enc. signals incorr. (can be cleared in PM)
F8042	Encoder 2 error: Signal amplitude incorrect
F8079	Velocity limit value exceeded
F8282	Error: Hardware enable
F8271	Valve monitoring

Tab. 8-12: Error suppression

Switching between error and warning can be configured by means of parameter P-0-2819. The parameter is structured as control word and features the following bit definition:

Bit number	Significance	Note
0	Excessive control deviation Value → 0 = F2028, 1 = **E2030**	-
1	Excessive position command value difference Value → 0 = F2037, 1 = **E2037**	-
2	Encoder 1: Incorrect encoder signals (can be cleared in PM) Value → 0 = F8022, 1 = **E8022**	-
3	Error encoder 2: Signal amplitude incorrect Value → 0 = F8042, 1 = **E8045**	For HDS only

4	Velocity limit value exceeded Value → 0 = 8079, 1 = **E8079**	-
5	Fault: Hardware enable Value → 0 = F8282, 1 = **A0521**	Not for HDS
6	Valve monitoring Value → 0 = F8271, 1 = **E8271**	Not for HDS
7-31	Reserved	

Tab. 8-13: Error suppression, switching over

☞ Converting an error into a warning results in a changed drive reaction. Warnings are cleared automatically when the cause of the warning is no longer present. They are reset without delay in the next motion clock cycle. In the case of a warning, no error reaction takes place on the drive side.

☞ In the case of "Error: Hardware enable", setting of the relevant bit in parameter "P-0- 2819, Error suppression control word", does not result in the generation of a warning but of message "A0521 Power loss, switching back to bb" instead of an error. The drive switches internally to "bb".

Pertinent parameters

- P-0-2819, Error suppression control word

Pertinent diagnostic messages

- F2028 Excessive deviation
- E2030 Excessive deviation
- F2037 Excessive position command difference warning
- E2037 Excessive position command difference
- F8022 Enc. 1: Enc. signals incorr. (can be cleared in PM)
- E8022 Encoder 1: Encoder signals incorrect
- F8042 Both travel range limit switches activated
- E8045 Encoder 2: Signal amplitude incorrect
- F8079 Velocity limit value exceeded
- E8079 Velocity limit value exceeded
- F8282 Error: Hardware enable
- A0521 Power loss, switching back to bb
- F8271 Valve monitoring
- E8271 Valve monitoring

8.5.5 Valve monitoring

Structure

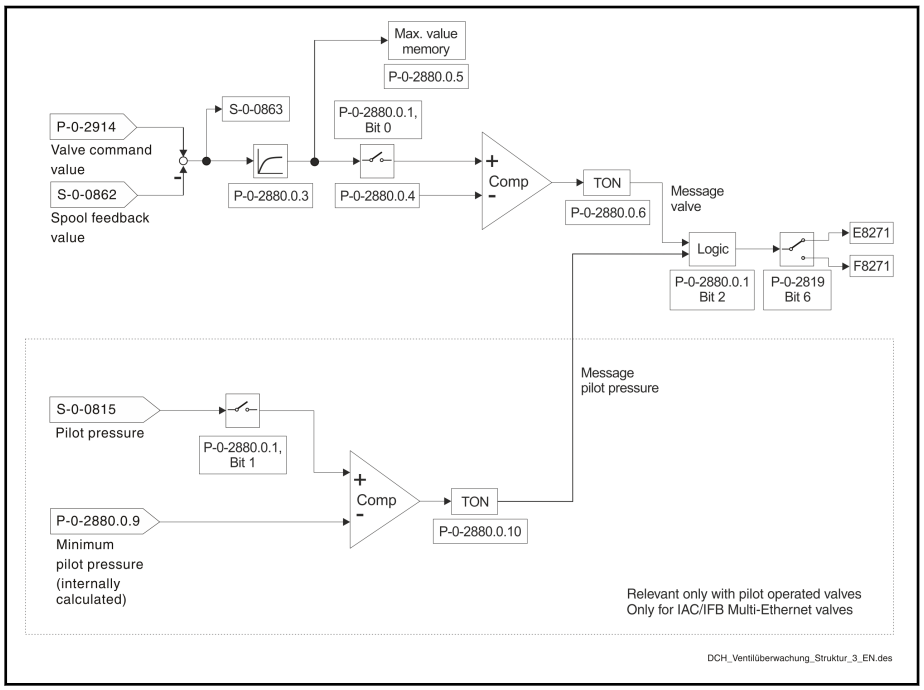


Fig. 8-22: Valve monitoring

Valve monitoring is used to determine by means of direct comparison of valve command value and actual valve value whether any malfunction is present.

Valve monitoring can be activated via "P-0-2880.0.1, Valve monitoring control word bit 0".

After filtering of "S-0-0863, Spool control deviation" using "P-0-2880.0.3, Valve monitoring filter time", the result is saved in "P-0-2880.0.5, Valve monitoring maximum valve error" and at the same time compared with the "P-0-2880.0.4, Valve monitoring threshold". When the threshold is exceeded and after a delay, which is parameterized in "P-0-2880.0.6, Valve monitoring delay ", has elapsed, either warning message "E8271, Valve monitoring" or error "F8271, Valve monitoring" is output depending on the setting in "P-0-2819, Error suppression control word, bit 6".

"P-0-2880.0.5, Valve monitoring maximum valve error" is also calculated, if monitoring is not active.



So far, the default behavior of monitoring was that only a warning message was issued.

As of firmware version 20V12 an error is output with the default setting.



If a valve is beyond its performance limit or if the pilot oil pressure is missing in the case of pilot operated valves, the warning or error may be trigged without an actual defect of the valve.

In pump control, the pilot valve is sometimes at the performance limit even in normal operating states. For this reason, this valve monitoring function should not be activated in pump control. For pump control there is an additional monitoring function ("F2281, Valve error pump controller"), which also takes account of the performance limit. This monitoring function is always active in pump control.

Pilot pressure monitoring is only available for pilot operated IAC/IFB Multi-Ethernet valves.

This function can be used to ascertain whether the current pilot pressure of the pilot operated valve is sufficiently high.

Pilot pressure monitoring can be activated via "P-0-2880.0.1, Valve monitoring control word, bit 1".

The current pilot pressure is checked for falling below the minimum pilot pressure. Following a "P-0-2880.0.10, Pilot pressure monitoring, delay time", either warning message "E8271, Valve monitoring" or error message "F8271, Valve monitoring" is output depending on the setting in "P-0-2819, Error suppression control word, bit 6".

By means of "P-0-2880.0.1, Valve monitoring control word, bit 2" the setting of "extended valve monitoring" can be activated. If valve monitoring results in an error or warning message, a check is carried out to see whether the reason is insufficient pilot pressure.

Logic of valve monitoring

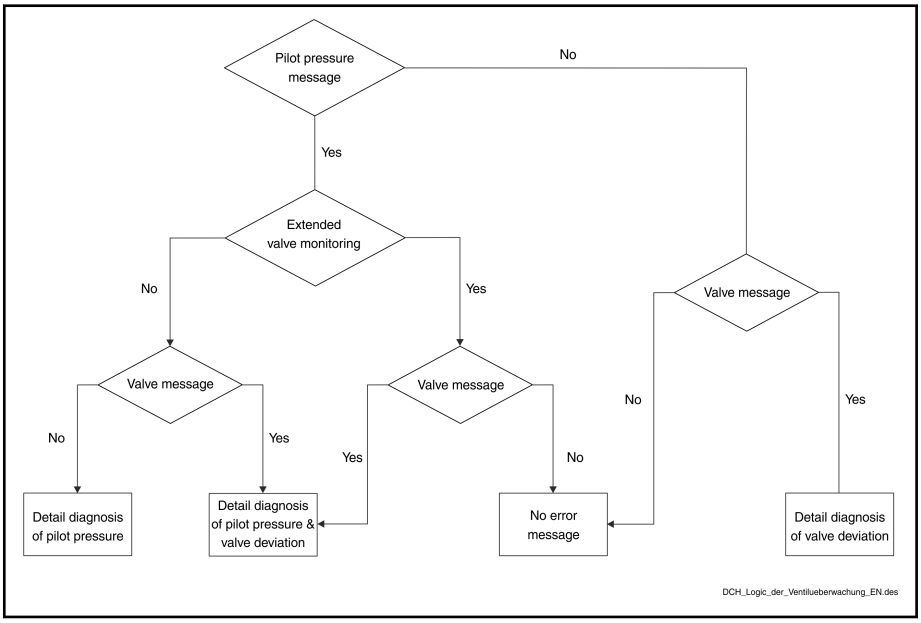


Fig. 8-23: Logic of valve monitoring

In the case of an error, the error message "valve monitoring" is always displayed. Depending on the cause of error, the error "excessive valve monitoring", "insufficient pilot pressure" or both are displayed as detailed diagnostics. The same is valid for the warning!

Non-return valves of sandwich plate design are currently not supported.

Pertinent parameters

- P-0-2819, Error suppression control word
- P-0-2880.0.1, Valve monitoring control word
- P-0-2880.0.3, Valve monitoring filter time
- P-0-2880.0.4, Valve monitoring threshold
- P-0-2880.0.5, Valve monitoring maximum valve error
- P-0-2880.0.6, Valve monitoring delay
- P-0-2880.0.7, Pilot pressure monitoring, spring pressure
- P-0-2880.0.8, Pilot pressure monitoring, area ratio
- P-0-2880.0.9, Pilot pressure monitoring, minimum pilot pressure
- P-0-2880.0.10, Pilot pressure monitoring, delay time

Pertinent diagnostic messages

- E8271 Valve monitoring
- F8271 Valve monitoring

8.6 E-Stop function

8.6.1 Brief description

The E-Stop function is used to stop the drive with a selectable drive reaction (see parameter description "P-0-0008, Activation E-Stop function") via a digital input of the drive controller.

For using the E-Stop input on the device, parameter "P-0-0223 E-Stop input" has to be assigned to a digital input on the drive via configuration of the digital I/Os.

The following options are available for utilizing the E-Stop function:

- E-Stop as error

  → **Reaction:**

  – Valve actuating variable reset with ramp → "F6034, Emergency-Stop activated"

  – Best possible deceleration (as set in P-0-0119) →"F4034 Emergency-Stop activated"

- E-Stop as fatal warning "E8034, Emergency-Stop activated"

  → **Reaction:** Best possible deceleration (as set in P-0-0119)

☞ If "E-Stop" is parameterized as warning, it is not necessary to clear the diagnostic message!

8.6.2 Functional description

By activating the E-Stop input (P-0-0008, bit 0 = 1) and assigning bit 0 of P-0-0223 to a digital input, the drive is caused to stop by carrying out the reaction defined via P-0-0008 when 0 V is applied at the E-Stop input.

E-Stop reaction according to P-0-0008, bit 2

The reaction firstly depends on the setting of bit 2 in P-0-0008.

If the interpretation as "fatal warning" is parameterized (bit 2 = 1) here, the drive reacts like upon the withdrawal of the external drive enable with the reaction set in "P-0-0119, Best possible deceleration":

- The warning "E8034 Emergency-Stop activated" appears. In "S-0-0012, Class 2 diagnostics" bit 15 is set (manufacturer-specific warning).
- At the same time, bit "change bit class 2 diagnostics" is set in the drive status word.

☞ By reading "S-0-0012, Class 2 diagnostics" this change bit is cleared again. Via "S-0-0097, Mask class 2 diagnostics" warnings can be adjusted with regard to their effect on the change bit.

☞ To reactivate the drive, the E-Stop input must be deactivated and **another positive edge has to be applied to the external controller enable**.

If the interpretation is set as error in P-0-0008 (bit 2 = 0), the reaction selected in bit 1 is carried out:

- The diagnostic error message "F4034, Emergency-Stop activated" (or "F6034, Emergency-Stop activated") appears.
- In "S-0-0011, Class 1 diagnostics" bit 15 is set.
- In the drive status word of the drive telegram, bit 13 (drive locking, error in class 1 diagnostics) is set. The error message can be cleared via command "S-0-0099, C0500 Reset class 1 diagnostics", if the E-Stop input is no longer active.

☞ The error reaction is carried out without delay, irrespective of "P-0-0117, Activation of control unit reaction on error".

E-Stop reaction according to P-0-0008, bit 1

If bit 1 = 0 in parameter P-0-0008, the drive is stopped according to the error reaction parameterized via "P-0-0119, Best possible deceleration".

When the E-Stop input is activated, the diagnostic message is "F4034, Emergency-Stop activated".

If bit 1 = 0 in parameter P-0-0008, the drive, when the E-Stop triggers, is decelerated to standstill independently of the error reaction determined in P-0-0119 by ramping the valve control variable to zero. The corresponds to best possible deceleration "emergency halt" with the ramp time set in P-0-2928.0.8.

When the E-Stop input is activated, the diagnostic message is "F6034, Emergency-Stop activated".

8.6.3 Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-0008, Activation E-Stop function
- P-0-0223, E-Stop input

Pertinent diagnostic messages

- E8034 Emergency-Stop activated
- F4034 Emergency-Stop activated
- F6034 Emergency-Stop activated

8.7 Compensation functions/corrections

8.7.1 Axis error correction

Brief description

The position feedback value provided by the measuring system can differ from the real actual position value at the axis, e.g. at the point of chip removal in the case of metal-cutting machining, due to:

- Inaccuracy of the measuring system
- Backlash on reversal of components

- Transmission inaccuracy in mechanical transmission elements such as gear, coupling, feed spindle, etc.

The drive provides the following correction functions to compensate for the mechanically caused position error sources:

- Backlash on reversal correction
- Axis error precision correction
- Control-side axis error correction

The control-side axis error correction is always active. The correction value can be transmitted in the cyclic telegram or in the service channel. In addition, axis error precision correction or reversal backlash can be activated, with axis error precision correction having higher priority.

The sum of active correction values is shown in "P-0-0401, Axis correction active correction value".

The correction of the position feedback system is activated via the respective bit in "P-0-0413, Axis correction control word".

Axis error correction is available only with functional package "Axis Controller CL".

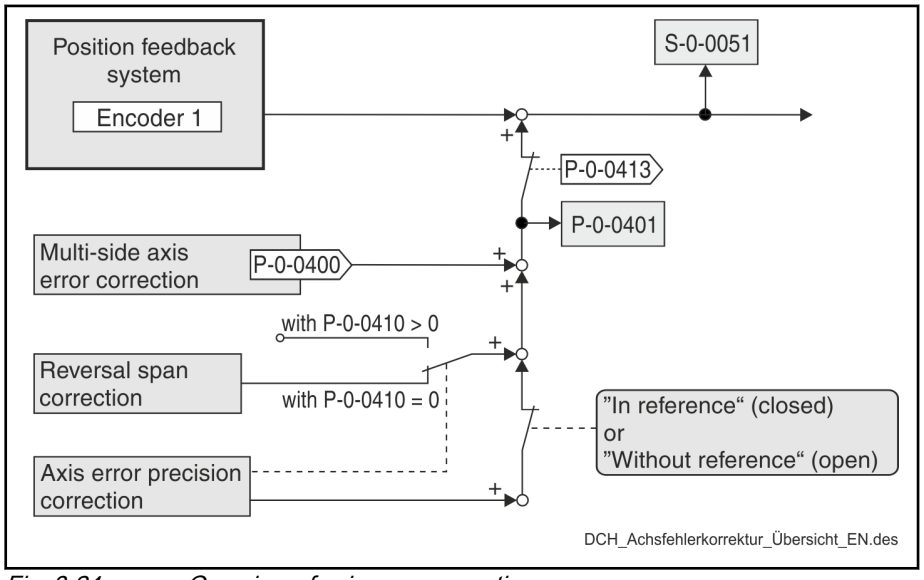


Fig. 8-24: Overview of axis error correction

Backlash on reversal correction

With the help of backlash on reversal correction, a backlash in the mechanical axis system can be easily corrected.

The function is activated by entering the backlash in "S-0-0058, Reversal clearance". The actual position values of the encoder selected via parameter "P-0-0413, Axis correction control word" are corrected with the value from S-0-0058, that is, with a negative direction, the backlash on reversal is added.

In the case of position control, the direction of movement is detected by the sign of the temporal change in the value of "P-0-0434, Position command value of controller".

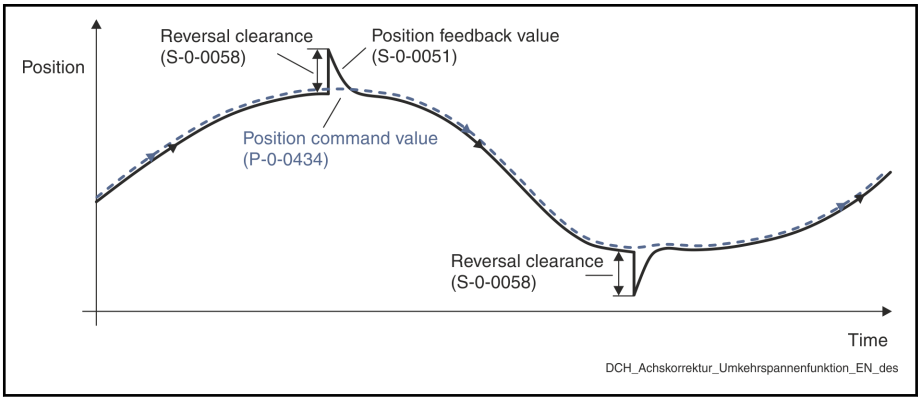


Fig. 8-25: Operating principle of the backlash-on-reversal function in the case of position control

With open/closed-loop velocity control, a reversal of the direction of movement is recognized when parameter "S-0-0036, Velocity command value" becomes greater than the amount of parameter "S-0-0124, Standstill window" in the positive or negative direction. The standstill window acts as hysteresis.

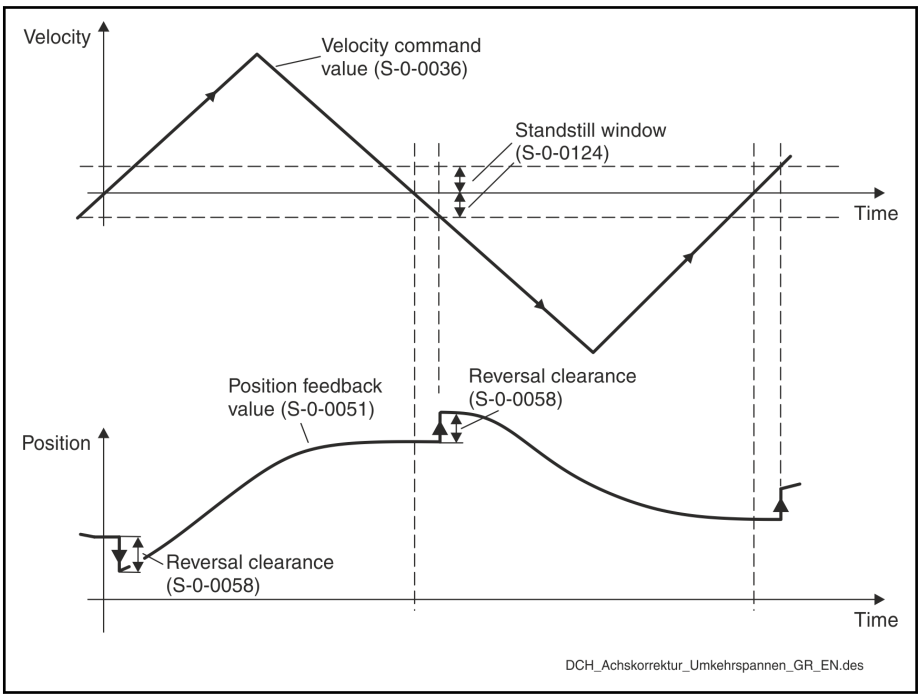


Fig. 8-26: Operating principle of backlash-on-reversal correction in closed-loop velocity control

Axis error precision correction

The axis error precision correction is used to correct non-linear axis errors and non-linear errors of the mechanical system; it is only available with functional package "Servo".

By means of tables "P-0-0411, Axis correction, correction table positive" and "P-0-0412, Axis correction, correction table negative" you can enter position- and direction-related correction values, so-called correction support points, within the correction range. At least 6 values of a maximum of 100 values of the table have to be written. With a reversal of direction, different correction values for the positive and the negative direction of movement at the same support point result in a step-change in the actual position value, which corresponds to the backlash on reversal.

The correction range is within the range of values, which is limited by the parameters "P-0-0408, Axis correction start position" and "P-0-0409, Axis correction end position". The start position P-0-0408 is to be defined by the user, the end position P-0-0409 is determined on the drive side on the basis of the maximum value of the correction table support points (P-0-0411 and P-0-0412) and the distance between the support points "P-0-0410, Axis correction support point distance". The required length of the correction range and the maximum value of the number of support points determine the minimum support point distance.

The positions, at which correction support points are included, are determined by parameters P-0-0410 and P-0-0408. Between the correction support points, the correction values are calculated by means of cubic spline interpolation. The actual position values of the encoder selected by means of "P-0-0413, Axis correction control word" are corrected with the interpolated values of parameters "P-0-0411, Axis correction, correction table positive" or "P-0-0412, Axis correction, correction table negative", respectively, taking account of the direction of movement. The direction of movement is recognized in different ways depending on the operation mode, see "Backlash on reversal correction".

Axis error precision correction is active, when "P-0-0410, Axis correction support point distance" contains a value > 0. Axis error precision correction is position-related and can therefore only become active with a position reference.

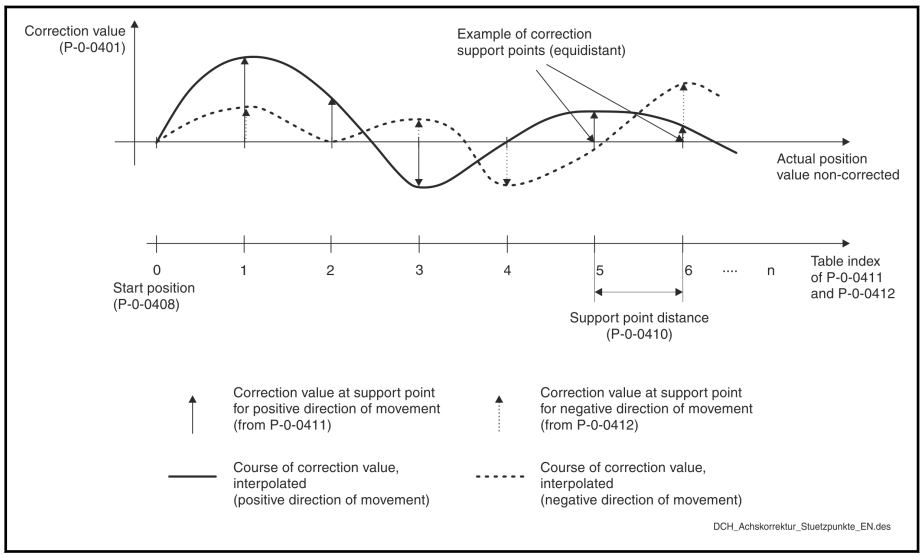


Fig. 8-27: Illustration of the creation of a correction value on the basis of the correction support points entered.

Axis error correction on the control side

The drive also offers the possibility of cyclically sending control-side correction values for the actual position value to the drive and considering them in the calculation of the actual position value within the position control clock cycle. Axis error correction on the control side is activated, when "P-0-0400, Axis correction external correction value" is available in the master data telegram; a reference is not required. The control-side axis error correction is only available with functional package "Servo".

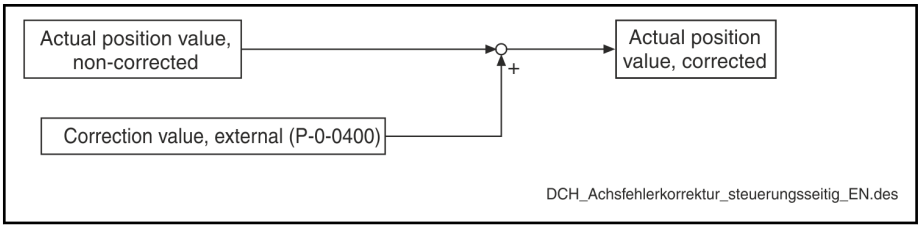


Fig. 8-28: Control-side axis error correction

8.7.2 Quadrant error correction

Brief description

Assignment to functional firmware package.

In the case of axis drives that are controlled, for example, in circular interpolation, static friction at the reversal points of the direction of motion can cause distortion of the circular contour.

In order to compensate this contour error at the so-called "quadrant transitions" (velocity reversal), HydraulicDrive controllers provide the "quadrant error correction" function.

This correction function is useful for such cases when drives are operated in cyclic position control and in circular interpolation by the control master.

Pertinent parameters

- P-0-0100, Position command value extension
- P-0-0435, Control word of position controller
- P-0-0436, Reference radius for quadrant error correction
- P-0-0437, Velocity time range for quadrant error correction
- P-0-0438, Table of path velocities for quadrant error correction
- P-0-0439, Table of velocity pulse for quadrant error correction

Functional description

For quadrant error correction, static friction possibly occurring at the reversal points of the direction of motion is compensated by adding an additional, pulse-shaped command value to the velocity command value at the output of the position controller. Due to this velocity feedforward the axis overcomes static friction faster and with a shorter following distance.

Sinusoidal position command value profile

For using quadrant error correction for circular interpolation, it is required that the control master operates two drives in cyclic position control. In this case, the drives are controlled by way of interpolation with sinusoidal position command value profiles, which are offset by 90 angular degrees to each another, related to the circle. The internally generated velocity command value profiles of the two drives are also sinusoidal and have an offset of 90°.

Velocity pulse with reversal of direction

When the direction of motion changes, a triangular velocity pulse with an adjustable velocity time range is added to the drive-internal velocity command value.

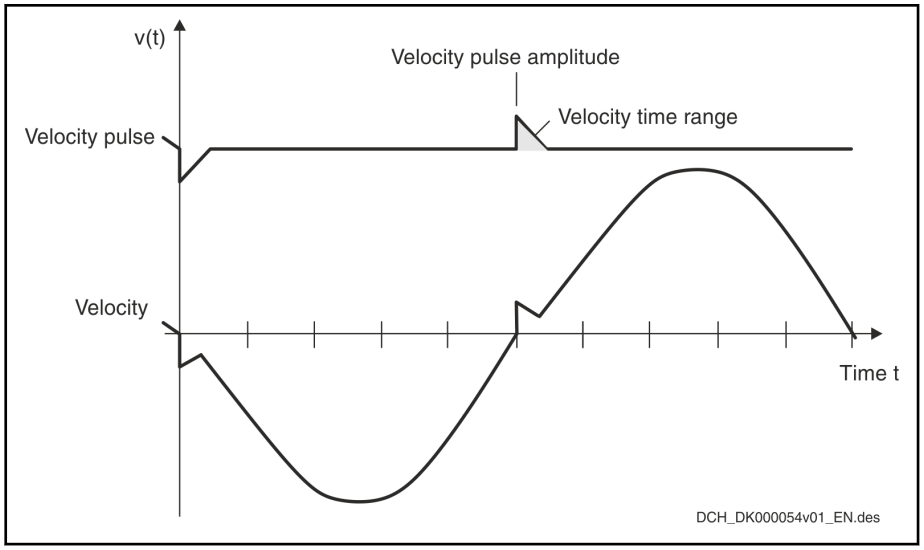


Fig. 8-29: Schematic curves of velocity pulse and velocity command value with quadrant error correction

The controller detects changes in the direction of motion by the time flow of the cyclic position command values.

Reference circle, reference radius

The settings for quadrant error correction are made when a reference circle is processed (radius of reference circle in "P-0-0436, Reference radius for quadrant error correction"), e.g. the circle that is demanded for the reference piece.

The amplitude of the velocity pulse of quadrant error correction is preset depending on the circular velocity. The pulse is fed forward abruptly and is ramped down.

The higher the path velocity, the higher the pulse and the steeper is the reduction to zero, because the velocity time range of the pulse is independent of the velocity. This corresponds to the value entered in "P-0-0437, Velocity time range for quadrant error correction".

Estimation for the velocity time range

For dimensioning of P-0-0437, it is recommended that the required pulse amplitude and the duration of the pulse be estimated. This should be done with regard to the path velocity and the duration for processing the reference circle (P-0-0436):

$$P\text{-}0\text{-}0437 = \frac{1}{2} \times \frac{a}{100\%} \times v_{path} \times \frac{b}{100\%} \times T_{circle}$$

P-0-0437	Velocity time range for quadrant error correction
a	percentage of path velocity
v_{path}	path velocity
b	percentage of duration for processing of circular contour
T_{circle}	duration for processing the circular contour

Fig. 8-30: Estimation for value of P-0-0437

By means of list parameters, the circular velocities and velocity pulse amplitudes are assigned to one another:

- P-0-0438, Table of path velocities for quadrant error correction
- P-0-0439, Table of velocity pulse for quadrant error correction

It is possible to store 20 pairs of values for velocity and pulse amplitude in the mentioned parameters. The velocities having to be entered in ascending order.

Determining the velocity pulse amplitude

The velocity pulse amplitude to be assigned to a current circular velocity is determined by means of the list parameter values:

- Between 2 pairs of values the pulse amplitude is linearly interpolated in dependence on the current path velocity.
- Below the lowest path velocity the pulse amplitude is set to zero.
- Above the highest path velocity the pulse amplitude assigned to the highest path velocity continues to take effect.

Determining the current circular velocity

The controller calculates the current circular velocity by means of the current acceleration command value of the drive calculated from the position command values. The reference radius (P-0-0436) is the basis for calculating the path velocity.

If the drive-internal resolution of the calculated acceleration command value is low, quadrant error correction sometimes is without effect. For this case, it is recommended to integrate the extended position command value ("P-0-0100, Position command value extension") in the cyclic master communication. This extends the decimal places of the position command value.

☞ Experience has shown that it is absolutely necessary to integrate the extended position command value (P-0-0100) in the cyclic master communication on the control side!

Activating the quadrant error correction

The quadrant error correction is activated by the control master by setting the respective bit of "P-0-0435, Control word of position controller". It is only advantageous to use the function, if a circular form is to be machined in the workpiece program.

The correction should be activated at the earliest one clock cycle after the start of circular interpolation so that the velocity pulse is not added when the drive is starting. Otherwise, high velocity pulses, which result from the mostly high starting accelerations and can damage contours, may occur when the drive is starting.

For machining other contours, quadrant error correction should be deactivated. To do this, the respective bit of P-0-0435 should be contained in cyclic master communication and activated depending on the kind of machining.

☞ Quadrant error correction remains without effect when the value "0" is contained in "P-0-0437, Velocity time range for quadrant error correction".

Notes on commissioning

For commissioning it is necessary to move the drive by the control master in cyclic circular interpolation. The quality of the circular form has to be determined, ideally with measuring equipment for ballbar testing.

Recommended commissioning steps

Quadrant error correction should be commissioned in the following steps:

1. Make the following presettings:
   - Enter value for "P-0-0436, Reference radius for quadrant error correction"
   - Set quadrant error correction inactive in "P-0-0435, Control word of position controller"

- Set "P-0-0437, Velocity time range for quadrant error correction" to "0"
- Write 50 % and 70 % (list lines 1 and 2), for example, of maximum circular velocity to "P-0-0438, Table of path velocities for quadrant error correction"
- Write the value "0" to the first two list lines in "P-0-0439, Table of velocity pulse for quadrant error correction"

2. Move drive on control side in circular interpolation at 50 % of maximum circular velocity and check quality of circular form with measuring equipment for ballbar testing.
3. Set quadrant error correction active in "P-0-0435, Control word of position controller".
4. Write ca. 1 % of the current circular velocity to list line 2 of "P-0-0439, Table of velocity pulse for quadrant error correction".
5. Increase value in parameter "P-0-0437, Velocity time range for quadrant error correction" starting with low values, observe quality of circular form with measuring equipment; increase values until maximum quality of circular form is reached.

   If quality of circular form does not improve, write lower or higher value to list line 2 of P-0-0439, depending on tendency of improvement of circular form quality.
6. After the optimum value was written to P-0-0437, operate drive at further, different circular velocities in order to determine optimum values for P-0-0439.

☞ Observe interpolation data (see above) for the velocity pulse amplitude depending on the current path velocities (P-0-0438 and P-0-0439)!

8.8 Positive stop drive procedure

8.8.1 Brief description

For special applications, it is required to move machine axes operated in position or velocity control up to a limit stop in order to generate compressive or pressing forces.

When an axis has moved to a limit stop in a standard situation, the drive should signal a drive error via the monitoring features of the position or velocity control loop and react with a shutdown.

But if the drive can detect the special case of operation "positive stop drive procedure", it can ignore the messages of the position and motion monitors and generate the required pressing force, if necessary.

The control master signals this special case to the controller via a command. Upon this command, the drive switches the respective monitors off and acknowledges, if an axis standstill is recognized and an adjustable force or torque threshold is exceeded.

Pertinent parameters

- S-0-0092, Bipolar torque/force limit value (2 bytes)
- S-0-0124, Standstill window
- S-0-0149, C1300 Positive stop drive procedure command
- S-0-0159, Monitoring window of following distance
- S-0-0331, Status "v_feedback = 0"

Pertinent diagnostic messages

- C1300 Positive stop drive procedure command
- C1301 Class 1 diagnostics error at command start

8.8.2 Functional description

Moving a machine axis to a limit stop in closed-loop position control, e.g. for generating a pressing force, is a process specifically provoked on the master side. To do this, the master provides a command value for the drive that the axis cannot reach, because the mechanical limit stop is situated before it.

In order to avoid error messages and reactions with the drive having been blocked, the execution of "C1300 Positive stop drive procedure command" (S-0-0149) is started before the limit stop is reached. This switches off the following monitors that would cause class 1 diagnostic errors:

- E2059 Velocity command value limit active
- E8260 Torque/force command value limit active
- F2028 Torque/force command value limit active
- F2037 Excessive position command difference

The command is acknowledged on the following conditions:

When the positive stop was recognized.

- Condition 1: Standstill of the drive was recognized (“S-0-0331, Status "v_feedback = 0"“)

  - and -

- Condition 2: The force controller is active (S-0-0092 has exceeded the torque/force limit value)

  or

  The following distance (S-0-0189) is greater than the monitoring window (S-0-0159).

The criteria for command acknowledgment can be set axis-specifically.

As command C1300 is reset, the monitors are switched on again!

NOTICE **Property damage can be caused by moving to positive stop too rapidly!**

⇒ Reduce approaching velocity and torque/force limit value (S-0-0092) to values that are not causing damage to the mechanical system!

☞ If the drive already signals a class 1 diagnostics error (e.g. has already reached positive stop), the command "positive stop drive procedure" cannot be started!

8.8.3 Notes on commissioning

For acknowledgment of command C1300 it is necessary to set:

- Threshold value for detection of axis standstill in parameter
  - S-0-0124, Standstill window
- Torque/force threshold in the parameters
  - S-0-0092, Bipolar torque/force limit value (2 bytes)

☞ The parameters S-0-0124 and S-0-0092 are also used by further functions. Specific changes of values made for the function "positive stop drive procedure" have to be undone, if necessary!

Before positive stop is reached, start:

- Recognition of controller deviation S-0-0159, Monitoring window of following distance
- S-0-0149, C1300 Positive stop drive procedure command

After the drive has moved away from the positive stop, reset the command, if necessary!

Diagnostics

The command has been executed when the "commands change bit" is set in parameter "S-0-0135, Drive status word" and no command error is present.

If a class 1 diagnostics error is present at the start of command C1300 (e.g. because the axis has already reached the positive stop), the command is not executed. The following message is displayed:

- C1301 Class 1 diagnostics error at command start

8.9 Parameter set switching

8.9.1 Brief description

HydraulicDrive drives are provided with four parameter sets, which can be switched during operation. One of the switchable parameter sets is always active. Switching takes place upon command of the control master.

Notes on utilization

By switching parameter sets during operation, the values of specific parameters can be adjusted to the different operating phases or machining processes. This supports the work flow in flexible production facilities.

Application examples of this:

- Adjusting the control loop gains to different load inertias or load masses (e.g. with very different workpieces)
- Changing over ramp times and limitations in generators

Classification of switchable parameters

The parameters to be switched are subdivided into the following groups taking account of application-related aspects:

- Application parameters
- Control loop parameters

Pertinent parameters

- S-0-0216, C4100 Switch parameter set command
- S-0-0217, Preselect parameter set command
- S-0-0219, IDN-list of parameter set

☞ List parameters S-**0**-0219 to S-**3**-0219 contain parameter sets no. 0 to no. 3

- S-0-0254, Current parameter set
- P-0-2216, Parameter set switching, configuration
- P-0-2217, Parameter set switching, preselection range
- P-0-2218, Parameter set switching, delay time

Pertinent diagnostic messages

- C4100 Switch parameter set command
- C4101 Switching only possible without AF

- C4103 Preselect parameter set forbidden value
- C4104 Error during parameter set switching (->S-0-0423)

8.9.2 Functional description

General information

Parameter set switching is activated:

- by triggering command "C4100 Switch parameter set command" (S-0-0216) via the control master

- or -

- in a "drive-controlled" manner by changing parameter "S-0-0217, Preselect parameter set command"

Triggering parameter set switching is determined in parameter "P-0-2216, Parameter set switching, configuration".

The drive firmware then activates the parameter set, which is defined by the value of parameter "S-0-0217, Preselect parameter set command". The parameter set currently active is shown in parameter "S-0-0254, Current parameter set". After switching on, it is always set 0 that is active.

To minimize switching, saving and loading times for the parameter sets of a drive, the switchable parameters are firmly assigned to the following groups:

- **Application** (e.g. parameters for the limit values of torque/force, position, velocity, etc.)
- **Control loop** (e.g. parameters for gain factors of position and velocity controllers, etc.)

Parameter "P-0-2216, Parameter set switching, configuration" determines, which of the parameters groups mentioned are to be switchable. Moreover, in parameter "P-0-2217, Parameter set switching, preselection range" you can determine, how many of the parameter sets are to be used. The parameters provided for parameter set switching are shown in list parameters S-**0**-0219 to S-**7**-0219 (IDN list of the respective parameter set). These list parameters are formed by the drive in dependence upon the determinations in parameters P-0-2216 and P-0-2217.



Parameters from non-configured sets or groups:

- are not listed in "S-0-0192, IDN-list of all backup operation data".
- are write-protected in the operating mode.

Parameters are addressed via their IDN. For the switchable parameters, the number for the respective parameter set, parameter set number (0 to 3), must be observed.

Determining parameter groups

Application parameters

The following switchable parameters are firmly assigned to the group "Application":

- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0057, Position window
- S-0-0091, Bipolar velocity limit value
- S-0-0092, Bipolar torque/force limit value (2 bytes)

- S-0-0124, Standstill window
- S-0-0125, Velocity threshold vx
- S-0-0126, Torque threshold Tx
- S-0-0138, Bipolar acceleration limit value
- S-0-0157, Velocity window
- S-0-0193, Positioning jerk
- S-0-0261, Coarse position window
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- S-0-0446, Ramp reference velocity for acceleration data
- S-0-0822, Torque/force ramp (2 bytes)
- S-0-0823, Torque/force ramp time
- P-0-0041, Position command average value filter time constant
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2
- P-0-1222, Velocity command filter

Control loop parameters

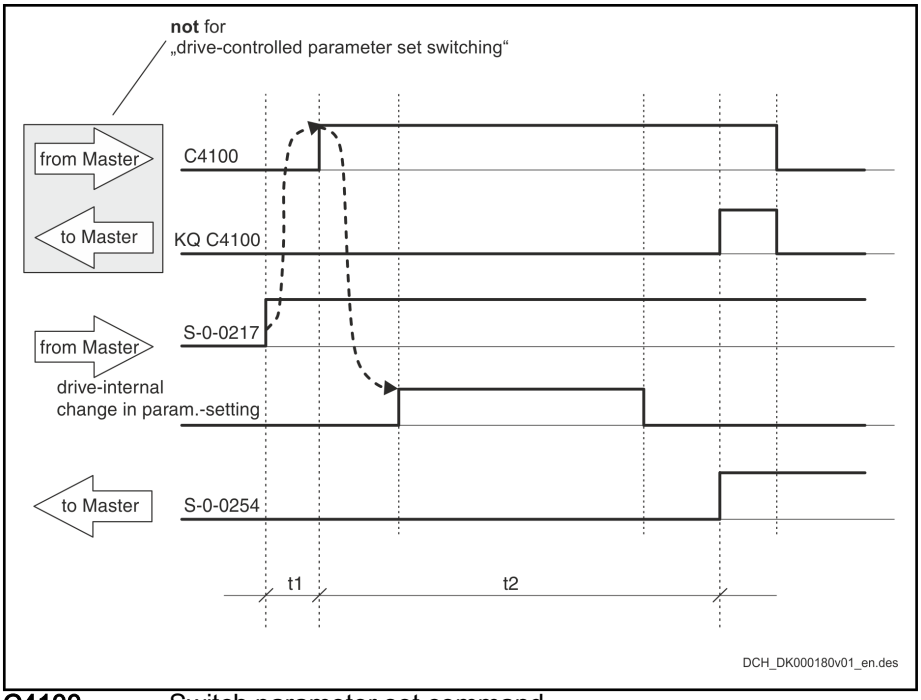
The following switchable parameters are firmly assigned to the group "Control Loop":

- S-0-0104, Position loop Kv-factor
- S-0-0826, Torque/force window
- P-0-0040, Velocity feedforward

Conditions and timing for parameter set switching

Parameter groups "Application" and "Control Loop"

The parameter sets of application and control loop parameters can be switched during operation, that is, when the drive is enabled ("AF"). For "drive-controlled parameter set switching", the timing is as follows:



C4100	Switch parameter set command
KQ C4100	Switch parameter set command acknowledgment
S-0-0217	Preselect parameter set command
S-0-0254	Current parameter set
t1	ca. 6 ms (drive-controlled parameter set switching)
t2	ca. 5…30 ms

Fig. 8-31: Sequence diagram for switching application and control loop parameters

8.9.3 Notes on commissioning

Presettings

Preset the parameter groups to be switched in:

- P-0-2216, Parameter set switching, configuration

Determine the number of parameter sets to be switched in:

- P-0-2217, Parameter set switching, preselection range

If desired, activate "drive-controlled parameter set switching" also in parameter P-0-2216.

Writing switchable parameters

Depending on the selected presettings, in communication phase 4 those parameters can be written, the IDNs of which are displayed in parameters S-"0"-0219 to S-"7"-0219 (IDN list of respective parameter set).

☞ All further parameters, which could also be included in parameter set switching (S-1-xxxx to S-7-xxxx or P-0-xxxx to P-0-xxxx), but are not listed in S-x-0219:

- are not listed in "S-0-0192, IDN-list of all backup operation data".
- are write-protected in the operating mode.

Initial state

After switching on, it is always "parameter set 0" that is active first. Parameter "S-0-0254, Current parameter set" shows "0".

Carrying out parameter set switching

Before the function is activated, the number of the parameter set you wish to switch to has to be entered in parameter"S-0-0217, Preselect parameter set command".

Sequence of function:

- Starting of command "C4100 Switch parameter set command" (S-0-0216) via the control master
- Successful parameter set switching is checked in parameter "S-0-0254, Current parameter set" (the new parameter set number must have been acknowledged in this parameter)
- Command C4100 is cleared by the control master

Diagnostic messages

While the command is being executed, the display of the controllers shows the message "C41".

Possible failures are displayed by the following diagnostic messages:

- C4101 Switching only possible without AF
- C4103 Preselect parameter set forbidden value
- C4104 Error during parameter set switching (->S-0-0423)

8.10 Drive-integrated command value generator

8.10.1 Brief description

The drive-integrated command value generator can be used for startup and controller optimization of drives. The command value generator is used to generate various signal shapes (square wave, sine, noise, sine sweep, triangular) that are added to the closed control loop as command values.



In conjunction with the integrated oscilloscope function, the drive-integrated command value generator also provides the possibility of measuring the frequency response.

Depending on the availability, the drive-internal command value generator can be assigned to the following command values:

S-0-0861, Spool command value additive

S-0-0801, Pressure command value additive

S-0-0881, Swivel angle command value, additive

S-0-0841, Flow command value additive

P-0-0059, Additive position command value, controller

S-0-0037, Additive velocity command value

S-0-0081, Additive torque/force command value (2 bytes)

Features

- Possibility of generating different signal shapes that are added as additive command values to the respective controller command value (valve, pressure, swivel angle, flow, position, velocity, and force)

  The following signal shapes are possible:

  - **Square-wave signals**
  - **Sine signals**
  - **Noise signals**
  - **Triangular signals**
  - **Modified sine signals**
  - **Sine sweep**

- Generating **velocity and position command values** in the position controller clock cycle; **current command values** in the velocity controller clock cycle
- With regard to **amplitude and frequency**, generated command values can be freely defined

Pertinent parameters

- P-0-1150, Command value generator output
- P-0-1151, Command value generator, list of possible target parameters
- P-0-1152, Command value generator, target parameter assignment
- P-0-1153, Command value generator, control word
- P-0-1154, Command value generator, offset
- P-0-1155, Command value generator, amplitude
- P-0-1156, Command value generator, duration 1
- P-0-1157, Command value generator, duration 2
- P-0-1158, Command value generator, periodic time
- P-0-1159, Command value generator, sine sweep start frequency
- P-0-1160, Command value generator, sine sweep end frequency
- P-0-0028, Oscilloscope: Control word
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory

8.10.2 Functional description

Setting/activating the function

Clock rate

For commissioning, the integrated command value generator offers the possibility of generating velocity and position command values in the base clock cycle and adding them to the respective main command value.

Current command values are generated in the velocity controller clock cycle.

Activation

The command value generator is activated and controlled via parameter "P-0-1153, Command value generator, control word" by setting the enable bit. The generator generates command values as the enable is set.

Parameter P-0-1153 can also be used to determine that the enable of the command value generator is automatically deactivated in the case of drive errors. In this case the enable has to be re-set after each drive error and after the control voltage is switched on.

Controller enable

In order that the generated, additive command values become active, the controller enable (bit "drive On" = 1) has to be set.

This can be carried out as follows:

- via a digital input
- via the Engineering Port in the "easy startup mode"
- via master communication

Selection of the target parameter

The IDN of the parameter on which the output signal of the command value generator is to act has to be entered in parameter "P-0-1152, Command value generator, target parameter assignment".

The IDNs of the possible target parameters for the generator output are provided in parameter "P-0-1151, Command value generator, list of possible target parameters".

See also parameter description "P-0-1151, Command value generator, list of possible target parameters"

The unit and the attribute of the generated signal are adapted according to the attribute and unit of the assigned parameter. As target parameter for the command value generator, S-0-0000, Dummy parameter may also be assigned in order to use the command value generator as pure signal shape generator.

The target parameter is written with the limitations according to the determined minimum and maximum values while the signal in the command value generator output (P-0-1150) is issued with the parameterized amplitude without any restrictions. If an amplitude is determined, which results in exceeding the maximum value or falling below the minimum value of the target signal, the signal course in the command value generator output and in the target parameter do not match!

Selection of signal shape

The shape of the desired output signal is determined via the relevant bits in parameter "P-0-1153, Command value generator, control word".

It is possible to select from the following signal shapes of the command value:

- **Square-wave signals**

  → Pulse generator with definable pulse/pause ratio, variable frequency and DC voltage component (offset)

- **Sine signals**

  → The sine generator generates a signal up to a theoretical maximum frequency of 2 kHz with variable frequency and DC voltage component (offset)

- **Triangular signals**

  → The triangular generator generates a signal up to a theoretical maximum frequency of 2 kHz with variable frequency and DC voltage component (offset)

- **Noise signals**

  → The noise generator generates a broad-band "Gaussian noise", for which the amplitude of the noise signal can be defined as pure factor or by means of an envelope curve (= square-wave signal)

- **Modified sine signals**

  → The modified sine generator generates a composite sine shape consisting of two half-waves of different periods and with different signs that are put together

- **Sine sweep**

  → The sine sweep generator generates a sine the frequency of which is variable with adjustable amplitude and offset. The frequency rises linearly from the initial frequency to the final frequency.

Extended settings

Further setting options in the control word of the command value generator:

- Activation of **periodic signal generation**

  → The selected signal is cyclically generated and output with a definable period (frequency)

- **Switch-off delay**

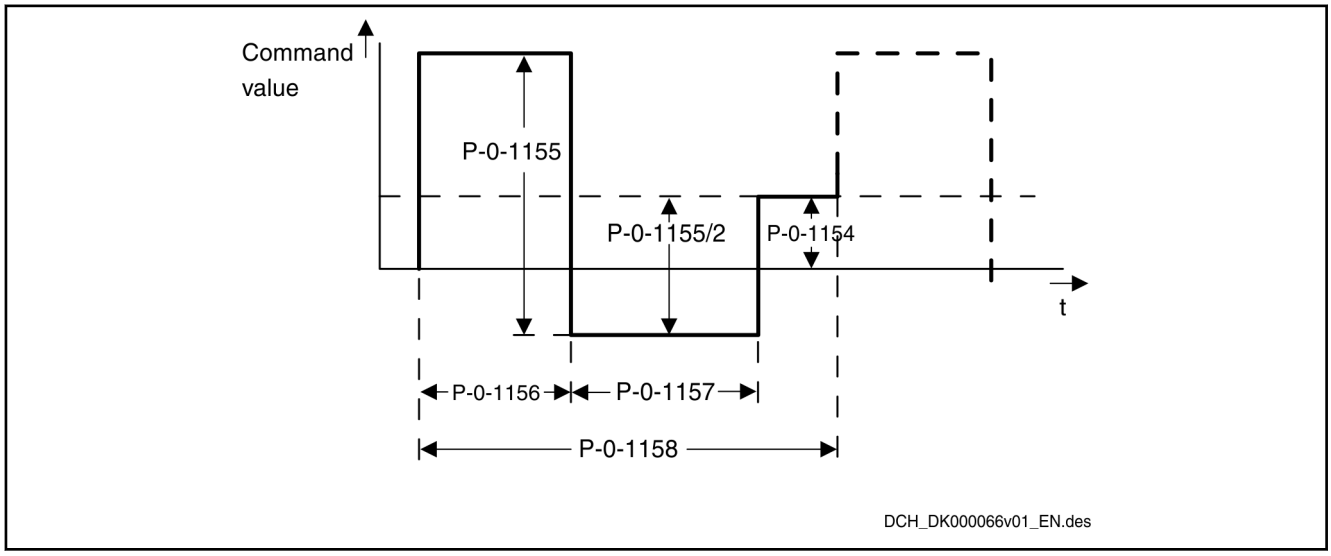
  → Switching off of the command value generator (command value generator output = "0") can be delayed, i.e. switching off is delayed until the signal period is completed.

Pulse generator (for square-wave signal)

The pulse generator generates a square-wave signal, which can be varied in the following properties:

- Frequency or period of the signal
- Amplitude
- DC component (DC offset; positive/negative)
- Pulse/pause ratio

The graphic below exemplarily shows the output signal of the pulse generator with intervention possibilities:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1156 Command value generator, duration 1
P-0-1157 Command value generator, duration 2
P-0-1158 Command value generator, periodic time

Fig. 8-32: Output signal of the pulse generator

☞ If periodic command value generation has been selected in the control word, parameter "P-0-1158, Command value generator, periodic time" determines the cycle time or the periodic time.

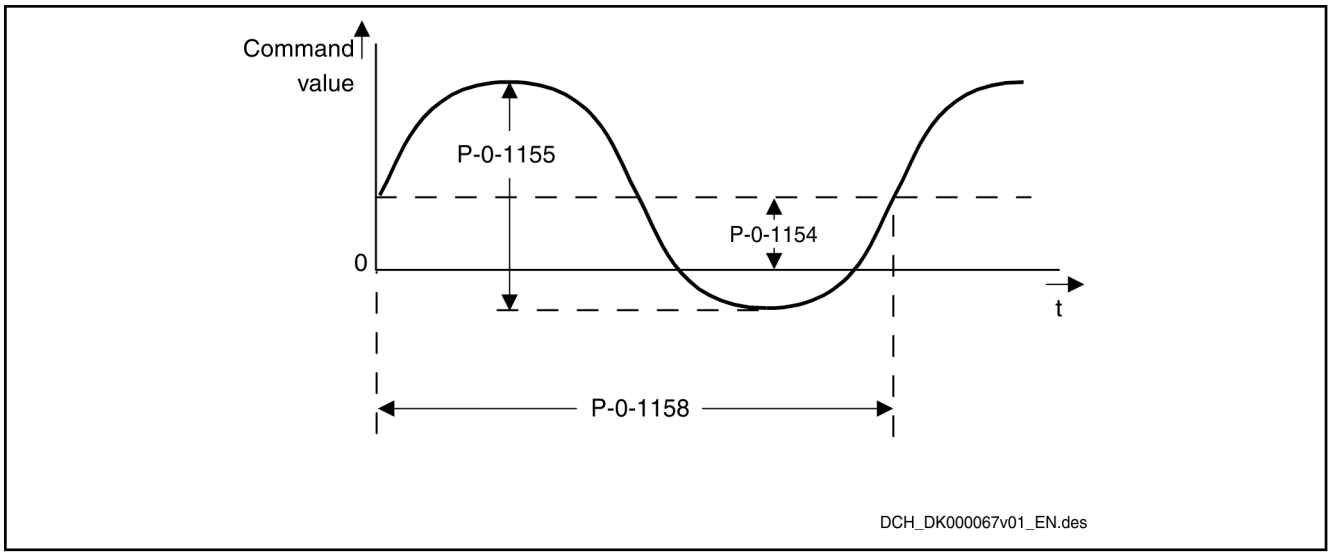
In the case of P-0-1158 = (P-0-1156) + (P-0-1157) this results in a periodic square wave signal, if periodic output has been activated additionally in the control word.

Sine generator

The pulse generator generates a square-wave signal, which can be varied in the following properties:

- Frequency or period of the signal
- Amplitude
- DC component (DC offset; positive/negative)

The graphic below exemplarily shows the output signal of the sine generator with intervention possibilities:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1158 Command value generator, periodic time
Fig. 8-33: Output signal of the sine generator

☞ The target parameter selected in parameter P-0-1152 determines the starting angle of the signal. In the case of currents and torque command values, this starts at 90° in order that the position deviation of the drive is again zero after a complete period.

Extended settings

Extended settings can be made in parameter "P-0-1153, Command value generator, control word":

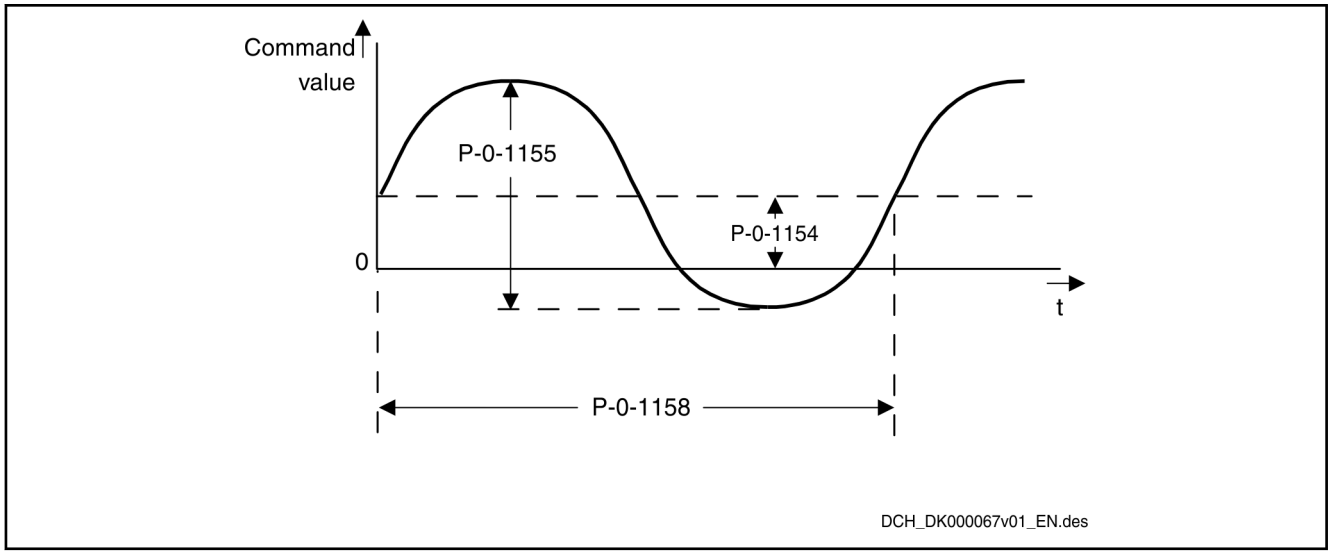
- In many cases it is important that the sine signal does not contain a DC component (area below the curve). Switching off of the command value generator can therefore be delayed until the period is complete (P-0-1153, bit 6).
- If no target parameter has been assigned for the output of the command value generator (P-0-1152 = S-0-0000), the signal shape can be switched from sine to cosine (P-0-1153, bit 9).

Triangular signal generator

The triangular signal generator generates a triangular signal, which can be varied in the following properties:

- Frequency or period of the signal
- Amplitude
- DC component (DC offset; positive/negative)

The graphic below exemplarily shows the output signal of the pulse generator with intervention possibilities:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1158 Command value generator, periodic time
Fig. 8-34: Output signal of the sine generator

Noise generator

For generating random numbers the method of the feedback shift register is applied. With every pass, a bit is generated for the output, which is virtually set or cleared randomly. The periodic time of the noise signal is determined to be 4095 clock cycles ($T_{A_position}$ or $T_{A_velocity}$).

☞ The noise signal generated has no average value over the entire period so that the drive does not drift away by noise fed forward additionally.

Output format (amplitude modulation)

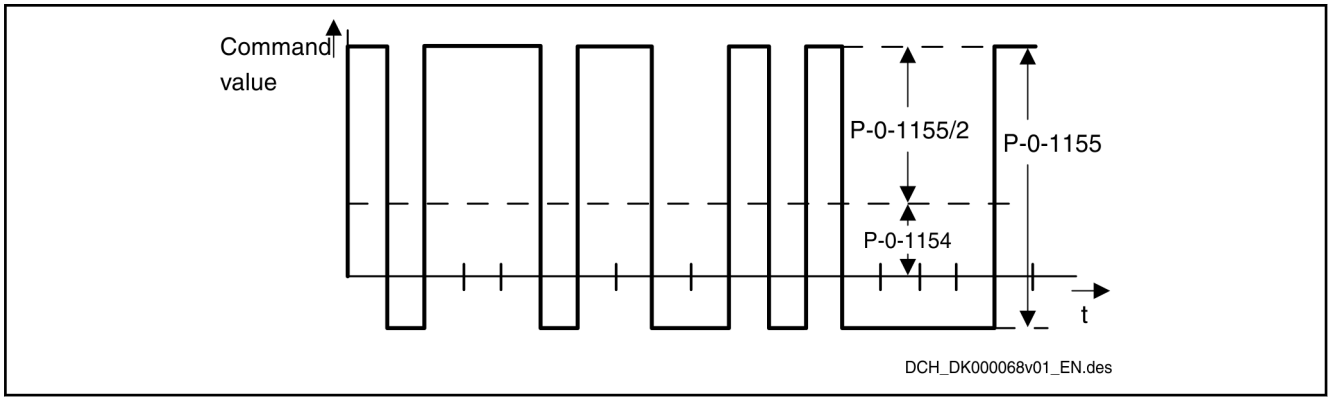
The pulse sequences can be issued in the following ways:

- Noise signal as square-wave signal with amplitude, which can be parameterized, and offset component, if necessary

  → Depending on the sign of the feedback shift register, the amplitude is preset positive or negative
- Noise signal with continuous amplitude

  → Feedback shift register is interpreted as numerical value and scaled with an amplitude

The graphic below exemplarily shows the output signal of the noise generator with intervention possibilities:



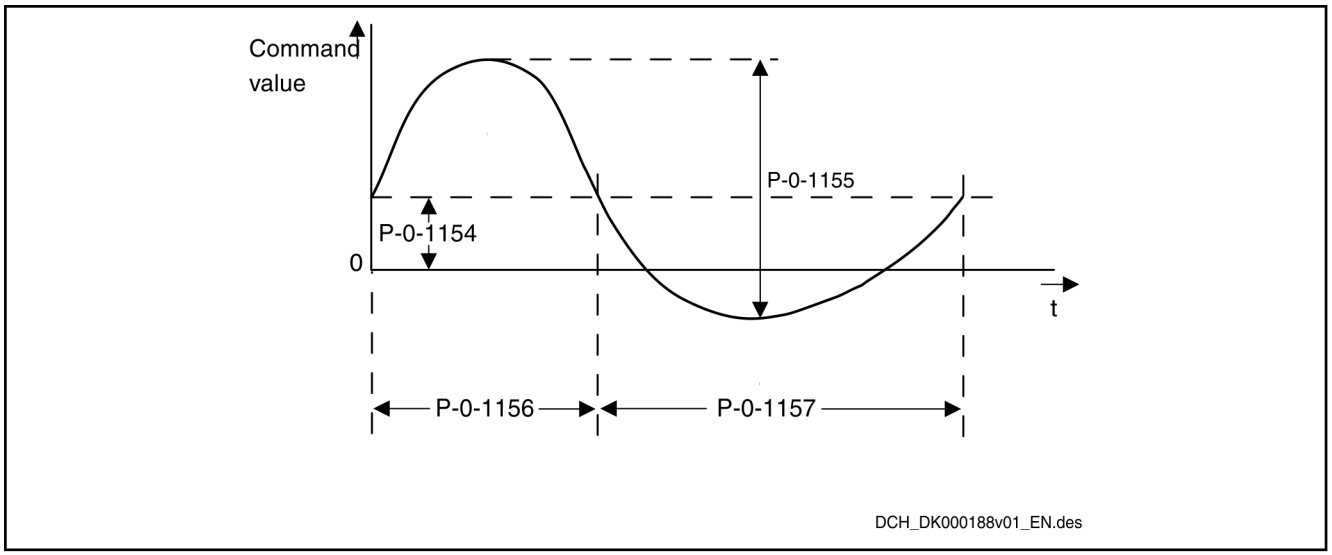
P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
Fig. 8-35: Output signal of noise generator

Modified sine wave generator

A modified sine generator with two different half-waves of the same amplitude is available additionally, the output signal of which can be varied in the following properties:

- Frequency or period of the signal
- Duration of the first half-wave
- Duration of the second half-wave
- Amplitude
- DC component (DC offset; positive/negative)

The graphic below exemplarily shows the modifiable output signal of the sine wave generator with intervention possibilities:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1156 Command value generator, duration 1
P-0-1157 Command value generator, duration 2
Fig. 8-36: Output signal of noise generator

Sine sweep generator

The sine sweep generator generates a sine with varying frequency. The frequency rises linearly from the initial frequency to the final frequency ("wobble

up") and then falls again linearly down to the starting frequency ("wobble down").

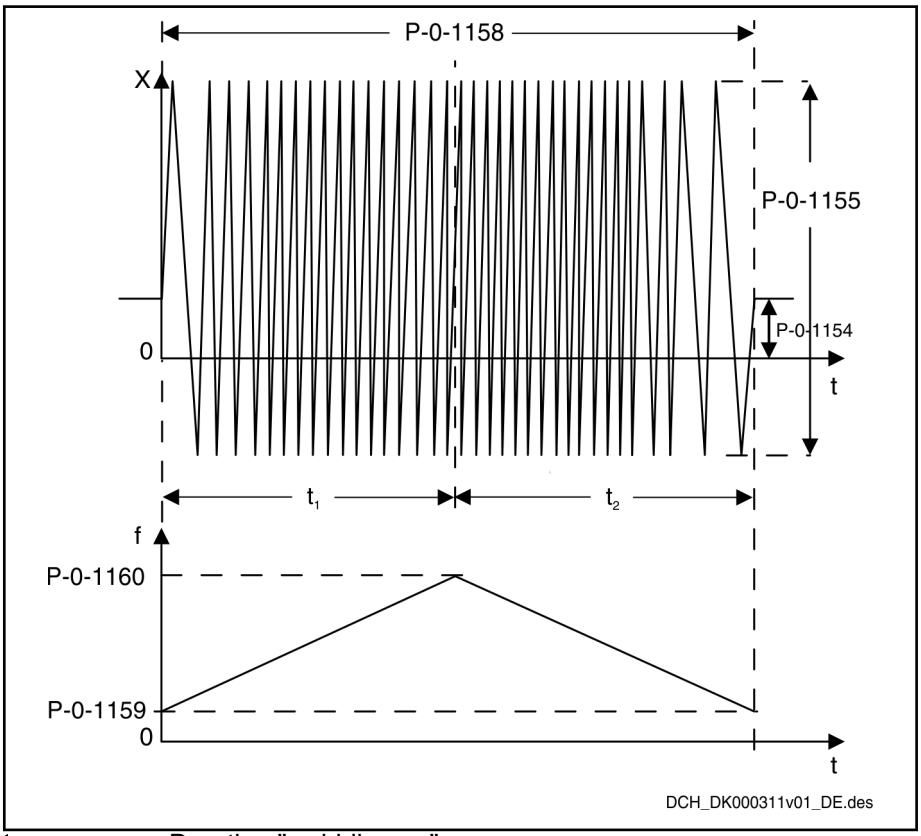
The output signal can be varied in the following properties:

- Initial frequency
- Final frequency
- Periodic time of the signal (duration of "wobbling up" and "wobbling down" together)
- Amplitude
- DC component (DC offset; positive/negative)

☞ The periodic time of sweep has to correspond at least to the quadruple of the duration of the minimum frequency to be passed (initial or final frequency). Otherwise, the command value generator cannot generate reasonable signals.

If, for example, 0.1 Hz is entered as initial frequency and the final frequency is higher, the periodic time of sweep has to be at least 4 × 1/0.1 Hz = 40 s.

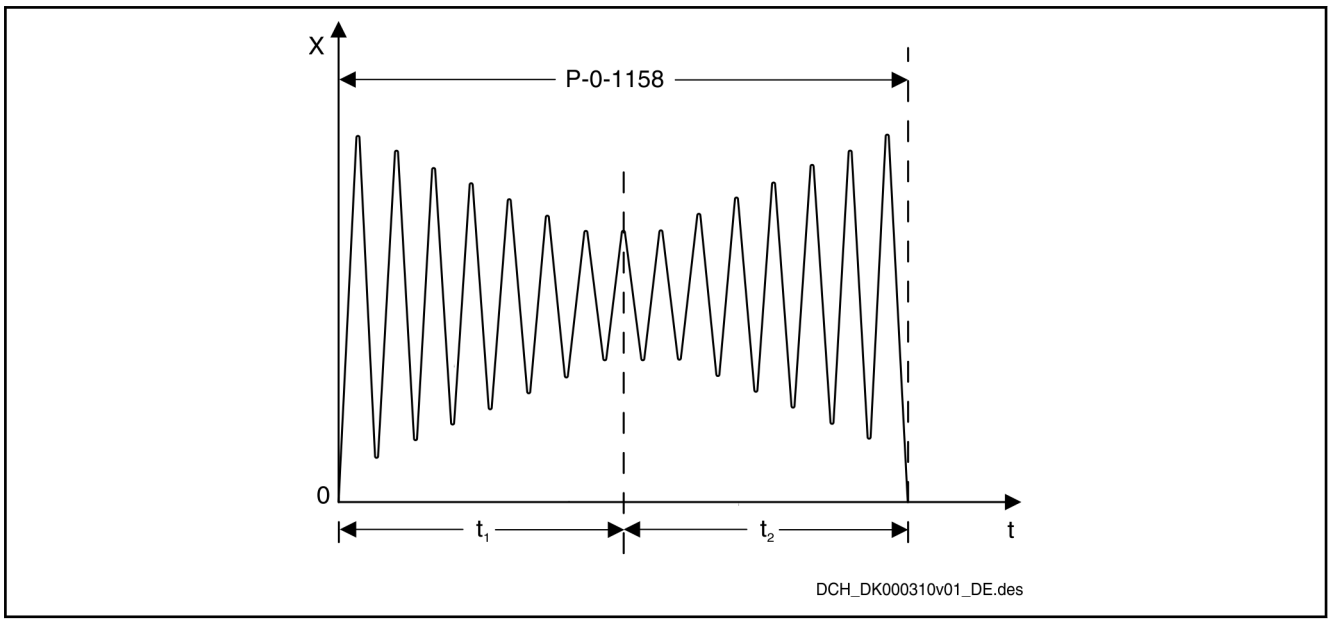
The graphic below exemplarily shows a sine sweep with intervention possibilities:



t_1	Duration "wobbling up"
t_2	Duration "wobbling down"
P-0-1154	Command value generator, offset
P-0-1155	Command value generator, amplitude
P-0-1158	Command value generator, periodic time
P-0-1159	Command value generator, sine sweep start frequency
P-0-1160	Command value generator, sine sweep end frequency

Fig. 8-37: Output signal of the sine sweep generator

☞ The sine sweep without offset has no average values over a whole period ("wobbling up and down"). During "wobbling up" a DC component builds up, which is reduced again during "wobbling down" as shown in the figure below.



t_1 Duration "wobbling up"
t_2 Duration "wobbling down"
P-0-1158 Command value generator, periodic time
Fig. 8-38: Integral sinus sweep without DC component (offset, P-0-1154 = "0")

8.10.3 Notes on commissioning

Controller optimization

The drive-integrated command value generator is excellently suited for optimizing the control loops (position, pressure, swivel angle), since it generates a defined command value course (e.g. pulse or square-wave signals).

Position controller

For examining the position controller, the drive has to be in one of the operation modes "position control with cyclic command value input", "drive-internal interpolation", "drive-controlled positioning" or in the state "Drive Halt".

Under this condition, the input value can be provided directly to the position controller via parameter "P-0-0059, Additive position command value, controller", and the oscilloscope function has to be used for examining the parameters "P-0-0434, Position command value of controller" and "S-0-0051, Position feedback value 1" or "S-0-0053, Position feedback value 2".

Swivel angle controller

The swivel angle controller can only be optimized in functional package DFE. The input value is parameter "S-0-0881, Swivel angle command value, additive". The parameters "P-0-2972, Swivel angle command value of controller and "S-0-0882 Swivel angle actual value" have to be recorded by means of the oscilloscope function.

Pressure controller

For optimizing the pressure controller, an operation mode with “pressure control” has to be selected. Make sure on the system side that the pressure controller is active. Parameter "S-0-0801, Pressure command value additive“ forms the input value for the controller. With the help of the oscilloscope function, the parameter "P-0-2803, Pressure command value of controller" and, depending on the application, the pressure feedback values

"S-0-0803, Pressure feedback value A" or "S-0-0804, Pressure feedback value B" or the resulting pressure feedback value "S-0-0809" have to be recorded.

8.11 Axis optimization

8.11.1 General features

Brief description

Axis optimization has been made available to facilitate the parameter setting of output adjustment in closed-loop operation. Axis optimization allows an automatic establishment of these parameters by traversing the axis with oscillating movements. During this the velocity of the axis is measured in conjunction with various valve command values. Based on these measurements the parameters are automatically computed and stored.

The following parameters can at present be established automatically within the framework of axis optimization:

- Valve standard velocity
- Direction-dependent gain
- Valve control variable offset
- Characteristic curve type

⚠ WARNING **During axis optimization, the axis is traversed with dynamic, oscillating movements at different velocity levels within a defined traversing range.**

In order to avoid **damage to property or even personal injury**, the maximum velocity ("P-0-0171, Optimization of axis, maximum velocity"), the maximum acceleration ("P-0-0170, Drive optimization, acceleration") and jerk ("S-0-0193, Positioning jerk") have to be appropriately set in accordance with the physical properties of the axis. In addition, the travel range for axis optimization has to be set properly with the help of parameters "P-0-0166, Optimization of axis, end position negative" and "P-0-0167, Optimization of axis, end position positive" in order to prevent **collisions with machine parts, tools or even persons** while the axis is being operated.

The emergency stop function of the machine should always be within reach!

Preconditions for axis optimization

In order that axis optimization functions properly, the following conditions must be fulfilled:

- It must be possible to move the axis in closed-loop control
- The axis must have been homed.
- When optimizing is started, "S-0-0108, Feedrate override" must have been set to 100 %

Activating and behavior of axis optimization

- Axis optimization utilizes the command "P-0-0162, C1800 Axis optimization procedure command"
- For this command, a configuration word is available: "P-0-0165, Axis optimization, control word"
- If a drive error occurs during optimizing, the command is aborted.

→ Modified parameters will not be reset.

- The command itself can be aborted at any time by writing the value 0.
  → Modified parameters will not be reset.
- Withdrawing the enable also aborts the command.
- → Modified parameters will not be reset.

Parameters for axis optimization

The user has to enter appropriate values for the following parameters:

- "S-0-0193, Positioning jerk"
- "S-0-0259, Positioning velocity"
- "P-0-0165, Axis optimization, control word"
- "P-0-0166, Optimization of axis, end position negative"
- "P-0-0167, Optimization of axis, end position positive"
- "P-0-0170, Drive optimization, acceleration"
- "P-0-0171, Optimization of axis, maximum velocity"

The end positions have been configured by means of the parameters stated. There is no monitoring for passing of the end positions. If travel range monitoring is required, it has to be activated separately from axis optimization.

The max. acceleration is determined by means of "P-0-0170, Drive optimization, acceleration". The maximum velocity for axis optimization is determined using "P-0-0171, Optimization of axis, maximum velocity". Should this velocity be significantly below the max. possible velocity of the drive, i.e. the valve opening has not exceeded 40 %, the optimization cannot be completed successfully.

When the command is started, a check is run to see whether axis optimization is possible with the parameters entered. If not, the command is aborted and a command error (C1810) is output. The reason for the abortion can be seen from the detailed diagnostics.

Recommended preconditions for establishing the valve characteristic curve

In order to lead the establishment of the valve characteristic curve to a useful result, the following conditions have to be fulfilled.

- A digital position encoder (SSI, 1Vpp, EnDat, incremental) with a resolution of at least 5 µm should be used. Analog position encoders are not suitable.
- When using an SSI encoder, see to it that it is set to “synchronous” (-> encoder synchronizes with the base clock cycle of the HydraulicDrive!). This results in the best possible actual velocity value.
- The natural frequency of the axis should be greater than 10 Hz.



The characteristic curve is calculated on the basis of the measured data. If this function fails, the command is aborted with command error "C1843, Axis optimization: calculation impossible".

Positioning

For optimum results, at the beginning of drive optimization the axis is to be moved to the center between the two end positions. Upon completion of the measurement, the axis moves again to the starting position before the optimization was carried out. The positioning velocity is determined by "S-0-0259, Positioning velocity".

Manual command abortion

The command itself can be aborted at any time by writing the value “0” to "P-0-0162, C1800 Axis optimization procedure command". In the case of a command abortion, the axis comes to a standstill at its current position! If the command is aborted while calculations are carried out, the calculation is completed. The result is rejected, whereas parameters already changed, e.g. valve actuating value offset, are retained.

8.11.2 Valve standard velocity

Determining the valve standard velocity

When bit 3 is set in parameter "P-0-0165, Axis optimization, control word", the valve standard velocity is determined.

Procedure of determining the valve standard velocity

To determine the valve standard velocity, the axis is to be traversed in open-loop control at a velocity set by means of "P-0-0171, Optimization of axis, maximum velocity" within the travel range defined by "P-0-0166, Optimization of axis, end position negative" and "P-0-0167, Optimization of axis, end position positive".

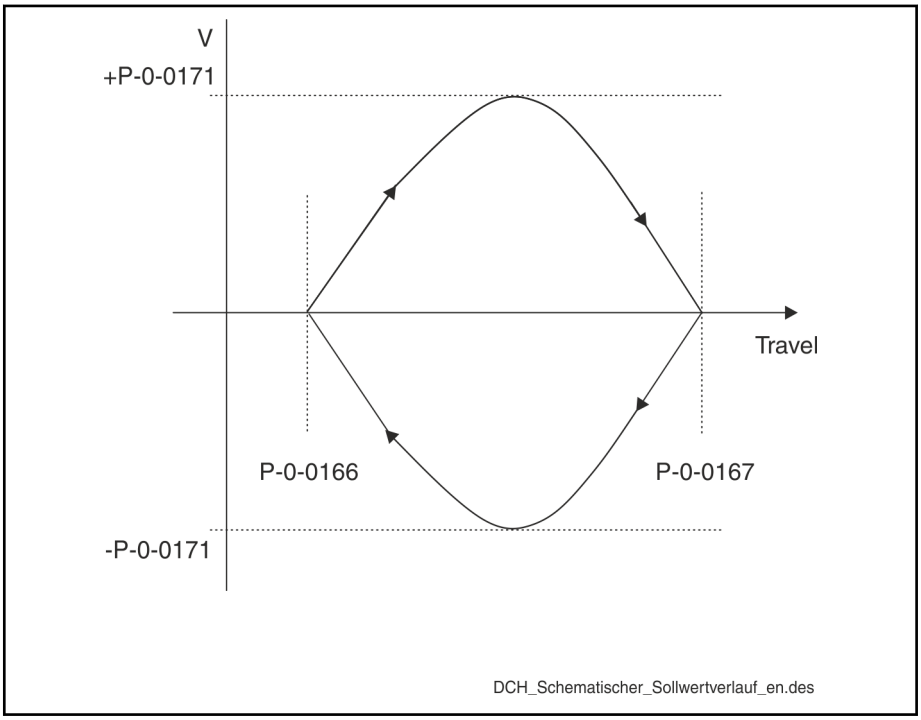


Fig. 8-39: Schematic command value course

The following parameters are modified through drive optimization. Depending on bit 15 in "P-0-0165, Axis optimization, control word", either only the current parameter set or the preselected parameter sets (preselection range according to P-0-2217) are considered.

- P-0-2873.0.1, Valve standard velocity
- P-0-2873.0.11, Valve standard velocity (negativ)
- P-0-2873.0.2, Direction-dependent gain
- P-0-2873.0.13, Valve control variable offset

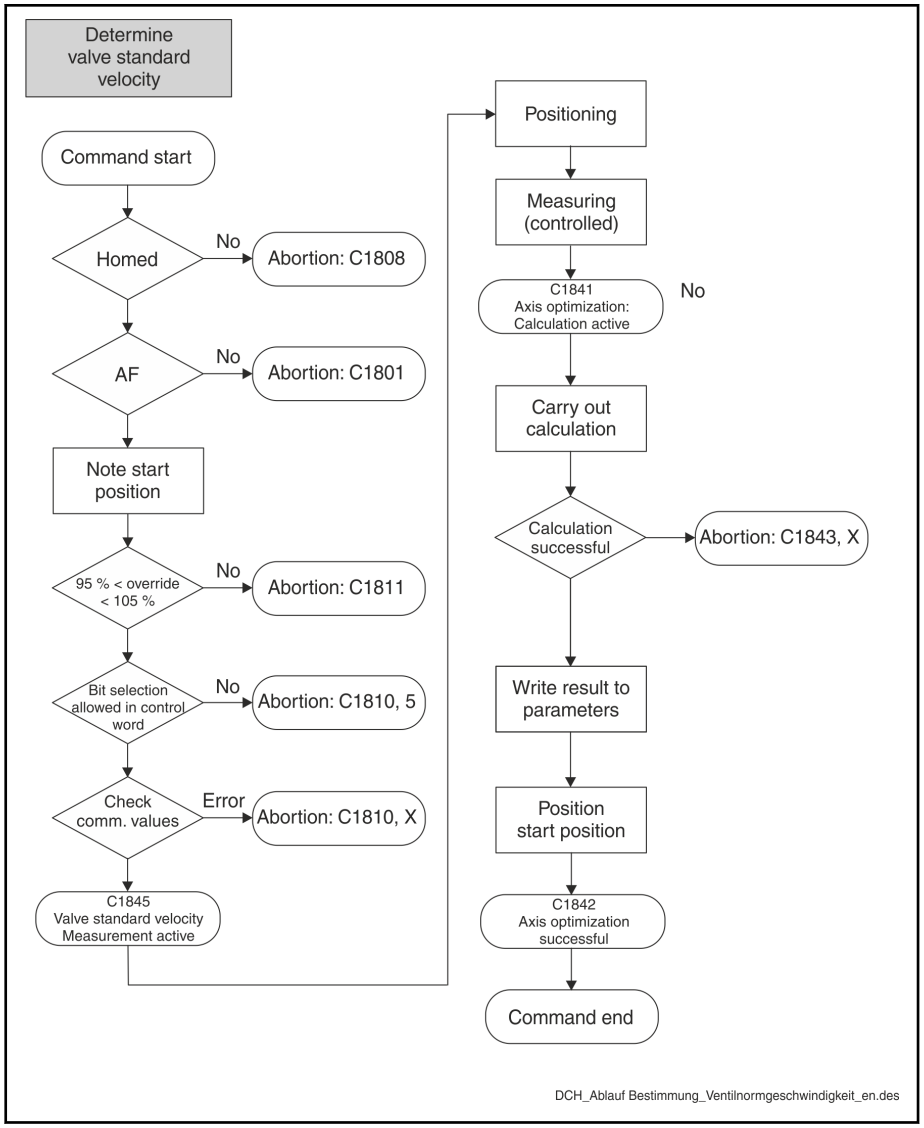


Fig. 8-40: Procedure of determining the valve standard velocity

8.11.3 Valve characteristic curve

Determining the valve characteristic curve

When bit 4 is set in parameter "P-0-0165, Axis optimization, control word", the valve characteristic curve and the valve standard velocity are determined.

Procedure of determining the valve characteristic curve

The sequence of establishing the valve characteristic curve is divided into 2 steps:

Coarse measurement and fine measurement

The coarse measurement is carried out to detect any inflection points and thus to achieve a more precise result in the fine measurement.

While the measurements are taken, the axis is traversed at various velocity levels between the end positions entered, see chapter "Procedure of determining the valve standard velocity" on page 524. The existing output adjustment is utilized. The active parameter set for valve standard velocity and direction-dependent gain is taken into account.

Any valve characteristic curve or valve overlap is not considered. After the valve characteristic curve was measured, the valve standard velocity (negative/positive), direction-dependent gain and valve offset are overwritten by the values established. The characteristic curve type is switched to "asymmetric" and the characteristic curve points are entered.

Any set valve overlap is switched off, since the valve overlap is contained in the established valve characteristic curve.

The current axis optimization progress is signaled by means of separate command diagnostic messages.

Upon completion of the command the axis returns to the position, at which the automatic measurement was started.

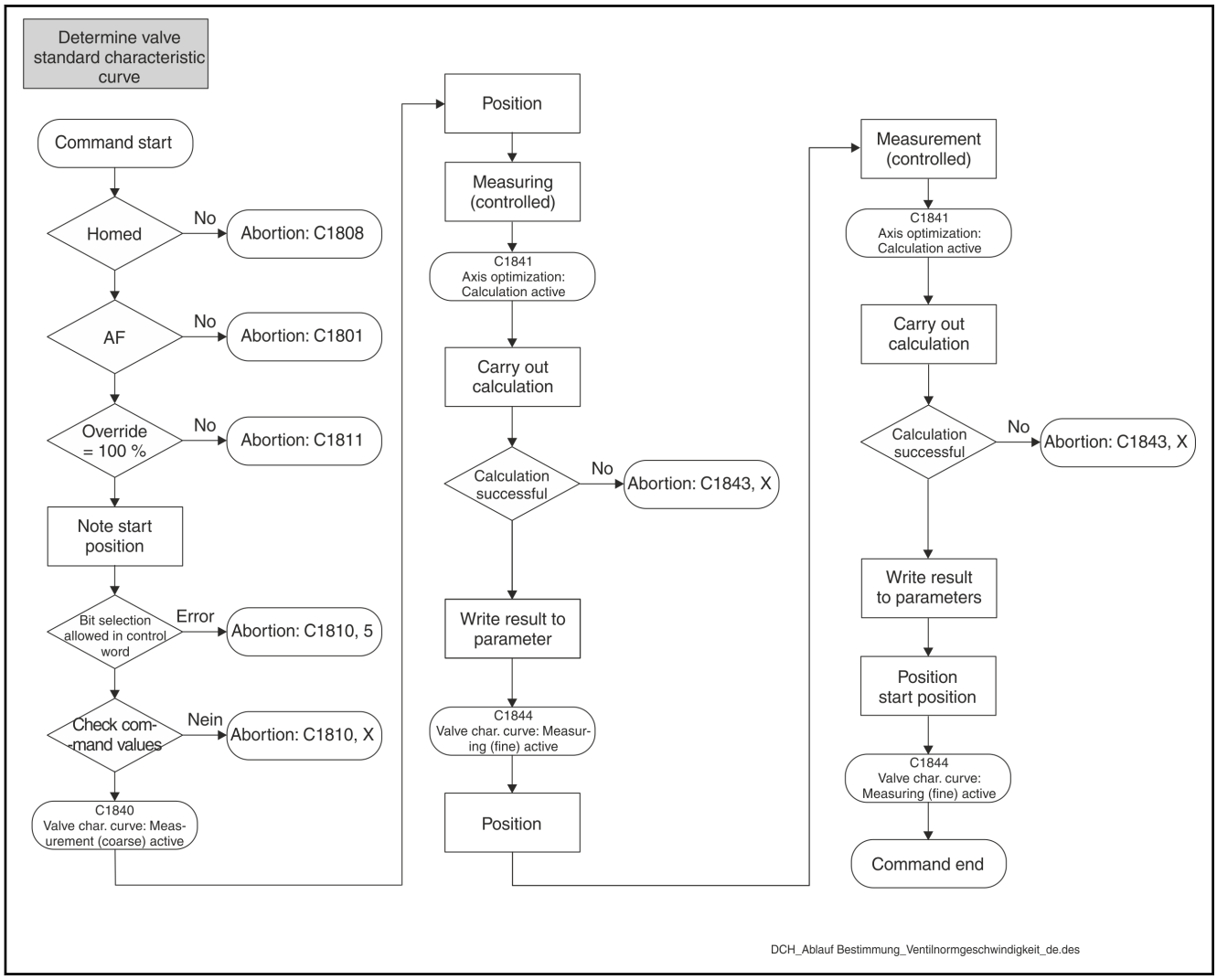


Fig. 8-41: Procedure of determining the valve characteristic curve

The following parameters are modified through drive optimization. Depending on bit 15 in "P-0-0165, Axis optimization, control word", either only the current parameter set or the preselected parameter sets (preselection range according to P-0-2217) are considered.

- P-0-2873.0.1, Valve standard velocity
- P-0-2873.0.11, Valve standard velocity (negativ)
- P-0-2873.0.2, Direction-dependent gain
- P-0-2873.0.4, Valve overlap type

- P-0-2873.0.8, Characteristic of type
- P-0-2873.0.9, Characteristic of flow
- P-0-2873.0.10, Characteristic of control variable
- P-0-2873.0.13, Valve control variable offset

8.11.4 Pertinent parameters and diagnostic messages

Parameters

- P-0-0162, C1800 Axis optimization procedure command
- P-0-0165, Axis optimization, control word
- P-0-0165.0.1, Optimization of axis, internal data 1
- P-0-0165.0.2, Optimization of axis, internal data 2
- P-0-0165.0.3, Optimization of axis, internal data 3
- P-0-0166, Optimization of axis, end position negative
- P-0-0167, Optimization of axis, end position positive
- P-0-0170, Drive optimization, acceleration
- P-0-0171, Optimization of axis, maximum velocity
- S-0-0193, Positioning jerk
- S-0-0259, Positioning velocity
- P-0-2873.0.1, Valve standard velocity
- P-0-2873.0.2, Direction-dependent gain
- P-0-2873.0.3, Control variable inversion
- P-0-2873.0.4, Valve overlap type
- P-0-2873.0.8, Characteristic of type
- P-0-2873.0.9, Characteristic of flow
- P-0-2873.0.10, Characteristic of control variable
- P-0-2873.0.11, Valve standard velocity (negativ)
- P-0-2873.0.13, Valve control variable offset
- P-0-2873.0.16, Output adjustment command value
- P-0-2876, Output control variable adjustment
- P-0-2914, Effective valve command value

Diagnostic messages

- C1800, Axis optimization command
- C1801, Start requires drive enable
- C1808, Drive not homed
- C1810, Incorrect configuration of axis optimization
- C1811, Override unequal to 100 %
- C1840, Valve characteristic: measurement (coarse) active
- C1841, Axis optimization: calculation active
- C1842, Axis optimization successful
- C1843, Axis optimization: calculation impossible
- C1844, Valve characteristic: measurement (fine) active
- C1845, Valve standard velocity: measurement active

9 Parameter, diagnosis and service functions

9.1 Parameters, basics

9.1.1 Properties/features of parameters

Brief description

The controller firmware maps the drive via data to an internal mathematical model. All relevant operating data are mapped to parameters. Each parameter is assigned an identification number (IDN). The IDN allows accessing operating data via

- the engineering interface (TCP/IP)

- or -

- a master communication interface suited for data transfer.

The operating data stored in parameters can be identified by means of the IDN. It can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. Specific parameter values (operating data) are checked for validity by the drive firmware.

Functional description

Parameter structure

Each parameter consists of seven data block elements.

Element no.	Designation	Remark
1	Identification number (IDN)	Parameter identification/ reading of data status
2	Name	Can be changed by means of language selection
3	Attribute	Contains decimal places, data length, data type and display format, function
4	Unit	Can be changed by means of scaling or language selection
5	Minimum input value	Minimum input value of operating datum
6	Maximum input value	Maximum input value of operating datum
7	Operating datum	Parameter value

Tab. 9-1: Data block elements of a parameter

Writing and reading a parameter

All data block elements can be read via an appropriate interface. Only the operating datum can be written.

The operating datum of a parameter can be permanently write-protected or always resp. temporarily be written. The user write access to parameters depends on

- the communication phase

- and -

- the activation of a password.

Parameters with 1-byte data length as single parameters

It is possible to define 1-byte single parameters for certain field buses (CoE, Ethernet POWERLINK, PROFINET, PROFIBUS, EtherNet/IP), where they are also displayed as 1-byte parameters.

In all other master communications and access procedures they are, however, always shown as 2-byte single parameter:

- S/IP
- BRWS protocol server
- SIS protocol
- PROFIBUS acyclic (via SIS protocol)
- Sercos service channel
- MLD
- Control panel
- ...

In our user documentation, these parameters are identified with "data length: 2 bytes/1 byte".

Parameters with 8-byte data length as single or list parameters

8-byte parameters are supported for selected functionalities. Here, certain properties/restrictions always have to be observed.

- Cyclic interfaces
  - can only be used with Sercos III as cyclic interface, but not with other cyclic master communications, analog inputs/outputs, digital I/O
- Oscilloscope function
  - is not possible as recording signal or trigger signal



Trigger time oscilloscope is available as 8-byte parameter

  - not as recording signal for PLC variables (via symbol patch function)
- Cannot be read and/or written via all acyclic communication channels/ services

  The following are possible:
  - Internet protocol services (S/IP)
  - BRWS protocol server
  - SIS protocol
  - PROFIBUS acyclic (via SIS protocol)
  - Sercos service channel
  - SDO services via Ethernet POWERLINK

  Not possible are:
  - SoE mailbox channel [1)]
  - SDO services via CoE, CoC

  [1)] For this reason, 8-byte parameters are introduced only as 32-bit IDN (SI or SE != 0) and are never mapped via the alias numbers (and are thus automatically suppressed with “16-bit master communication”).

  Alternative accesses then have to be realized accordingly.

- As standard procedure, corresponding 4-byte list parameters are used (display format is decimal without sign). Here, the 1st element corresponds to time (fine), the 2nd element to time (coarse). If necessary, an alias IDN may be assigned (see "P-0-0197, System time"
- If the data are to be used as process parameters, corresponding 4-byte single-parameters are created. The first parameter contains the fine value, the next one the coarse value (see "S-0-1305.0.2, System fine time", "S-0-1305.0.3, System coarse time"
- If the original parameter is already an 8-byte list parameter, corresponding parameters are created as 4-byte list parameters. The first parameter list then contains all the fine values, the next one all the coarse values (see "S-0-1303.0.13, Diagnostic trace system time fine", "S-0-1303.0.14, Diagnostic trace system time coarse"

Data status

Each parameter has a data status. The data status contains information on:

- Validity/invalidity of the operating datum (parameter value)
- Status of commands (command acknowledgment) for parameters used for activating commands (see "Terms, basic principles: Commands").

The controller checks the data status of the parameters for validity of the operating datum when changing from parameter mode to operating mode. When this happens, the operating data (parameter values) of the parameters contained in the following list parameters are checked for validity:

- S-0-0018, IDN-list of operation data for CP2
- S-0-0019, IDN-list of operation data for CP3

The control master can query the IDNs of the parameters with invalid operating data (parameter values) via:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

The data status is signaled when the control master executes a write command to the data block element no. 1 of a parameter. This allows the control master to recognize the status of a command which was started.

See "Basic functions of master communication: Command processing"

Language selection

In parameter "S-0-0265, Language selection" you can set the language in which parameter names and text in units of parameter values will be displayed.



The language selection made via parameter S-0-0265 will only take effect in parameter "S-0-0095, Diagnostic message", when the diagnostic message changes, too, after language selection.

Structure of the IDN

With regard to the IDN we distinguish between

- IDN: 16-bit value
- EIDN: 32-bit value. It can only be used in master communications with 32-bit addressing. To be able to access such parameters also in 16-bit-addressed master communications, alias parameters are available as IDN.

IDN structure

Bit no.	Value	Description
15		Standard or product-specific IDN (S or P)
	0	Standard IDN (S-0-nnnn)
	1	Product-specific IDN (P-0-nnnn)
14-12		Parameter sets
	0-7	Parameter set
11-0		Data block or function group
	0-4095	Data block number

Tab. 9-2: IDN structure

EIDN Structure

Bit no.	Value	Description	Comments
31-24		Structure instance (SI)	
	0-255	Number of structure instance (SI)	
23-16		Structure element (SE)	
	0-127 (bit 23 = 0)	Standard SE	Defined by Sercos (bit 15 = 0)
	128-255 (bit 23 = 1)	Product-specific SE	Defined by manufacturer (bit 15 = 0)
15		Standard or product-specific IDN (S or P)	
	0	Standard IDN (S-0-nnnn)	SE (0-127), SI and data block number determined by Sercos
	1	Product-specific IDN (P-0-nnnn)	Bit 31-0 determined by manufacturer
14-12		Parameter sets	
	0-7	Parameter set	Sercos specifies IDNs only for parameter set 0
11-0		Data block or function group	
	0-4095	Data block number (if SI = SE = 0) Function group (if SI or SE unequal to 0)	

Tab. 9-3: EIDN Structure

Notes on commissioning

During the drive-internal check of parameter values carried out when changing from parameter mode to operating mode, the following command errors can be signaled:

- C0201, Invalid parameters (->S-0-0423)
- C0202, Parameter limit error (->S-0-0423)
- C0203 Parameter conversion error (->S-0-0423)

When errors of this category are detected, the IDNs of the parameters with the incorrect operating data are listed in:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

A valid value has to be written to the listed IDNs. The value range limits are contained in the data block elements no. 5 and no. 6. When inputting single parameters, the limits are directly displayed via the "IndraWorks Ds/D/MLD" commissioning tool.

Language setting

The desired display language of parameter names and text in units of parameter values has to be set in parameter

- S-0-0265, Language selection.

9.1.2 Loading, storing and saving parameters

Brief description

Parameters

All relevant operating data are mapped to parameters and stored in the controller.

Data memory

HydraulicDrive controllers are provided with

- a non-volatile memory
- a volatile data memory (working memory)

Condition as supplied

Condition as supplied of the Rexroth drive components:

- The controller memory contains the drive firmware and the controller-specific parameter values.

Storing the application-specific parameter values

The application-specific parameter values are stored in the controller. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can also be stored in the working memory (volatile memory).

Storing parameter values

Saving application-specific parameter values is required in the following cases:

- After initial commissioning of the machine axis
- Before replacing the controller in the case of repairs (if possible)

Application-specific parameter values can be saved via:

- Commissioning tool "IndraWorks Ds/D/MLD" → Saving of parameter values to external data carrier
- Control master → Saving parameter values on master-side data carrier

Parameter IDN lists

The drive supports saving of parameter values on the master side by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer.

Loading parameter values

Loading parameter values is required in the following cases:

- Initial commissioning (loading of default values)
- Serial commissioning of machine axes on series machines (loading the parameter values saved after initial startup)
- Restoring of a defined initial state (re-loading of the parameter values saved after initial startup)
- Replacing the controller in the case of a failure (loading the current parameter values saved before the failure)

Possibilities of loading parameter values to the controller:

- Commissioning tool "IndraWorks Ds/D/MLD" → Loading parameter values from an external data carrier
- Control master → Loading of parameter values from master-side data carrier

Checksum of parameter values

By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive correspond to the values saved on the master side.

Pertinent parameters

- S-0-0017, IDN-list of all operation data
- S-0-0192, IDN-list of all backup operation data
- S-0-0262, C07_x Load defaults procedure command
- S-0-0263, C2300 Load working memory procedure command
- S-0-0264, C2200 Backup working memory procedure command
- S-0-0269, Storage mode
- S-0-0270, IDN-list of selected backup operation data
- S-0-0293, C2400 Selectively backup working memory procedure command
- S-0-0326, Parameter checksum
- S-0-0327, IDN list of checksum parameter
- S-0-0531, Checksum of backup operation data
- P-0-0013, List of all IDNs not corresponding to default value
- P-0-0660.0.1, Configurable factory default values
- P-0-4023, C0400 Communication phase 2 transition
- P-0-4090, Configuration for loading default values

Pertinent diagnostic messages

Loading default values:

- C0700, Load defaults proced. Command
- C0702, Default parameters not available
- C0703, Default parameters invalid
- C0704, Parameters not copyable
- C0706, Error when reading the controller parameters
- C0730, Load defaults procedure command (MLD)
- C0740, Command Activate field bus profile settings
- C0743, Error in activation of field bus profile settings
- C0750, Load defaults procedure command (factory settings)
- C0751, Parameter default value incorrect (-> S-0-0423)
- C0752, Locked with password
- C0761, Factory default values incorrect (->S-0-0423)
- C0799, An invalid index was set

Backup working memory:

- C2202, Error when writing data to non-volatile memory
- C2200, Backup working memory procedure command

Loading working memory:

- C2300, Load working memory procedure command
- C2301, Error when reading non-volatile memory

- C2302, Error when converting parameters

Selective backup of working memory:

- C2400, Selectively backup working memory procedure command
- C2402, Error when saving parameters

Further diagnostic messages:

- F2100, Incorrect access to command value memory

Functional description

Parameter and operating mode

Parameters the operating datum of which can be changed, can be written with values in one or possibly several communication phases. We basically distinguish between

- Parameter mode (PM) and
- Operating mode (OM)

As a matter of principle, all parameters that can be changed can be written in the parameter mode.

Storage mode

Depending on "S-0-0269, Storage mode", the application-specific parameter values are stored in the controller in volatile form (in the working memory) or non-volatile form (in the flash memory).

Non-volatile storage is carried out with each write access to the respective operating datum.

Volatile storage of parameter values is recommended when application-specific parameters are cyclically written. Otherwise, the service life of the non-volatile storage media is affected.

NOTICE **Damage to the internal memory (flash) caused by cyclic command execution (write access to the flash)!**

During the execution of some commands (see description of the respective diagnostic command message; e.g. C0500), data are written to the internal memory (flash), too. This memory, however, only allows a limited number of write accesses. For this reason, it is to be ensured that such write accesses are not carried out too often (maximum of approx. 100,000 writing cycles).

Parameter IDN Lists

For saving the relevant application-specific parameter values the drive makes lists of IDNs available that support the complete storage of the values of parameter groups:

- S-0-0192, IDN-list of all backup operation data
- S-0-0270, IDN-list of selected backup operation data

Parameter S-0-0192 contains a list of IDNs that cannot be modified. Parameter S-0-0270 contains an empty list in which certain IDNs according to application-specific requirements can be entered.

For saving all parameter values, the drive makes available the list of the IDNs of all parameters in

- S-0-0017, IDN-list of all operation data

To identify the parameters the value of which has changed compared to their default value, the drive makes available the parameter

- P-0-0013, List of all IDNs not corresponding to default value

Command "backup working memory" or "selectively backup working memory"

If the option "volatile storage" was set in parameter "S-0-0269, Storage mode", the values of the parameters contained in the list parameter S-0-0192

can be saved in the non-volatile flash memory when "S-0-0264, C2200 Backup working memory procedure command" is started.

If the parameter values of the list of S-0-0270 are to be saved, "S-0-0293, C2400 Selectively backup working memory procedure command" must be activated. Unless the storage mode (S-0-0269) is changed, the values once saved in the flash memory via the commands C2200 or C2400 remain unchanged.

Command "load working memory procedure"

By means of "S-0-0263, C2300 Load working memory procedure command", the values from the non-volatile flash memory are copied to the volatile working memory.

☞ This only makes sense when volatile storage mode was set (S-0-0269) and parameter values were saved in the controller-internal flash memory!

Saving application-specific parameter values

The application-specific parameter values, e.g. after initial commissioning, can be stored in different ways:

- Commissioning tool "IndraWorks Ds/D/MLD"

  → The parameter values of the list of S-0-0192 are stored on an external data carrier (hard disk, floppy disk or the like); target assignment is carried out via the menu of the tool. This requires an engineering connection to the drive.

- Control master

  → The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are stored on a master-side data carrier by command of the control master.

Loading application-specific parameter values

To load saved parameter values or transmit axis-specific parameter values to controllers of other axes, there are the following possibilities:

- Commissioning tool "IndraWorks Ds/D/MLD"

  → The parameter values (according to list of S-0-0192) stored on an external data carrier (hard disk, floppy disk or the like) are loaded to the controller; source are assigned via the menu of the tool. This requires an engineering connection to the drive.

- Control master

  → The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are loaded from a master-side data carrier to the controller by command of the control master.

Parameter checksum via list parameter S-0-0327

When reading the parameter "S-0-0326, Parameter checksum", the checksum of all parameter values is generated, the IDNs of which are contained in parameter "S-0-0327, IDN list of checksum parameter". Changes in the parameter settings can be detected by comparing the checksums.

By comparing the checksum of the parameter values currently active in the drive to a checksum value stored at the time of parameter saving, it is possible to determine whether the active application-specific parameter values are correct.

By default, there haven't any IDNs been entered in parameter S-0-0327!

Parameter checksum via list parameter S-0-0192

When reading the parameter "S-0-0531, Checksum of backup operation data", the checksum of the parameters is generated, the IDNs of which are contained in parameter "S-0-0192, IDN-list of all backup operation data".

☞ In list parameter S-0-0192, the IDNs of those parameters are stored the values of which are axis-specific and have to be loaded to the drive of the respective axis for regular operation.

When the installation has been completely set up, the checksum for each drive can be read via the parameter S-0-0531. The control master can store these values. By comparing the checksum which was saved to the new checksum which was read, it is possible to find out whether data relevant to operation have changed.

Notes on commissioning

Initial commissioning

At the beginning of initial commissioning of a machine axis, first make sure the desired firmware is active in the drive. To do this, read parameter

- S-0-0030, Manufacturer version.

If the desired firmware is not available in the controller, carry out a firmware update or firmware upgrade (see "Firmware replacement").

Loading default values

If the desired firmware is available in the controller, load basic parameter values of the firmware by carrying out the following steps:

1. Make determinations in parameter "P-0-4090, Configuration for loading default values"
2. Start "S-0-0262, C07_x Load defaults procedure command"

Associated diagnostic command message:

- C0750, Load defaults procedure command (factory settings)

Associated diagnostic messages in the case of possible command errors:

- C0751, Parameter default value incorrect (-> S-0-0423)
- C0752, Locked with password

With storage mode "volatile storage"

When the option "volatile storage" was set in parameter "S-0-0269, Storage mode", the parameter values are not automatically stored in the drive-internal flash memory. After complete input, the application-specific parameter values therefore have to be saved drive-internally in the flash memory by

- starting "S-0-0264, C2200 Backup working memory procedure command"

This guarantees that the parameter values suitable for the axis are automatically loaded to the controller's working memory from the flash memory after the drive is switched on again.

Associated diagnostic command message:

- C2200, Backup working memory procedure command

Associated diagnostic messages in the case of possible command errors:

- C2202, Error when writing data to non-volatile memory

After all application-specific parameter values are saved (C2200), it is also possible to only save selected parameter values in the flash memory. These parameters are overwritten with a current value. This is done by

- starting "S-0-0293, C2400 Selectively backup working memory procedure command"

The C2400 command can be used for internally saving a parameter group the values of which have to be optimized again during operation, for example. It is advisable to determine the IDNs of this parameter group by clearing IDNs that are not required from the default setting of the list parameter

- S-0-0270, IDN-list of selected backup operation data

☞ In the case of the "volatile storage" mode, the command C2200 has to be executed at least once before starting the command C2400, because otherwise basic parameter values are maintained for some parameter values in the flash memory.

Associated diagnostic command message:

- C2400, Selectively backup working memory procedure command

Associated diagnostic messages in the case of possible command errors:

- C2402, Error when saving parameters

Loading and saving parameter values via control master or "IndraWorks Ds/D/MLD"

An appropriate master communication interface or the serial interface can be used for loading and saving parameter values via the control master or "IndraWorks Ds/D/MLD".

9.1.3 IDN lists of parameters

General information

Some parameters saved in the drive contain as operating datum (parameter value) a list of IDNs of drive parameters, which correspond to a certain, given criterion. These so-called IDN lists allow target-oriented handling of drive parameters by the master or commissioning software.

IDN list of all operation data (S-0-0017)

The parameter "S-0-0017, IDN-list of all operation data" contains the IDNs of all parameters available in the drive.

IDN list of backup operation data (S-0-0192)

Parameter "S-0-0192, IDN-list of all backup operation data" contains the IDNs of all parameters that are stored in the non-volatile memory (flash memory). These parameters are required for correct operation of the drive. In conjunction with the master or a commissioning software it is possible to use this IDN list for making a backup copy of the drive parameters.

IDN-list of invalid operation data for CP2 (S-0-0021)

In parameter "S-0-0021, IDN-list of invalid operation data for CP2", the IDNs of those parameters are automatically entered which the drive software detects as being invalid when executing the command "S-0-0127, C0100 Communication phase 3 transition check".

Parameters are detected as being invalid, if:

- Their checksum does not match the operating datum [the checksum is stored together with the operating datum in a non-volatile memory (flash memory, amplifier or encoder data memory)]

- or -

- Their operating datum is outside the minimum or maximum input limits

- or -

- Their operating datum violates specific validation rules.

In any event, the parameters entered in parameter "S-0-0021, IDN-list of invalid operation data for CP2" must be corrected upon negative acknowledgment of the command "S-0-0127, C0100 Communication phase 3 transition check".

IDN-list of invalid operation data for CP3 (S-0-0022)

In parameter "S-0-0022, IDN-list of invalid operation data for CP3", the IDNs of those parameters are automatically entered which the drive software de-

tects as being invalid or unduly configured when executing the command "S-0-0128, C5200 Communication phase 4 transition check".

Parameters are detected as being invalid, if:

- Their checksum does not match the operating datum [the checksum is stored together with the operating datum in a non-volatile memory (flash memory, amplifier or encoder data memory)]

- or -

- Their operating datum is outside the minimum or maximum input limits

- or -

- Their operating datum violates specific validation rules.

Parameters are detected as being unduly configured, if

- they were configured more than once for writing by a cyclic interface.

In any event, the parameters entered in parameter "S-0-0022, IDN-list of invalid operation data for CP3" must be corrected upon negative acknowledgment of the command "S-0-0128, C5200 Communication phase 4 transition check".

IDN list of invalid data for parameterization levels (S-0-0423)

When command "C0200, Exit parameterization level procedure command" is executed, the drive parameters are checked and converted. If errors occur during this check, the IDNs of the faulty parameters are written to the list parameter "S-0-0423, IDN-list of invalid data for parameterization levels".

IDN list of operation data for communication phase 2 (S-0-0018)

The IDNs that are checked for validity when command "S-0-0127, C0100 Communication phase 3 transition check" is executed are stored in the operating datum of parameter "S-0-0018, IDN-list of operation data for CP2".

IDN list of operation data for communication phase 3 (S-0-0019)

The IDNs that are checked for validity when command "S-0-0128, C5200 Communication phase 4 transition check" is executed are stored in the operating datum of parameter "S-0-0019, IDN-list of operation data for CP3".

IDN list of all command parameters (S-0-0025)

The operating datum of parameter "S-0-0025, IDN-list of all procedure commands" contains the IDNs of all parameters available in the drive.

IDN list of selected backup operation data (S-0-0270)

The IDNs of those parameters that are to be saved when command "S-0-0293, C2400 Selectively backup working memory procedure command" is executed are stored in parameter "S-0-0270, IDN-list of selected backup operation data".

IDN list of password-protected operation data (S-0-0279)

The parameter "S-0-0279, IDN-list of password-protected operation data" contains the IDNs of those parameters that can be protected by a customer password (S-0-0267). By default, no IDNs have been entered in this parameter.

IDN list of checksum parameters (S-0-0327)

The parameter "S-0-0327, IDN list of checksum parameter" contains the IDNs of those parameters from which the content of parameter "S-0-0326,

Parameter checksum" is to be generated. By default, no IDNs have been entered in this parameter.

IDN list of all parameter values not corresponding to default value (P-0-0013)

All parameters whose default operating datum was changed are stored in parameter "P-0-0013, List of all IDNs not corresponding to default value".

9.1.4 Password protection

Brief description

HydraulicDrive controllers provide the possibility of protecting parameter values against accidental or unauthorized change by means of a password. With regard to write protection, there are 3 groups of writable parameters:

- Parameters that are generally write-protected, such as valve parameters, hardware code parameters, error memories, etc. ("administrative parameters"). The values of these parameters ensure correct functioning and performance of the drive.
- Parameters, which the customer can combine in groups and protect with a so-called customer password. This allows protecting parameter values that are used for adjusting the drive to the axis after their definition.
- All other writable parameters not contained in the above-mentioned groups. They are not write-protected.

The drive firmware allows activating and deactivating the write protection for parameter values by means of three hierarchically different passwords:

- **Customer password**

  → The parameter values of a parameter group combined by the customer can be protected.
- **Control password**

  → Parameters protected by a customer password are writable; "administrative parameters" remain read-only.
- **Master password**

  → All writable parameters, including "administrative parameters" and parameters protected by a customer password, can be changed.



The customer password can be defined by the customer, the control password and the master password are defined by the manufacturer!

Pertinent parameters

- S-0-0192, IDN-list of all backup operation data
- S-0-0267, Password
- S-0-0279, IDN-list of password-protected operation data
- P-0-4064, Password level
- P-0-4064.0.1, Password configuration
- P-0-4064.0.2, Password token

Functional description

The write protection for parameter values is activated or deactivated by three hierarchically different passwords by an input in parameter "S-0-0267, Password".

Customer password

By a password defined by the customer, the parameters of a parameter group to be defined can be protected against unauthorized or accidental write access.

The customer password has to comply with the following conditions:

- At least 3 characters long
- A maximum of 10 characters long
- May only include the characters a…z, A…Z and the numbers 0…9

The group of parameters the values of which can be protected by the customer password is defined in parameter "S-0-0279, IDN-list of password-protected operation data". In the condition as supplied the parameter S-0-0279 does not contain any IDN. In list parameter S-0-0279 parameter IDNs can be entered according to application-specific requirements.

☞ The customer password is not obligatory! If it has not been activated, the values of the parameters listed in the list parameter S-0-0279 can still be written.

Control password

After the firmware-specific control password defined by the manufacturer was entered, it is also possible to write parameters protected by a customer password. The control password therefore allows the NC control unit to ignore the write protection established by the individual (unknown) customer password.

The functions of

- locking the FW update functionality by a customer password
- using the set customer password for IP services

are also cancelled by the control password.

☞ The control password valid for the respective firmware is only available from the manufacturer on demand!

Master password

The master password is also defined by the manufacturer, but is exclusively available to development and service staff of Rexroth.

The functions of

- locking the FW update functionality by a customer password
- using the set customer password for IP services

are also cancelled by the control password.

☞ The master password is secret! It must not be used on the control unit side or by the customer, because it also allows changing the values of "administrative parameters" (valve parameters, hardware code parameters, error memory, etc.).

Activating/deactivating the write protection

In the condition as supplied, "S-0-0267, Password" contains the value "007". The write protection is activated and deactivated by means of the customer password according to the following procedure:

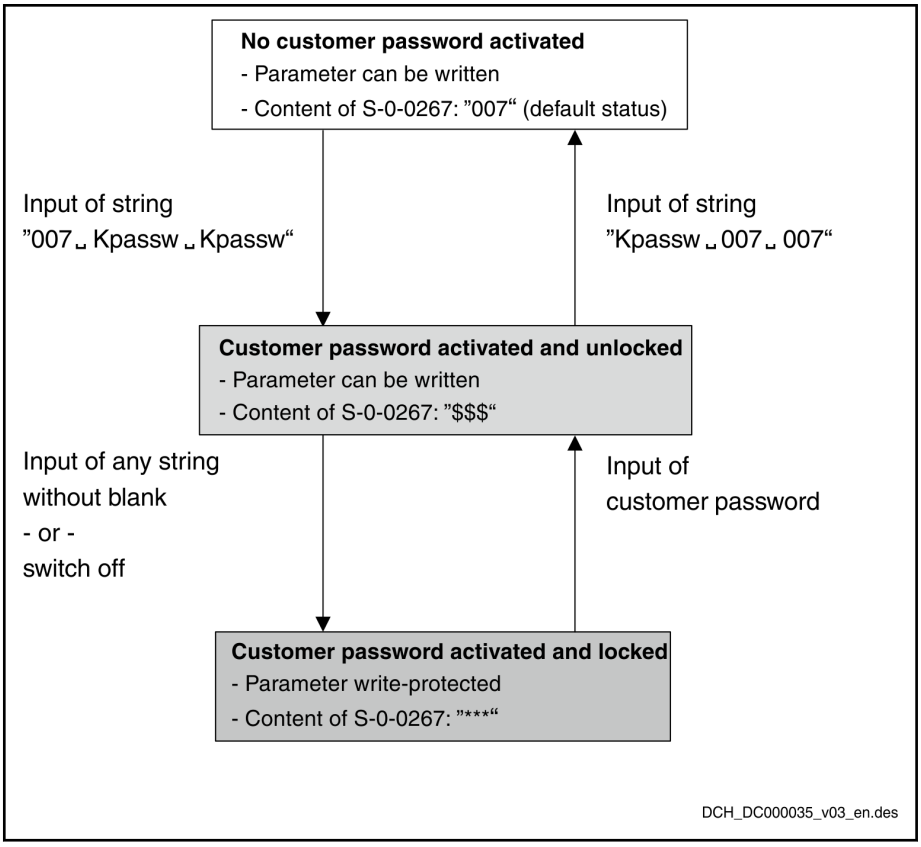


Fig. 9-1: Activating and deactivating the write protection by means of the customer password

The write protection activated via customer password is deactivated by entering the control password in S-0-0267. The write protection required by the customer can be activated again by entering any string of characters in S-0-0267.

The write protection for all parameters that can generally be written can only be deactivated by means of the master password and the right to do this is exclusively reserved to the development and service staff of Rexroth!

Overview of password levels (P-0-4064.0.0)

Content of P-0-4064	Content of S-0-0267	Description	Parameters according to S-0-0279	Administration parameters	Remaining parameters
0	"007"	No password available	S, L	L	S, L
1	"$$$"	Customer password available, but deactivated	S, L	L	S, L
2	"***"	Customer password available and activated	L	L	S, L
-[cnt] Cnt[sec] -30 ... -1	"XXX"	Temporary password input lock active (30 sec)	L	L	S, L
3	"$$$"	Control password entered	S, L	L	S, L

S: Write access, L: Read access

Tab. 9-4:

NOTICE **Incorrect activation of drives when changing parameter values that are write-protected on the firmware side ("administrative parameters")!**

⇒ The master password must not be used on the control unit side or by the customer!

Series commissioning, including customer password

To provide the possibility of series commissioning including customer password without the clear text password appearing in the parameter file, the customer password is coded and stored in a parameter (P-0-4064.0.2), with which it can be read and written.

A customer password already set on a target device is only overwritten when the target device is unlocked, that is, at password level unequal to 2.

Protection against brute force attack

To increase protection against trying passwords, a 30-second lock is activated after 3 wrong passwords entries (no distinction between customer, control or master password). Wrong entries, which trigger a lock, will generate an entry in the diagnostic message memory. An active lock is visualized by a negative value in the password level (P-0-4064.0.0) and string “XXX” in S-0-0267. The negative value in the password level visualizes the remaining time of the lock in seconds.

Blocking the FW update functionality

In password level 2 the regular FW update can be optionally deactivated (can be configured using bit 0 in P-0-4064.0.1; default: no update lock).

Updating attempts made when the function is locked are reported via the relevant FW download log.

Exception: If the device does not boot due to problems, the firmware can be updated via the internal boot kernel / loader independently of the password level.

Attention:

Before downgrading to a version before 20V12 (without coded password storage) it is indispensable:

- that a set customer password is removed (enter: "<Password> 007 007")

  or

- that the "load defaults procedure" command is executed (will also remove the customer password)

If this procedure is not adhered to, the device will be locked after downgrading and can only be unlocked again with the control or the master password.

Using the set customer password for IP services

Optionally, the customer password assigned for the FTP and telnet access can be used as user password. This can be configured via bit 1 in P-0-4064.0.1 (default: standard accounts are used).

FTP:

When the bit is set in password level 2, the guest access (“anonymous”/mail address; read only) and the user “backup” are locked.

If no customer password is set, the default password continues to be accepted for the user “boschrexroth”.

Telnet:

If bit 1 is set in P-0-4064.0.1 and a customer password is set, it will be used. Otherwise, the default password is used.

Also here, after 3 failed login attempts, a 30-second lock becomes active and then the connection is closed. The counter for failed login attempts is only reset after a successful login or after a reboot.

Locking the (soft) reboot functionality (S-0-1350.0.0 / C6400) and C9900 service functions (P-0-0260.0.0 / C9900)

No specific action required. This can be accomplished by an entry in the list of protected parameters.

Notes on commissioning

Define the IDNs of the group of parameters the values of which are to be write-protected in parameter

- S-0-0279, IDN-list of password-protected operation data.

The customer-side write protection via the customer password for the parameters contained in S-0-0279 can be activated and deactivated by writing the parameter

- S-0-0267, Password.

 Observe the conditions for defining the customer password!

If the active write protection for the parameters defined in S-0-0279 is to be disabled on the master side or without knowledge of the customer password, enter the control password in parameter

- S-0-0267, Password.

 The control password has to be obtained from the vendor!

Status query for write protection

The current status of write protection can be queried via parameter

- P-0-4064, Password level.

Diagnostics

In an attempt to write data to a write-protected parameter, an error code is transmitted to the Sercos master via the non-cyclic data channel, according to the Sercos specification. The master then recognizes that the respective parameter is write-protected and that it is impossible to write data to it.

9.1.5 Reset to default values

Brief description

By executing command "S-0-0262, C07_x Load defaults procedure command" a defined initial state of the parameter values can be restored.

This results in clearing of any PLC program (MLD) or the settings for master communication and the engineering interface are reset, unless this was excluded from loading of default values.

The saving mode is set to "saving" at the beginning of the command so that non-volatile parameters are then permanently stored.

The scope of functions of this command can be determined by configuring the parameter "P-0-4090 Configuration for loading default values".

- **Selection of the scope of functions of the command** (bit 0...2, P-0-4090):
  - Load default values (factory settings), bit 0 = 1

    Loading default values for all non-volatile parameters
  - Load default values (MLD), bit 1 = 1

    Resetting of parameters (including boot project) of the PLC integrated in the drive
  - Activate field bus profile settings, bit 2 = 1

Field bus-related parameters are activated in dependence on their profile

→ see "Profile types (with field bus interfaces)"

- **Scaling of command execution** (Bit 4...6, P-0-4090):

  With the command "load default values", you have the option to load default values for all parameters or to selectively exclude the following groups:

  – Master communication parameters, bit 4 = 1
  – MLD parameters, bit 5 = 1
  – Parameters of the engineering interface, bit 6 = 1

 See also parameter description "P-0-4090, Configuration for loading default values"

Load default values (factory settings)

By setting bit 0 in P-0-4090, "S-0-0262, C07_x Load defaults procedure command" (factory settings) is carried out for all non-volatile parameters when the command is executed.

Preconditions:

In order that command "S-0-0262, C07_x Load defaults procedure command" can be successfully executed, the following conditions have to be fulfilled:

- The axis, for which the command is to be executed, has to be in the parameterization mode (PM). In the case of a multi-axis device, the other axes have to be in the parameterization mode as well.
- No axis of the device must be locked by a customer password.

Scaling of command execution

Apart from the possibility of loading default values for all non-volatile parameters, the following groups can be selectively excluded by setting the relevant bits 4...6 in parameter P-0-4090.

The exclusions may also be combined:

- Exclusion of master communication parameters, bit 4 = 1
- Exclusion of MLD parameters, bit 5 = 1
- Exclusion of the parameters of the engineering interface, bit 6 = 1

Depending on the operating state, it may be necessary to exclude a group in order that the command can be successfully executed.

Example:

Parameters of master communication have to be excluded, if master communication is in cyclic operation and the default values are to be loaded via master communication.

Possible diagnostic messages:

- C0750, Load defaults procedure command (factory settings)
- C0751, Parameter default value incorrect (-> S-0-0423)
- C0752, Locked with password
- C0798, All axes of the device must be in the parameter mode

Load default values (MLD)

By setting bit 1 in P-0-4090, default values are loaded for the MLD when command S-0-0262 is executed. With this command, the following is carried out:

- Clearing of the MLD program (including boot project)
- Setting of non-volatile MLD parameters to their default values
- Resetting of MLD register attributes

Preconditions:

In order that command S-0-0262 can be successfully executed, the following conditions have to be fulfilled:

- The axis, for which the command is to be executed, has to be in the parameterization mode (PM). In the case of a multi-axis device, the other axes have to be in the parameterization mode as well.
- No axis of the device must be locked by a customer password.

Possible diagnostic messages:

- C0730, Load defaults procedure command (MLD)
- C0752, Locked with password
- C0798, All axes of the device must be in the parameter mode

Activate field bus profile settings

By setting bit 2 in P-0-4090, the field bus profile settings are activated when command S-0-0262 is executed. Field bus-related parameters are activated in dependence on the profile. See "Profile types (with field bus interfaces)"

Precondition:

In order that command S-0-0262 can be successfully executed, the following conditions have to be fulfilled:

- The axis, for which the command is to be executed, has to be in the parameterization mode (PM). In the case of a multi-axis device, the other axes have to be in the parameterization mode as well.
- No axis of the device must be locked by a customer password.

Possible diagnostic messages:

- C0740, Command Activate field bus profile settings
- C0743, Error in activation of field bus profile settings
- C0752, Locked with password
- C0798, All axes of the device must be in the parameter mode

9.1.6 Command processing

Overview

Commands are used to control complex functions in the drive. For example, the functions "drive-controlled homing procedure" or "transition check for communication phase 3 to 4" are defined as commands.

All commands available in the drive are stored in parameter "S-0-0025, IDN-list of all procedure commands".

Types of commands

Three types of commands are distinguished:

- **Drive control commands**
  - can cause automatic drive motion,
  - can only be started when drive enable has been set
  - deactivate the active operation mode during its execution

- **Administration commands**
  - carry out administration task,
  - cannot be interrupted

Command execution

General information

Observe the following aspects for command execution:

- Belonging to each command there is a parameter with which the command execution can be controlled.
- The higher-level master can start, interrupt and clear commands.
- While the command is being executed, parameter S-0-0390, Diagnostic message number displays the complete command.
- Each command that was started by the master must be actively cleared again.

NOTICE **Damage to the internal memory (flash) caused by cyclic command execution (write access to the flash)!**

⇒ During the execution of some commands (see description of the respective diagnostic command message; e.g. "C0500, Reset class 1 diagnostics, error reset"), data are written to the internal memory (flash), too. This memory, however, only allows a limited number of write accesses. For this reason, it is to be ensured that such write accesses are not carried out too often (maximum of approx. 100,000 writing cycles).

Controlling the command execution

The command execution is controlled and monitored by command input and command acknowledgment. By the input the drive is informed on whether the command execution is to be started, interrupted or completed. The information is provided via the operating datum of the respective parameter.

Commands are started or terminated by:

- Direct writing to the respective command parameter (e.g. "S-0-0099, C0500 Reset class 1 diagnostics" with command "C0500, Reset class 1 diagnostics, error reset") via master communication

- or -

- a positive edge when the command was assigned to a digital input

  See also chapter:
  - "Configurable signal control word"
  - "Digital inputs/outputs"

Possible command inputs

For command execution, we distinguish the following inputs (= content of command parameter):

- **0:** Not set and not enabled
- **1:** Interrupted
- **3**: Set and enabled

Command acknowledgment

In the command acknowledgment, the drive provides information about the current status of the command execution. The current status is contained in the data status of the command parameter.

☞ The command status can be obtained by executing a write command to parameter element 1 (data status) of the command parameter.

Command status

The command status can be:

- **0x0:** not set and not enabled
- **0x7:** in process
- **0xF:** Error, command execution impossible
- **0x5**: Command execution interrupted
- **0x3:** Command correctly executed

Command change bit

For master-side detection of a change of the command acknowledgment by the drive, the "change bit commands" (KA bit) is available for Sercos in parameter "S-0-0135, Drive status word".

- The drive sets this bit when the command acknowledgment changes from the "in process (0x7)" state to one of the following states:
  - Error, command execution impossible (0xF)

  - or -

  - Command correctly executed (0x3)
- The bit is cleared when the master clears the input (0x0), i.e. writes "0" to the parameter belonging to the command.

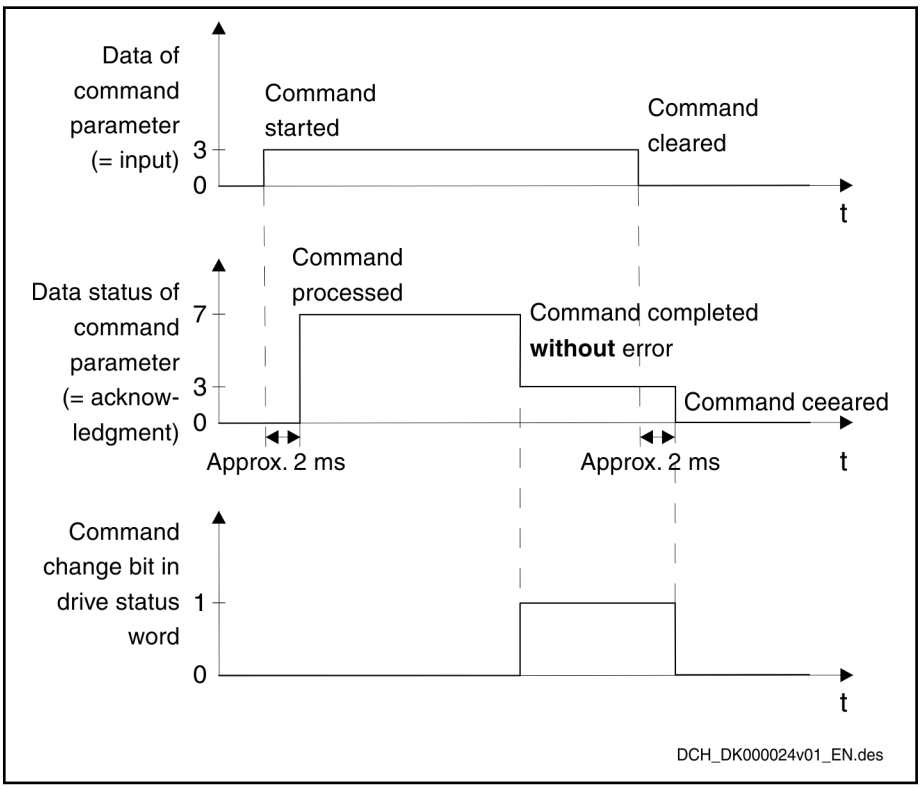


Fig. 9-2: Input, acknowledgment and command change bit in the case of correct execution

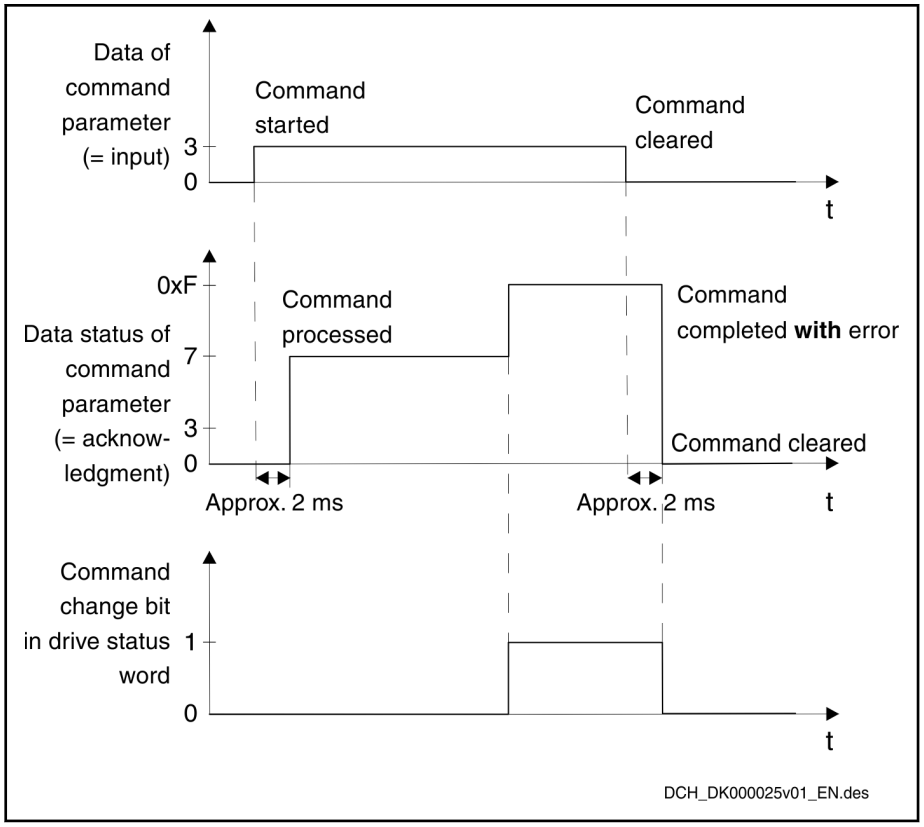


Fig. 9-3: Input, acknowledgment and command change bit in the case of incorrect execution

9.2 Backup and restore function

9.2.1 Backup and restore function

Overview

The backup and restore function is designed so that all operating data of a drive can be saved to a backup memory on the SD card by means of the "backup" command and retrieved from the backup memory as required by means of the "restore" command. The data in the backup memory can, however, also be transferred in whole or in part with the help of file services (e.g. FTP) to the update memory of another system in order to update it with the transferred operating data using the "update" command.

Generally, the following operating data are contained in the backup and restore function and have to be distinguished:

- Firmware (ibf file)
- Drive retain data according to P-0-0195 (par file)
- Operating data to be saved according to S-0-0192 (par file)
- MLD boot project in the parameter memory, including MLD administration data (par file)
- MLD retain data (par file)
- All files from the "PLC" directory on the SC card

The scope of functions of the backup and restore function are described in detail in the following.

Description

The backup/restore function can be used to easily and efficiently save all essential device data of a HydraulicDrive in a backup memory (= backup directory) on the SD card and to restore them from there. Apart from the backup directory, updating data can be stored in an update directory in the backup memory:

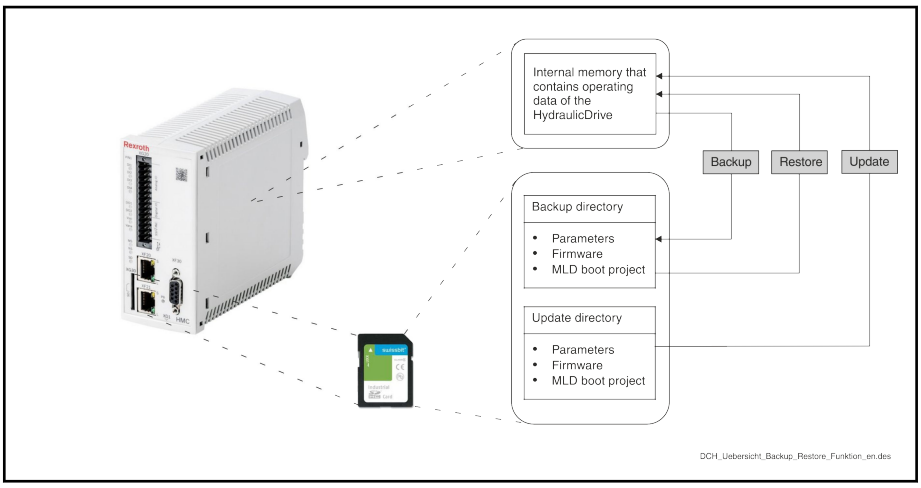


Fig. 9-4: Overview of the backup/restore function

Compressing the device data in a zip file is supported. This means that the data are stored “loosely” in the backup memory in two directories and also in a machine archive.

Backup directory Contains all device data of the drive that are required for restoring the drive configuration, i.e. operating data including firmware. The device data are stored in several files in the directory. This includes a file, which contains all administration data that are required for controlling the restoration.

Update directory Contains all device data or only a subset of them. A file containing administration data is also necessary.

In the following the data are distinguished between backup data (machine archive or “loose files” in the backup directory) and update data (update archive or “loose files” in the update directory).

Applications The following applications can be realized with them:

1. Backup:
   - Saving of all device data on the SD card.
2. Restore:
   - Restoring of all data, with the exception of retain data, in the case of new backup data
   - Check for new backup data when booting
   - Duplication of an existing system, including axis identifiers (clones)
   - Restoring of all modified data after temporary or unauthorized modification of operating data
3. Update
   - MLD project update with or without MLD retain data, symbol files, etc.
   - Operating data update
   - Firmware update and upgrade

- Duplication of an existing system, excluding axis identifiers (copy of operating data)
- Check for update when booting

In concrete terms, this means:

- For saving/restoring no special knowledge is required (which operating data are stored where and have to be saved via which protocols, ...). Appropriate commands are available for this.
- The backed up data can be read and written efficiently and in a standardized manner via file services.
- Series commissioning of systems is supported.

The function therefore forms the basis for handling service cases such as new backup data, operating data storage and updating of operating data on devices that are fitted with an SD card.

For the applications mentioned, the procedure of series commissioning can exemplarily be as follows: The numbers of the sections describe the order of actions. You have to:

1. Create a backup at the reference system and copy the data stored in the backup directly to the service PC.
2. The data stored on the service PC are copied to a backup directory on an SD card.
3. Plug the SD card in the de-energized condition in the series system.
4. The series system recognizes by the serial number that backup data of another system are available and automatically triggers the “restore” command while booting.

The SD card then has to remain in the system in order to allow any existing PLC programs to be accessed.

Step 1: Create a backup by means of IndraWorks

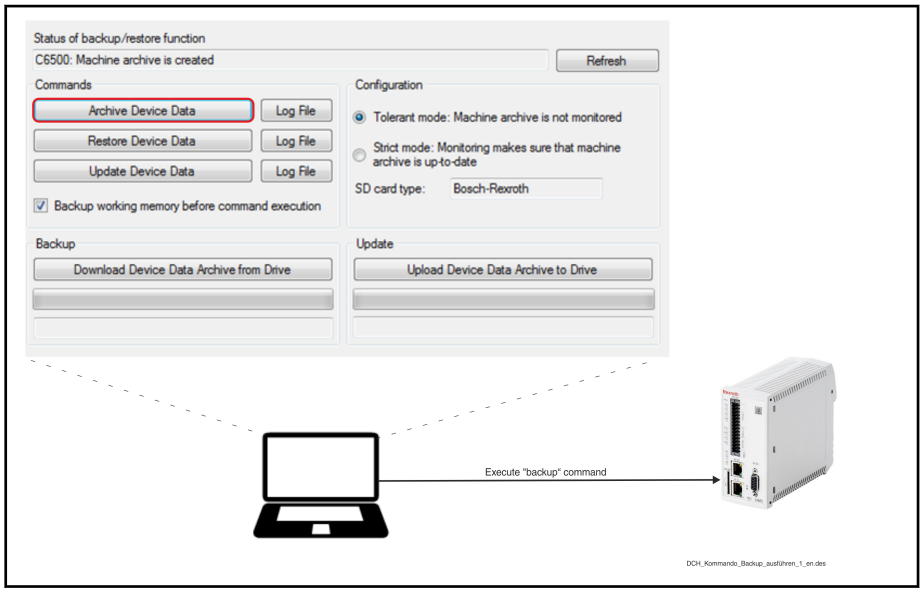


Fig. 9-5: Execute the “backup” command

Step 2: Upload machine archive to PC by means of IndraWorks

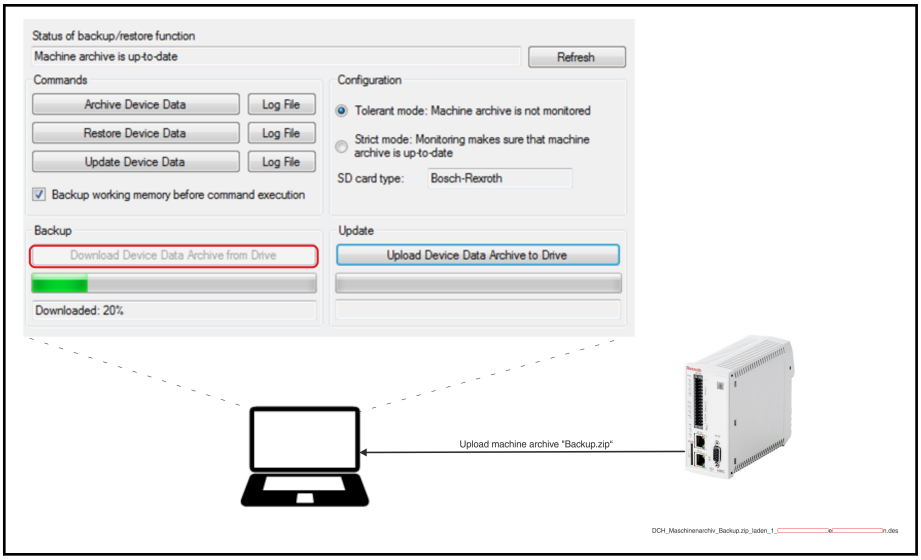


Fig. 9-6: Load machine archive “backup.zip”

Step 3: Copy the machine to the backup directory archive on the SD card

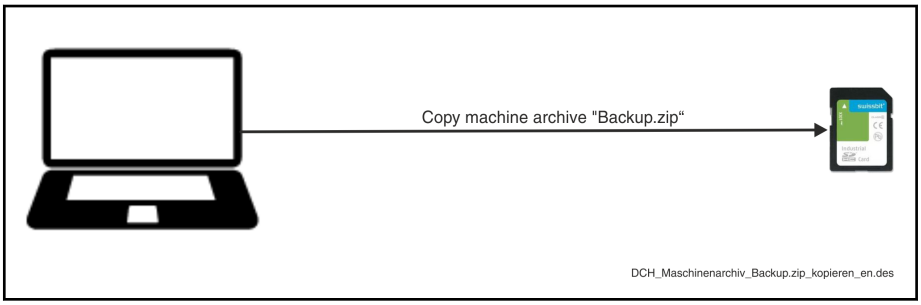


Fig. 9-7: Copy machine archive “backup.zip”

Step 4: Insert the SD card and switch on the power supply

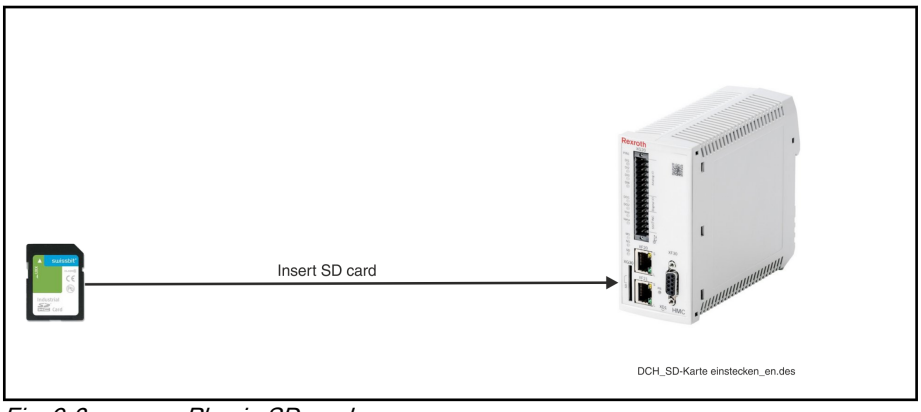


Fig. 9-8: Plug in SD card

Step 5: The “restore” command is executed automatically

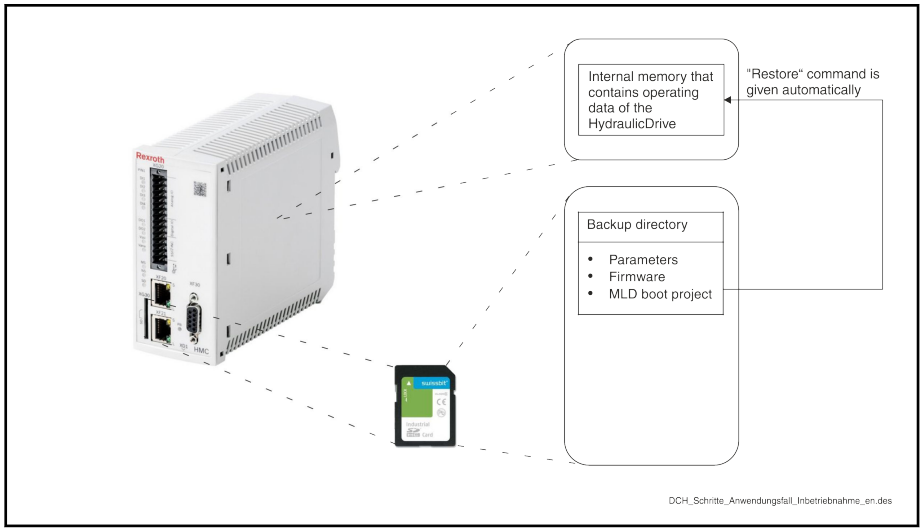


Fig. 9-9: Steps for the use case “series commissioning”

Structure of the backup memory

On the SD card the subdirectories “backup” and “user/update” are provided for this function. They contain the machine archive and the update archive in the standard zip format and individual backup and update files. The individual files are stored in a separate directory for each axis of the device (at present not more than 1 axis). The designation of the directories is based on the logical subindex (LSI) of the axis in the device (C format string: "Axis%02u"), which is increased by 1 to start at “Axis01“:

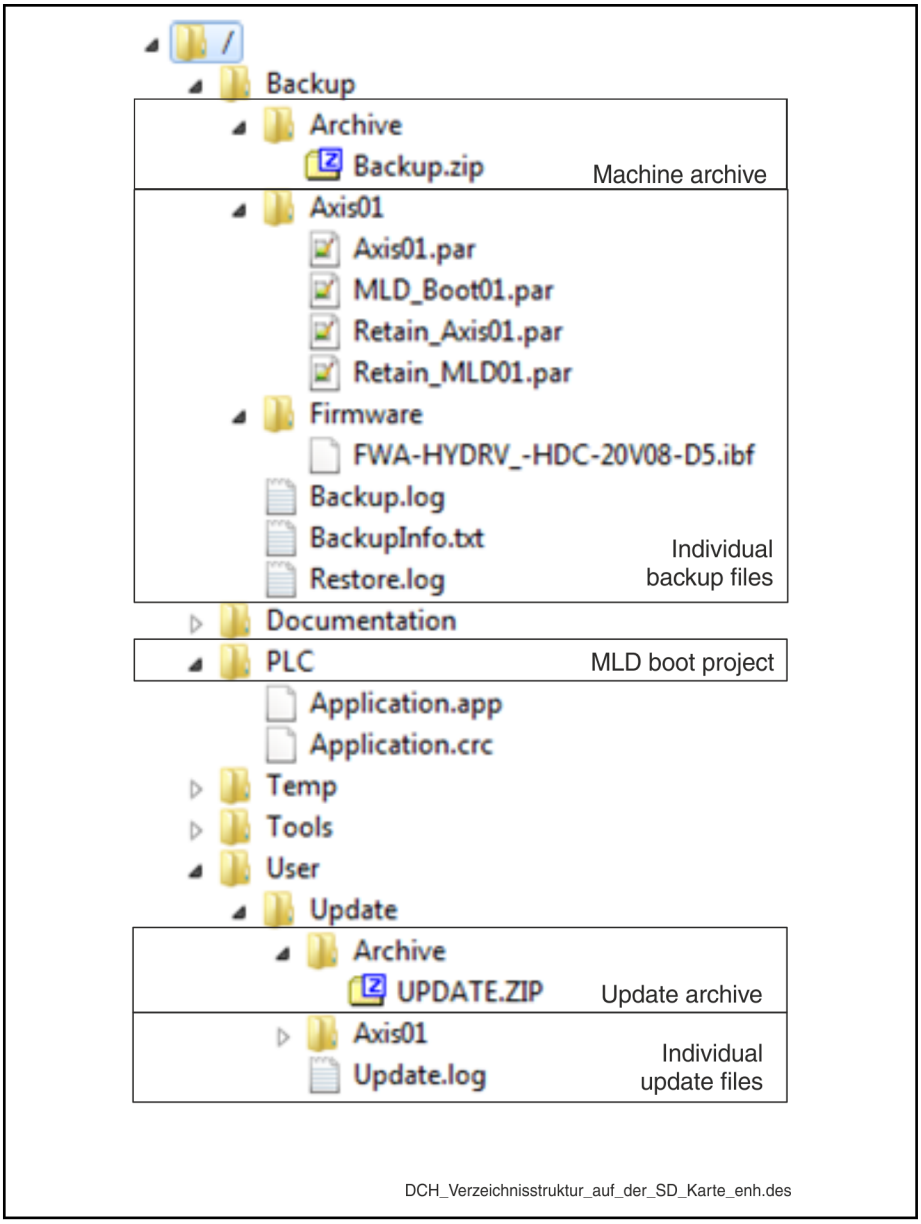


Fig. 9-10: Directory structure on the SD card

Scope of backup data

The device data saved in the machine archive are based on files with established file formats. To allow a simple comparison between the device data stored in the machine archive and the current device data, comparative data that suit the device data are saved as well. With the help of the comparative data it can be established whether device data were changed and which device data have to be restored when the restore function is carried out. The comparative data are supplemented by further meta data like master communication and TCP/IP addresses of the subdevices so that these can be easily accessed:

Machine archive	Comparative data	Included data
Axis?\Retain_Axis?.par	S-0-1300.0.12	All parameters listed in "P-0-0195, IDN list of retain data (replacement of devices)", excluding P-0-1359.
Axis?\Axis?.par	S-0-0531	All parameters listed in "S-0-0192 IDN-list of all backup operation data"
Axis?\MLD_Boot?.par	P-0-1360[1]	P-0-1352, PLC user program administration data
Axis?\Retain_MLD?.par	P-0-1360[1]	P-0-1359, PLC retain data
PLC*.*	P-0-1360[1]	#All files available on the SD card of the device in directory //PLC
Firmware*.ibf	S-0-0030	Firmware file (share for all axes)
	Comparative datum	
BackupInfo.txt	---	For each individual axis one data set with the following parameters:
	Material no.	S-0-1300.0.11, Order Number
	Serial no.	S-0-1300.0.12, Serial Number
	Type of control	P-0-1520, Control section type
	Checksum data	S-0-0531, Checksum of backup operation data
	Checksum boot project	P-0-1360[1], PLC program identifier (PID)
	MLD boot project on SD card	P-0-1367[8], PLC configuration
	MLD retain on hardware	P-0-1367[9], PLC configuration
	Firmware	S-0-0030, Manufacturer version (firmware version as text)
	FWA file	Name of ibf file
	Sercos address	S-0-1040, Drive address of master communication
	Application type	S-0-0142 or S-0-1392.x.03, Application type
	FWA TFTP remote IP	P-0-1531, Engineering: IP address (FWA download)
	Checksum P-0-1352	Checksum portion of P-0-1352 in S-0-0531
	Device type	S-0-1300.0.5, Vendor Device ID (as of HDx 20v14)

Tab. 9-5: Scope of machine archive

Comparative data

With the help of the comparative data it can easily be checked, whether the machine archive is still up to date or whether device data were changed. The following checks are carried out:

1. While the “restore” command (C6600) is being executed in order to prevent unchanged device data from being loaded.
2. In the **strict mode** when switching from PM to OM in order to compare the content of the machine archive with the current device data. If the machine archive is not up to date, a switching error is triggered.
3. For new backup data the FW string is checked to prevent an unnecessary restoration of the drive firmware, since this cannot be modified, but can clearly be identified via S-0-0030. All the other device data are restored without any checks.
4. Check that comparative data are unequal to “0”. If a comparative datum is “0”, the correlated reaction is not carried out.

☞ Since it must be possible to stop the MLD without any effect on the comparative status so that the MLD can also be updated in the strict mode, the content of P-0-1352 is ignored in the comparative data (don't care). To this end, the share of P-0-1352 in the checksum is calculated and saved in the comparative data in order that the checksum can be corrected with this value in S-0-0531. **Consequently, the state of the MLD (start/stop) is not taken into account. If necessary, the user has to be make sure externally that the MLD is running.**

Applications for restore

When a device is replaced the operating data and the firmware have to be restored. In addition, the restore function can be used to transfer operating data from one system to another:

	Applications	Action required for restoring
1.	Replacement of the complete device after complete failure (comparative datum S-0-1300.0.12 "Serial number")	Complete loss of data. All data, with the exception of retain data, have to be restored.
2.	New backup data (transfer of operating data, including axis identifiers)	New backup data were made available. In terms of the firmware, this case is to be handled in the same way as a device replacement, and all data, except for the retain data, are to be restored (cf. 1).

Tab. 9-6: Applications in the case of a replacement of the device

During the booting process it is **always** checked whether the device was replaced. If a device replacement as described in the table is detected, the "restore" command is started automatically during booting. The following figure shows the decision tree that can be used for treating a detected device replacement.

The execution of the restore command is signaled by a red-green blinking code of the status LED. During this time the power supply to the device must not be interrupted.

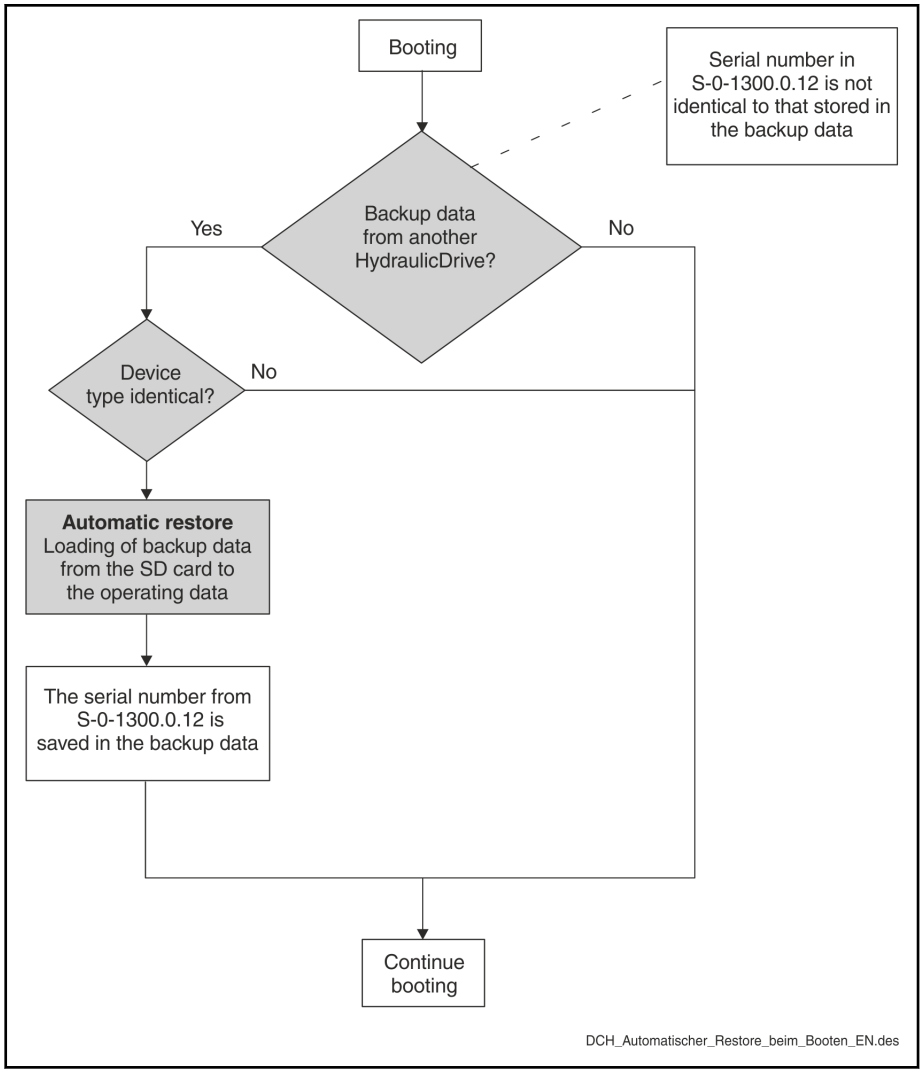


Fig. 9-11: Automatic restore during booting

1. The retain data (P-0-0195 excluding P-0-1359) are always ignored while the restore function is carried out, since it cannot be ensured that the data are up to date (e.g. absolute encoder position). However, in case servicing is required the corresponding par files can be taken from the backup data and uploaded manually with the help of a tool. It is up to the user to decide whether they are up to date.
2. While data are being restored, the axis identifiers of the drives are overwritten by the data from the backup.
3. By duplicating the backup data, a reference system can be cloned for series commissioning.

Updating

Generally, the “update” command can be used for initializing a system during commissioning or updating an existing system at the customer’s end. For this, following the check for new backup data during booting, a check is run to establish whether update data are available in the update directory. If this is the case, the “update” command is started automatically.

The following figure shows the decision tree for the “update” command during booting.

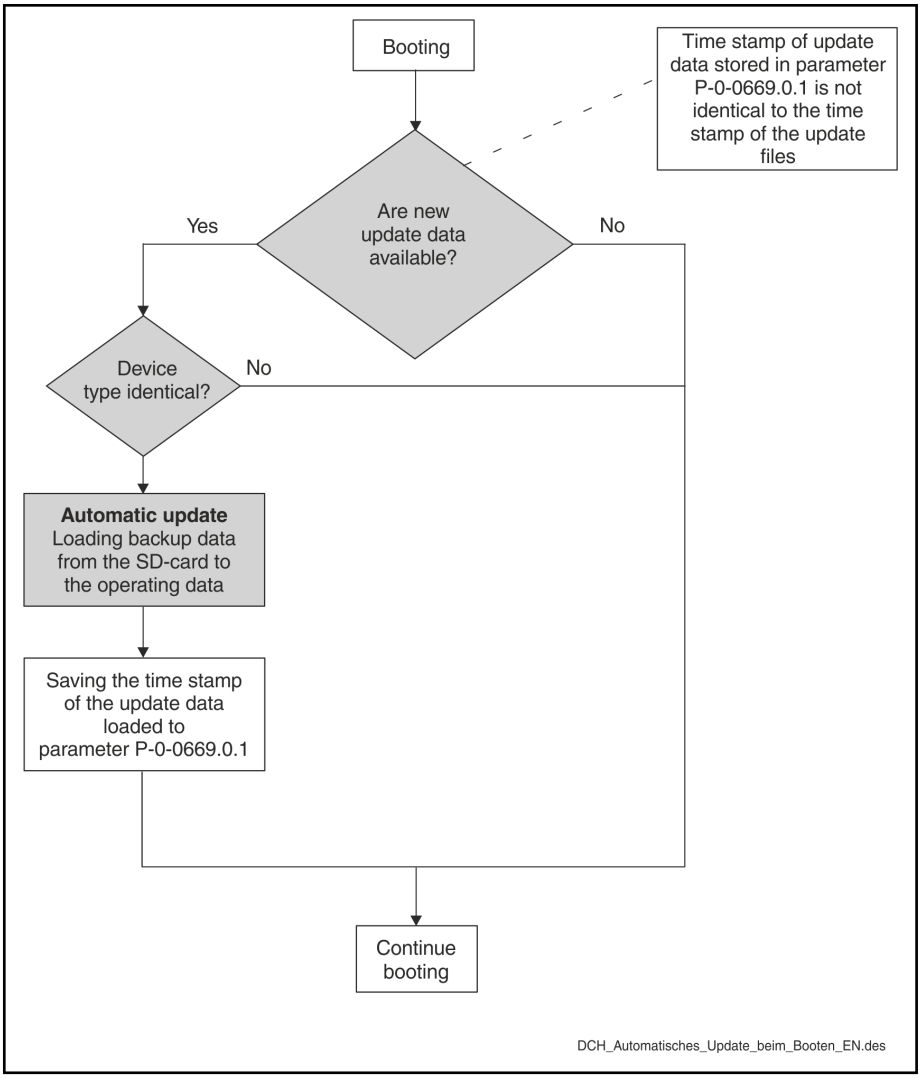


Fig. 9-12: Automatic update during booting

The execution of the update command is signaled by a red-green blinking code of the status LED. During this time the power supply to the device must not be interrupted.

The source of the update files is selected according to the following prioritization:

1. **Update archive**

   An update archive was created on a reference system. All files contained therein form a unit. It is therefore sufficient to ask the update question only once. The type of application saved in the comparative data is displayed as information text.

2. **Individual update files (firmware and parameters)**

   If a new firmware file is available, the information text contains the file name. If no firmware file is available or if it was already uploaded, it is the application type (cf. S-0-0142 or S-0-1302.x.03, Application Type) stored in the header of the parameter file. In this context, it must be noted that after a firmware update a reboot is carried out so that the message is shown again after the reboot, if there is an imminent parameter update.

1. While updating the data, not all of the parameters are taken over from the update data. The data that are ignored include the parameters (all parameter IDs) that can be started via the commands.
2. During the update, the Sercos header in the par files is always ignored. This is to allow updating of the parameters of a drive even if the Sercos address stated in the Sercos header is not correct.

Operation modes

The following two operation modes are available with the backup/restore function:

1. **Tolerant mode**: All commands are available. When switching to OM takes place and within the “update” command, the machine archive is not checked for up-to-dateness.
2. **Strict mode**: The machine archive is monitored for up-to-dateness. Switching to OM is only possible, if the machine archive is current.

   If, in the strict mode, the backup data are not current, warning E2667 “Machine archive is not up-to-date“ is activated. This is the case if, when switching to OM, a discrepancy is found on the basis of comparative data (checksum of parameters and the MLD boot project). The warning can be cleared using the command “restore” or “backup” and the control command.

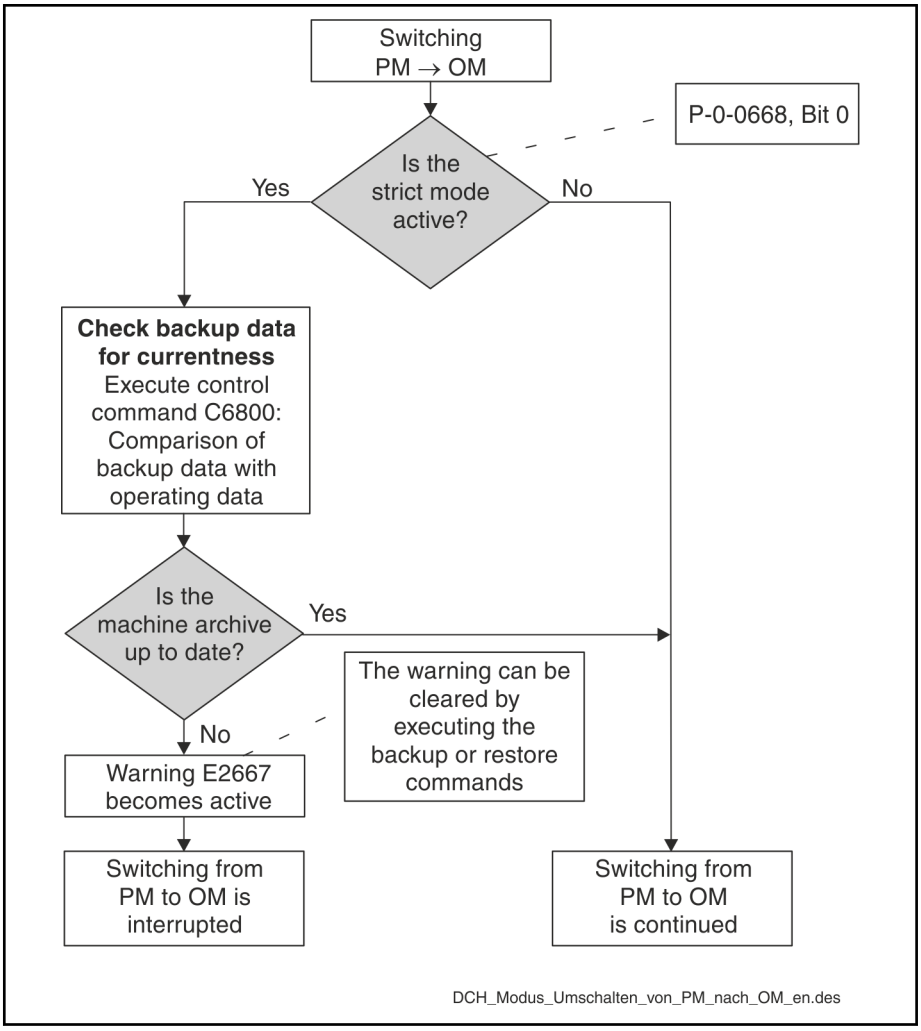


Fig. 9-13: Strict mode when switching from PM to OM

Integrated firmware management

All firmware files, which are administrated by the backup/restore function and stored in the backup memory, are named for the firmware string without identification of the language and the packages. The administration differs depending on the fact whether the backup files are stored in a machine archive or as individual files. In the case of a HydraulicDrive with SD card, the firmware is stored in the firmware directory “\Backup\Firmware“ or “\User\Update \Firmware“ in the backup or update data.

While reading a firmware (upload) is possible without any reactions to the device, downloading requires additional actions if, apart from the firmware, parameters are to be restored or updated. It must be noted that parameters should only be loaded after the firmware was downloaded. This means that following a firmware download a restoration or update of parameters might be required under certain circumstances after the new firmware was activated after a restart. If, while parameters are being written, the enable of functional packages is changed, it might even be necessary to carry out a further restart. Therefore, the sequence of a firmware download is basically as shown in the figure. In the end, the command, which resulted in the firmware download, might have to be resumed after the restart. Any restarts required and the continuation of the command after a restart are carried out automatically.

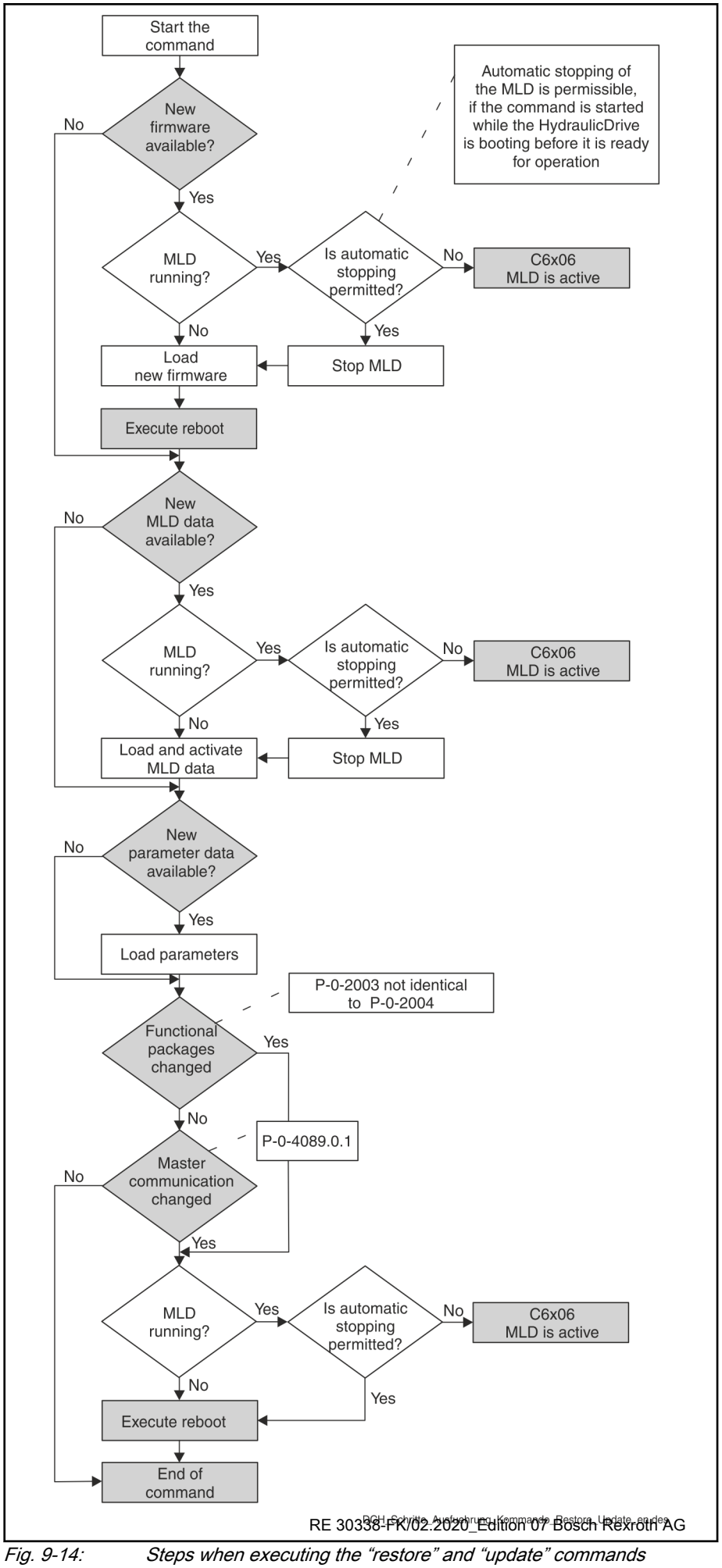


Fig. 9-14: Steps when executing the “restore” and “update” commands

“Backup” command (C6500) Saving of all relevant device data in the backup memory.

“Restore” command (C6600) Loading of all relevant device data from the backup memory for the applications mentioned above. The conditions for restoring the data are shown in the following table:

General use case	Firmware update	Retain data (P-0-0195 excluding P-0-1359)	Parameters to be saved (S-0-0192)	Retain data MLD (P-0-1359)	MLD project
Device change	Always	Data are only saved, but not loaded via one of the commands, since their up-to-dateness cannot be ensured	Always	If P-0-1367.9 = 0	Always
Restore	If S-0-0030 ! = comparative datum		If S-0-0030 ! = comparative datum	If P-0-1360[1] = comparative datum	If P-0-1360[1] = comparative datum

Tab. 9-7: Conditions for restoring data

“Update” command (C6700) Activation of new device data. These can be made available as an update archive for all axes or separately for each axis as individual files. Retain data (P-0-0195 excluding P-0-1359) are not considered. If the directory “User/Update/Archive” contains an update archive, the device data contained therein are activated. Otherwise, the device data stored in the axis directories ”User/Update/Axis...“ are activated. Neither the update archive nor the individual files are deleted after the update. In this case, the user has to delete device data or device files, which are no longer required, in the “User/Update” directory or remove the memory card before the command is called again.

Control command (C6800) The control command is used to establish the status of the backup/restore function. Since comparative data have to be collected from the axes for this purpose, the process takes some time. The data are therefore acquired within the control command. The status is stored in parameter "P-0-0669, Device data archiving, status" and can be read from this parameter after the command was executed.

Configuration The function can be configured in parameter "P-0-0668, Device data archiving, configuration".

Status The status of the function is mapped in parameter P-0-0669, Device data archiving, status and is updated merely during initializing (booting) and when a command is executed. To update the status, call the control command (C6800).

Pertinent parameters

- P-0-0664, C6800 Control command device data archiving
- P-0-0665, C6500 Command Archive device data
- P-0-0666, C6600 Command Restore device data
- P-0-0667, C6700 Command update of device data
- P-0-0668, Device data archiving, configuration
- P-0-0669, Device data archiving, status

Pertinent diagnostic messages

- C6500, Archive device data
- C6501, Error when creating machine archive
- C6502, Error when reading device data
- C6503, Inconsistent backup of machine archive

- C6600, Restore device data
- C6601, Error when accessing machine archive
- C6602, Error when writing device data
- C6604, Error when reading device data
- C6605, Device data incompletely restored
- C6606, PLC user program is active
- C6700, Update of device data
- C6701, Error when accessing update archive
- C6702, Error when writing device data
- C6703, Warning - Incomplete update of device data
- C6706, PLC user program is active
- C6800, Control command device data archiving
- E2667, Machine archive is not up-to-date

9.3 Diagnostic system

9.3.1 Coded diagnostic messages of the drive

Brief description

The drive provides a diagnostic system including different options that are basically subdivided into two groups:

- Recognizing and displaying the current drive status by means of drive-internal, priority-dependent generation of diagnostic messages

☞ As of HDx-18, the diagnostic message number is generated according to the sercos specification. For this, bits 31-24, too, are written in parameter "S-0-0390, Diagnostic message number". In earlier versions, they were always "0". In IndraWorks dialogs, these bits are hidden. In these dialogs, the representation remains unchanged.

- Collective messages for various status messages

Moreover, there are parameters for all important operating data, the values of which can be transmitted either via master communication (e.g. sercos) or via a parameter interface.

Pertinent parameters

- S-0-0095, Diagnostic message
- S-0-0390, Diagnostic message number
- P-0-0390.0.136, Detailed diagnostic message
- P-0-0006, Diagnostic message configuration

Drive-internal generation of diagnostic messages

Operational states, activities and reactions of the drive controller are acquired through drive-internal generation of diagnostic messages. These diagnostic messages can be transferred to a master (control) and displayed and evaluated in service and commissioning software (e.g., "IndraWorks Ds/D/MLD").

We distinguish the following categories of diagnostic messages (kinds of diagnostic messages):

- Error
- Warnings

- Commands/command errors
- Status displays/operational states

Generally, the current diagnostic message with the highest priority is displayed at the following locations in the drive:

- **Parameter "S-0-0095, Diagnostic message"**

  → This parameter contains the currently relevant operational status of the drive in the form of plain text. Preceding the text is the respective content of parameter S-0-0390 in short form.

- **Parameter "P-0-0006, Diagnostic message configuration"**

  This parameter can be used to switch the display of diagnostic messages in S-0-0390 to the compatibility mode. In HDx-17VRS and earlier firmware versions, only bits 0 to 19 are written in S-0-0390; bits 20-31 are always 0.

- **Parameter "S-0-0390, Diagnostic message number"**

  → The number of the diagnostic message is stored in this parameter.

Display priorities

For displaying the current diagnostic message, the following order of priorities applies:

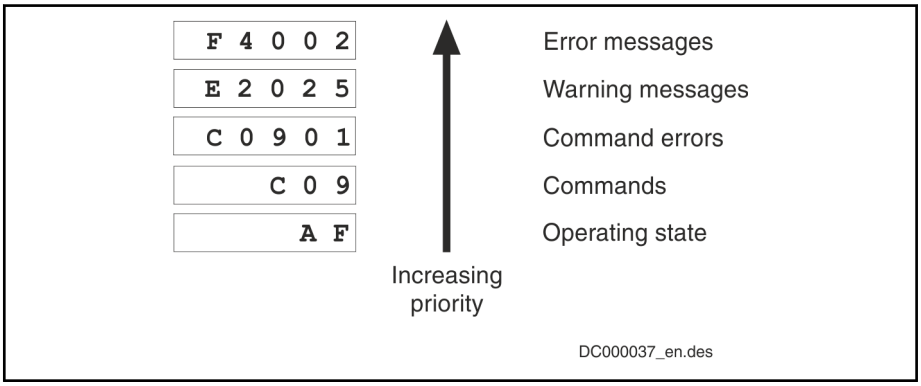


Fig. 9-15: Priorities of displays (with example displays)

An overview of all diagnostic messages and their meaning is contained in the documentation "Troubleshooting Guide (description of diagnostic messages)".

Structure of a diagnostic message

General information

Every diagnostic message consists of

- Diagnostic message number

  - and -

- diagnostic text.

The diagnostic message for the non-fatal error "F2028, Excessive deviation", for example, has the following structure:

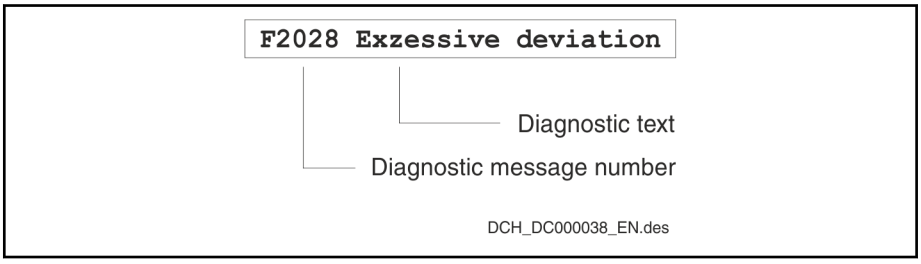


Fig. 9-16: Structure of a diagnostic message

The diagnostic message number is contained in parameter "S-0-0390, Diagnostic message number" in hexadecimal form (for this example: 0xC00F2028). Parameter "S-0-0095, Diagnostic message" contains the diagnostic message number and the diagnostic text as string "F2028 Excessive deviation".

Diagnostic message in plain text

The diagnostic message in plain text contains the diagnostic message number followed by the diagnostic message text. It can be read via parameter "S-0-0095, Diagnostic message" and directly displayed on an operator interface as a language-dependent description of the drive status.

The diagnostic message in plain text is switched to the selected language via parameter "S-0-0265, Language selection".

Diagnostic message number

The diagnostic message number contains only the diagnostic number without the diagnostic text. It can be read via parameter "S-0-0390, Diagnostic message number" and is a language-independent possibility of determining and displaying the drive status on an operator interface.

Language selection

Via parameter "S-0-0265, Language selection", it is possible to define or change the language of diagnostic message texts.

See also parameter description "S-0-0265, Language selection"

9.3.2 Status classes, status displays, control parameters

General information

In the drive there are many parameters that contain important status information (bit strings). Some of the bits contained in these strings can be used for configuring real-time status bits and additionally can be assigned to digital outputs or to the configurable signal status word.

See "Digital inputs/outputs"

See "Configurable signal status word"

The statuses of errors, warnings and messages are distinguished in the drive (diagnostic classes).

Within the drive, there are parameters

- with direct reference to the status of the sequence of various functions (fixed status displays)
- for controlling the drive functions (control parameters)

Status classes

Brief description

The drive differentiates between 3 states (error, warning and message) for which there is status information. To make the status information available, there are so-called class diagnostics parameters (S-0-0011, S-0-0012, S-0-0013) which contain the respective status bits.

In addition to these class diagnostics parameters, there are change bits contained in the status word of the field bus (e.g. S-0-0135 in the case of Sercos) which display changes in one of the above-mentioned class diagnostics parameters (collective information).

Features

- Class diagnostics parameter for **errors** (cf. S-0-0011)

- Class diagnostics parameter for **warnings** (cf. S-0-0012)
- Class diagnostics parameter for **messages** (cf. S-0-0013)
- **Change bits in status word** of master communication (e.g. S-0-0135 in case of Sercos)
- Change bits of class 2 and 3 diagnostics (S-0-0097 and S-0-0098) **can be masked** in the status word of master communication (e.g. S-0-0135 in case of Sercos) to suppress individual bits or status messages

Pertinent parameters

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, Class 3 diagnostics
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0135, Drive status word

Functional description

Status class parameters

- **S-0-0011, Class 1 diagnostics** (status parameter for drive error)
  - In case a drive error occurs, the bit assigned to the error is set in parameter S-0-0011. A separate bit is assigned in S-0-0011 to errors defined according to Sercos.

    Manufacturer-specific errors cause bit 15 to be set in parameter S-0-0011 (see also parameter description "S-0-0011, Class 1 diagnostics").
  - In case a drive error occurs, bit 13 (drive locked; error in class 1 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in the case of Sercos).

☞ All bits in class 1 diagnostics are cleared by executing command C0500 (reset class 1 diagnostics).

See also parameter description "S-0-0099, C0500 Reset class 1 diagnostics"

- **S-0-0012, Class 2 diagnostics** (status parameter for drive warnings)
  - In case a drive warning occurs, the bit assigned to the warning is set in parameter S-0-0012. A separate bit is assigned in S-0-0012 to warnings defined according to Sercos.

    Manufacturer-specific warnings cause bit 15 to be set in parameter S-0-0012 (see also parameter description "S-0-0012, Class 2 diagnostics").
  - In case a drive warning occurs, bit 12 (change bit class 2 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in case of Sercos), when the content of S-0-0012 changes (i.e. at least one bit toggles).
  - The bits in parameter S-0-0012 are automatically cleared when the warning disappears. The change bit in the status word of master communication (S-0-0135 in case of Sercos) remains, however, set until parameter S-0-0012 has at least been read once.

☞ Via parameter "S-0-0097, Mask class 2 diagnostics", warnings can be masked out in terms of their effect on the change bit.

- **S-0-0013, Class 3 diagnostics** (status parameter for drive messages)

- Messages of the drive are listed in parameter S-0-0013. A separate bit is assigned in S-0-0013 to messages defined according to Sercos (see also parameter description "S-0-0013, Class 3 diagnostics").
- If a drive message occurs, bit 11 (change bit class 3 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in case of Sercos).
- The bits in parameter S-0-0013 are automatically cleared when the message disappears. The change bit in the status word of master communication (S-0-0135 in case of Sercos) remains, however, set until parameter S-0-0013 has at least been read once.

☞ Each of these messages is stored in a separate parameter (S-0-0330 to S-0-0342).

Change bits in drive status word

If the state of a bit in parameter "S-0-0012, Class 2 diagnostics" or "S-0-0013, Class 3 diagnostics" changes, the change bit for class 2 or 3 diagnostics is set in the field bus status word (e.g., S-0-0135 in case of Sercos). A change bit in the status word (bit 11 or 12) is always set due to a change of the parameter content of S-0-0012 or S-0-0013. This enables the master to recognize very quickly whether a change occurred in S-0-0012 or S-0-0013.

A read access to one of the two parameters clears the respective change bit again.

Masking the change bits

By means of parameters "S-0-0097, Mask class 2 diagnostics" and "S-0-0098, Mask class 3 diagnostics", it is possible to mask certain bits with regard to their effect on the change bit of the status word (bit 12 or bit 11).

The figure below illustrates the principle of masking by means of an example:

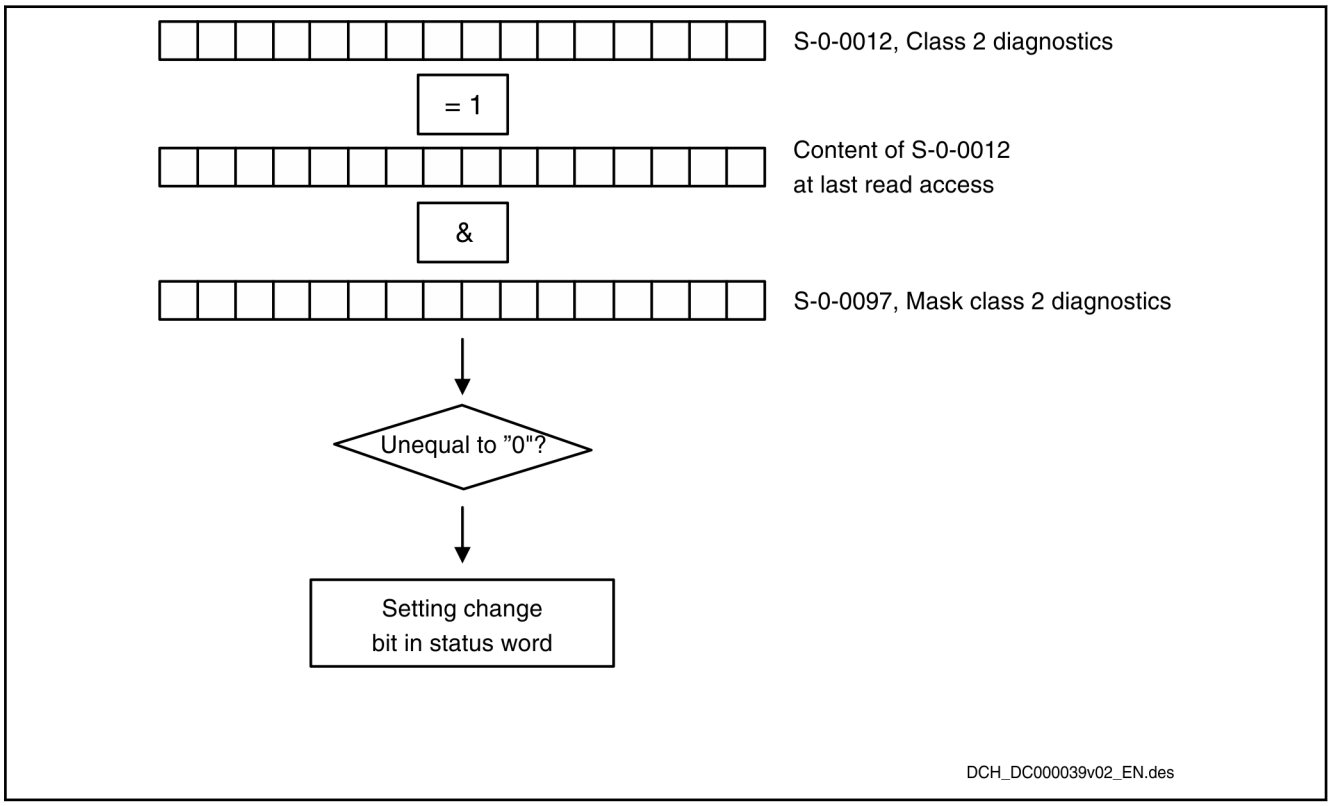


Fig. 9-17: Generating the change bit of class 2 diagnostics

Notes on commissioning

The figure below illustrates handling of the change bits in the status word and of the status class parameters:

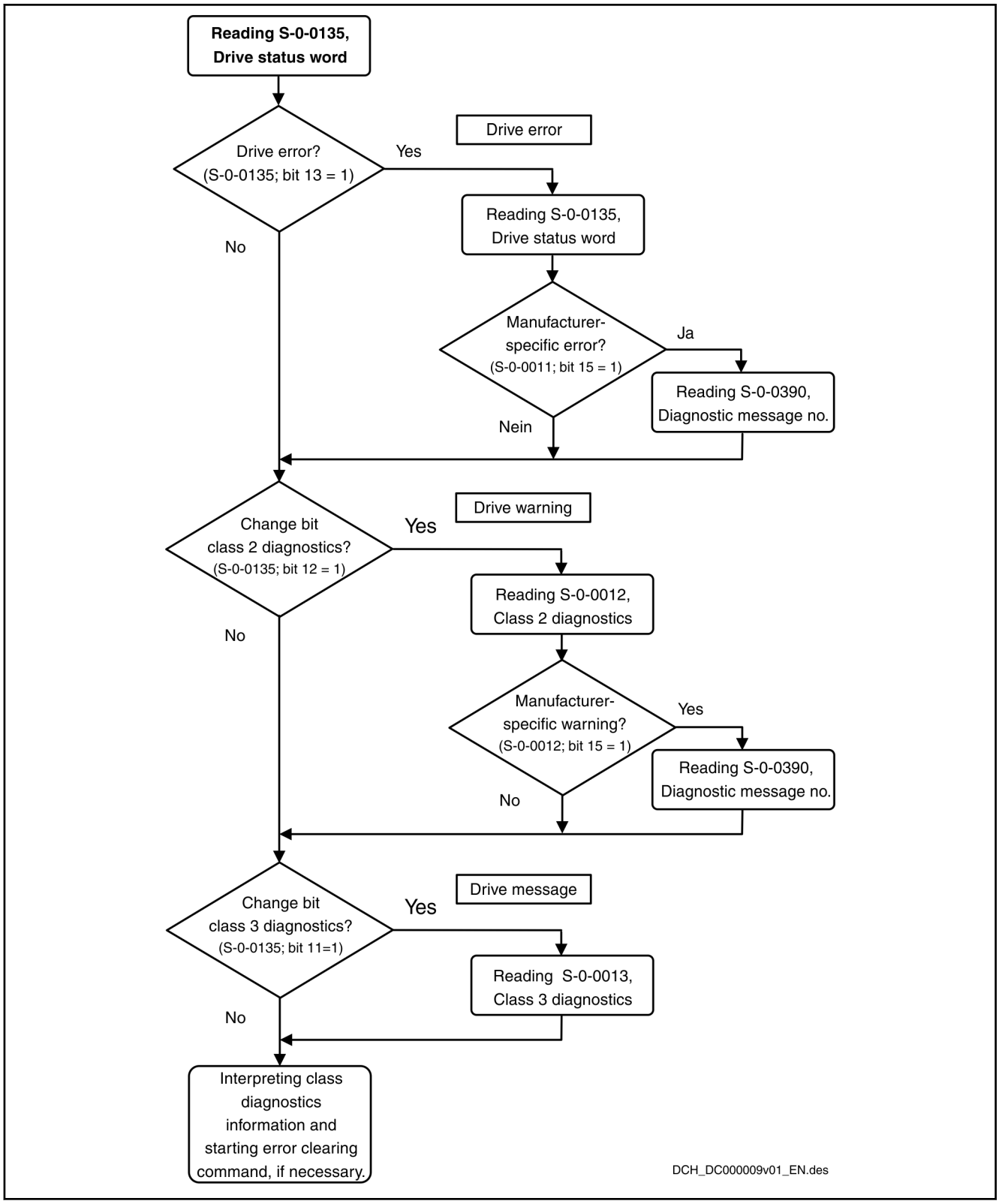


Fig. 9-18: Handling the change bits and status class parameters

Fixed status displays

Function-related status parameters

The drive contains parameters the content of which is directly related to the status of the sequence of various drive functions. These parameters are used to display the current status information of the assigned function.

The following parameters are available for function-related status display:

- **S-0-0014, Interface status**

  This parameter displays the state of the communication phase transition and cyclic communication.

- **S-0-0135, Drive status word**

  This is the status word of the master communication (Sercos) and contains all essential status information for the master.

- **S-0-0403, Position feedback value status**

  This parameter contains status bits for the position data reference of the individual measuring systems.

- **S-0-0419, Positioning command acknowledge**

  This status information is used for acknowledgment in the "drive-controlled positioning" mode.

- **P-0-0115, Device control: Status word**

  This parameter contains status bits of the device control (see also "Device control and state machines").

- **P-0-0222, Travel range limit switch inputs**

  This parameter displays the status of the travel range limit switch inputs.

- **P-0-0223, E-Stop input**

  This parameter displays the status of the E-Stop input.

- **P-0-0555, axis controller messages**

  This parameter displays messages with regard to velocity and limits that have been reached.

- **P-0-4029, Diagnostic report SCSB module**

  Parameter for reading master communication settings and states (with Sercos).

- **P-0-4086, Master communication status**

  This parameter displays control information of the master communication for handling phase switching, drive enable, etc., defined during initialization.

Status parameters for real-time status bits

The following list contains status parameters that only contain one bit and can therefore be used for configuring real-time status bits (see "Sercos":

- S-0-0330, Status "v_feedback = v_command"
- S-0-0331, Status "v_feedback = 0"
- S-0-0332, Status "v_feedback < vx"
- S-0-0333, Status "T >= Tx"
- S-0-0334, Status "T >= Tlimit"
- S-0-0335, Status "v_command > v_limit"
- S-0-0336, Status "In position"

- S-0-0341, Status "In coarse position"
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"

Control parameters

Apart from the parameters for status display, there are parameters available in the drive that are used to control the drive functions (see also description of the relevant parameter):

- P-0-0556, Config word of axis controller
- P-0-4028, Device control word

9.3.3 Operating hours counter

Brief description

The drive comprises operating hours counters, which record the operating time separately for power section and control section. The respective operating time is shown in parameter P-0-0190 or P-0-0191. These times are stored directly in the control section or the power section, respectively, so that the assignment is retained also in the case of a failure.

A high-resolution system time, which is highly accurately synchronized across the devices is made available via the hardware connection of the Multi-Ethernet protocols and is defined in Sercos in the form of parameters S-0-1305.0.x.

Operating hours counter

Parameter "P-0-0190, Operating hours control section" displays the operating time of the drive's control section. The unit is seconds.

For the control section, the time the drive has been switched on is considered as the operating time.

System time

For updating and setting the system time, the parameters S-0-1305.0.1, System time,

S-0-1305.0.2, System fine time, and

S-0-1305.0.3, System coarse time are available in the drive.

Pertinent parameters

- S-0-1305.0.1, System time
- S-0-1305.0.2, System fine time
- S-0-1305.0.3, System coarse time
- P-0-0190, Operating hours control section

Intended use

The system time is used in the drive for diagnostic and motion functions such as, for example, the diagnostic message memory.

The system time is represented in data format IEC 61588. As a standard, the system time is accessed via the 8-byte parameter (S-0-1305.0.1). For systems, which do not support 8-byte parameters, an alternative read access is provided via two 4-byte parameters (S-0-1305.0.2 and S-0-1305.0.3).



When reading 4-byte parameters (S-0-1305.0.2 and S-0-1305.0.3) it has to be noted that always the current value is read, that is, the two values are not consistent to each other and cannot form an 8-byte system time.

Notes on commissioning

Setting the system time via master communication

The system time can be highly accurately set and updated via a master connection of the master communication protocols of Sercos or EtherCAT. The system time is transmitted via bus-specific mechanisms, so that all slaves get the same system time. When the system time is transmitted for the first time, the slave's system time counter is initialized with the transmitted value. Then, cyclic checks are run (every 64 ms) to see whether the transmitted master system time deviates from the own slave system time. In the case of deviations > 5 µs the master system time is adopted by the slave's system time counter.

Setting the system time in IndraWorks

In IndraWorks the system time of the drive can be synchronized with the system time of the connected engineering PC with the help of a dialog.

Calling the diagnostic message memory:

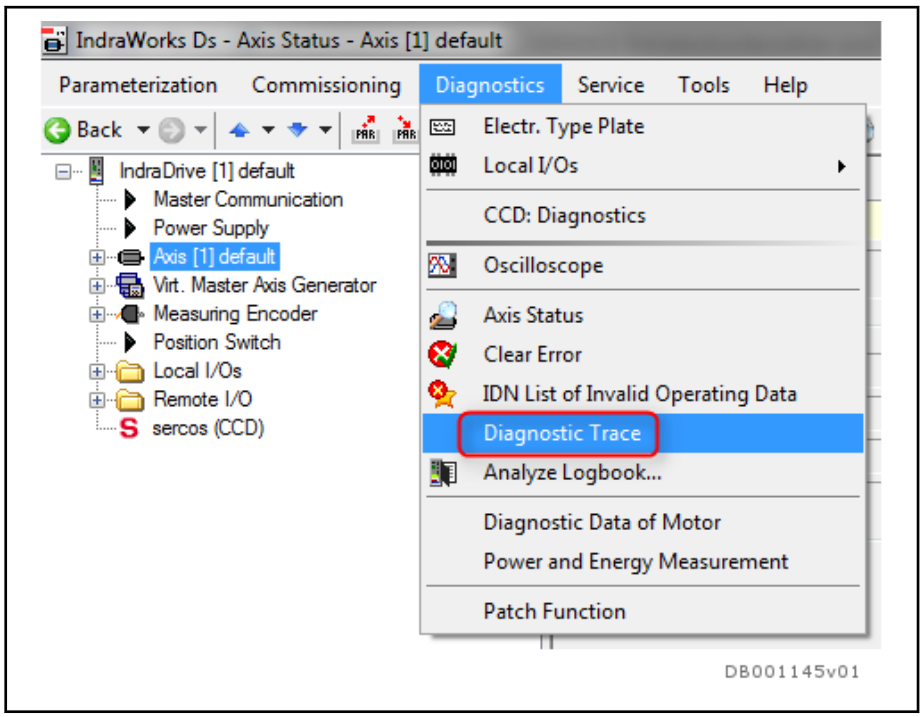


Fig. 9-19: Dialog of diagnostic message memory

Synchronizing the drive system time with the system time of the engineering PC by clicking on the exclamation mark icon.



Fig. 9-20: Setting the system time

9.3.4 Error and diagnostic memory

Brief description

In the drive, all errors occurred are logged in an error memory on the control section.

☞ When an error occurs, the diagnostic message number and the current count of the operating hours counter are automatically stored.

Pertinent parameters

- S-0-0390, Diagnostic message number
- P-0-0190, Operating hours control section
- P-0-0192, Error memory of diagnostic numbers
- P-0-0193, Error memory operating hours of control section

Functional description

Error memory in control section

When the drive detects a class 1 diagnostics error, a bit is set in parameter "S-0-0011, Class 1 diagnostics", and bit 13 for "error in class 1 diagnostics" is set in the drive status word.

In order to allow a more detailed diagnosis

- the diagnostic message number is saved in parameter "S-0-0390, Diagnostic message number" (in "hex format"),
- the plain text of the diagnostic message is stored in parameter "S-0-0095, Diagnostic message",
- the content of parameter "P-0-0190, Operating hours control section" at the time the error is detected is stored in parameter "P-0-0193, Error memory operating hours of control section",
- the diagnostic message number belonging to the error according to parameter "S-0-0390, Diagnostic message number" is stored in parameter "P-0-0192, Error memory of diagnostic numbers" in the same order.

The parameters P-0-0192 and P-0-0193 have a stack structure and contain, in chronological order, the diagnostic message numbers or the counts of the operating hours counter of the last **50 errors** that occurred.

☞ The count of the operating hours counter at the time the last error occurred is entered at the top of parameter P-0-0193, and the diagnostic message number of the last error occurred at the top of parameter P-0-0192.

9.3.5 Diagnostic LED

Brief description

General information

The module status LED indicates the current state of the HDx firmware (e.g. PM, error present) in the form of blinking codes or permanent illumination. The module status LED can light up in the following 3 colors:

- Green
- Red
- Orange

Due to the specifications from the EtherNet/IP standard, two indicator modes were implemented for the module status LED:

- Indication for EtherNet/IP in conformity with standard
- Extended indication for other bus systems

Indication of module status LED

When the bus system EtherNet/IP is active, the indication complies with the stipulations in the standard for module status LEDs. When another bus system is active, an extended indication is active, which also utilizes the color orange. The two indicator modes are summarized in the following table.

Drive status	Module status LED with EtherNet/IP (indication in conformity with standard)				Module status LED with other bus systems (extended indication)			
De-energized (ENIP: No power)	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Command active	- - -	- - -	- - -	- - -	Green	Green	Orange	Orange
Command error	- - -	- - -	- - -	- - -	Orange	OFF	OFF	Green
PM (ENIP: Standby)	Green	OFF	Green	OFF	Green	OFF	Green	OFF
Bb (drive ready for operation) (ENIP: Standby)	Green	OFF	Green	OFF	Green	OFF	Green	OFF
Ab (drive ready, power on) (ENIP: Operational)	Green	Green	Green	Green	Green	Green	Green	Green
AH (Drive Halt) (ENIP: operational)	Green	Green	Green	Green	Green	Green	Green	Green
AF (drive in control) (ENIP: operational)	Green	Green	Green	Green	Green	Green	Green	Green
F2 non-fatal errors (ENIP: minor recoverable fault)	Red	OFF	Red	OFF	Red	OFF	Red	OFF
F4 communication errors (ENIP: minor recoverable fault)	Red	OFF	Red	OFF	Red	OFF	Red	OFF
F6 travel range errors (ENIP: minor recoverable fault)	Red	OFF	Red	OFF	Red	OFF	Red	OFF
F8 fatal errors (ENIP: minor recoverable fault)	Red	OFF	Red	OFF	Red	OFF	Red	OFF
F9 fatal system errors (ENIP: major unrecoverable fault)	Red	Red	Red	Red	Red	Red	Red	Red
E2 drive warning	- - -	- - -	- - -	- - -	Orange	OFF	OFF	OFF
E4 communication warning	- - -	- - -	- - -	- - -	Orange	OFF	OFF	OFF
E6 travel range warning	- - -	- - -	- - -	- - -	Orange	OFF	OFF	OFF
E8 fatal warning	- - -	- - -	- - -	- - -	Orange	Orange	Orange	Orange
Reloading process (LW/FW) (ENIP: self-test)	Green	Red	Green	Red	Green	Red	Green	Red
FW update active	Green	Green	Orange	Orange	Green	Green	Orange	Orange
FW update error	Red	Orange	Red	Orange	Red	Orange	Red	Orange
Boot kernel error	Red	Red	Red	Red	Red	Red	Red	Red
	0.5 s	0.5 s	0.5 s	0.5 s	0.5 s	0.5 s	0.5 s	0.5 s

Tab. 9-8: Indication modes of module status LED

During EtherNet/IP startup an LED test (green/red flashing) takes place.

9.3.6 Device monitoring

Function of the hardware

Depending on the device, various monitoring functions are realized to ensure proper functioning of the device.

The implementation of the monitoring function is closely connected to the device, since the device hardware has to provide the function.

Function	WRxD, SY(H)DFED, HS5E	WRxF, WRxQ, SY(H)DFEF	HMC	HPC
Temperature	Yes	Yes	Yes	Yes
Supply voltage	Yes	Yes	Yes	Yes
Sensor supply (dependent on product, e.g. encoder, main stage, swivel angle sensor)	Yes (main stage sensor or swivel angle sensor)	Yes (main stage sensor or swivel angle sensor)	Depending on the set encoder 24 V / 5 V	Yes (swivel angle sensor)
Sensor supply analog	No	Yes	Supply of pressure transducers (24 V)	Supply of pressure transducers (24 V)
Load current	No	No	Total power consumption of the digital outputs and the 24 V supply of encoders and pressure transducers	Total power consumption of the digital outputs and the 24 V supply of encoders and pressure transducers
Solenoid current cables	Yes	Yes	No	Yes

Tab. 9-9: Function of device hardware

Temperature

The current device temperature is cyclically acquired and shown in "P-0-2885.0.1, Control section temperature".

In addition, there are a warning threshold and an error threshold, which depend on the concrete device and signal whether the device is operated outside the permissible temperature range.

Exceeding these thresholds results in logging of this event in a persistent memory area.

The other elements of parameter "P-0-2885.0.2, Temperature monitoring of control section" reflect the temperature profile, in which the device has been operated so far. To this end, the temperature profile is acquired within the range of 0 °C to 100 °C in 10-°C steps. Temperatures below 0 °C are acquired in a separate element.

Supply voltage

The supply voltage of the devices is cyclically acquired and compared with the thresholds stored in the device. These ensure that the devices are operated within the permissible voltage range.

If the supply voltage falls below the minimum value, error "F8072 Control voltage failure" is triggered. This makes certain that all device functions are immediately brought to a safe state, since the function of device peripherals can no longer be ensured.

If the maximum supply voltage is exceeded, warning "E8071 Overvoltage of control voltage" is triggered.

The current value of the supply voltage can be read in parameter "P-0-2885.0.3, Supply voltage, actual value".

Further monitoring functions

Sensor supply / internal voltages

Electronics for control cabinet mounting make available the current values of the sensor supplies of encoders and pressure transducers in parameters "P-0-2885.0.4, Sensor supply, actual value" and "P-0-2885.0.5, Sensor supply, analog, actual value". For electronics for control cabinet mounting with "axis" extension card, the current values of the extension card are shown in parameters "P-0-2885.0.7, Sensor supply, extension card, actual value" and "P-0-2885.0.8, Sensor supply, analog, extension card, actual value".

For on-board electronics, the voltage supply to the main stage or the swivel angle sensor is shown in parameter "P-0-2885.0.4, Sensor supply, actual value".

Digital outputs

The devices cyclically monitor the digital outputs for overloading. If overloading is detected, warning "E2260 Warning Defect of digital outputs" is issued for proportional and high-response valves.

In contrast to this, for control cabinet electronics, error "F8283 Overload" is generated, since the circuitry of the digital outputs also includes the 24-V supply of the pressure transducers and the encoders.

With control cabinet electronics, the current load current of the digital outputs and the 24-V supply of the pressure transducers and the encoders can be read from parameter "P-0-2885.0.6, Load current, actual value". For control cabinet electronics with "axis" extension card, the current load current of the peripherals of the extension card is given in parameter "P-0-2885.0.9, Load current extension card, actual value".

Solenoid current cables

In the case of devices, which activate solenoids for position control of a valve via external cables, these cables are monitored for both, cable break and short-circuit. If an error is recognized, "F8288 Fault in solenoid current cable" is output. In this case, monitoring is firmly set and cannot be deactivated.

Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-2885.0.1, Control section temperature
- P-0-2885.0.2, Temperature monitoring of control section
- P-0-2885.0.3, Supply voltage, actual value
- P-0-2885.0.4, Sensor supply, actual value
- P-0-2885.0.5, Sensor supply, analog, actual value
- P-0-2885.0.6, Load current, actual value
- P-0-2885.0.7, Sensor supply, extension card, actual value
- P-0-2885.0.8, Sensor supply, analog, extension card, actual value
- P-0-2885.0.9, Load current extension card, actual value

  Parameters P-0-2885.0.7 to P-0-2885.0.9 are provided only for the HMC with “axis” extension card.

Pertinent diagnostic messages

- F8072 Control voltage failure
- F8288 Fault in solenoid current cable
- F8069 Error in device-internal power supply

- E8071 Overvoltage of control voltage
- F8283 Overload
- E2260 Warning Defect of digital outputs

9.4 Oscilloscope function

9.4.1 Functional description

The oscilloscope function can be used to record drive-internal and external status variables (parameter contents). This function can be effectively used for both initial commissioning and troubleshooting. Its functionality can be compared to that of an 8-channel oscilloscope.

The total scope of the oscilloscope function is divided into the following function blocks:

- **Measured value recording**

  It is possible to record 8 channels at the same time, with the signals being selected by configuration of signal selection lists (IDN lists).

- **Configuration (basic settings)**

  The control/status block determines the basic functions (start/stop, time resolution, size of memory, operation mode). Generally, the current status (status diagram) of the oscilloscope is continuously transmitted to the master.

- **Trigger function**

  Besides extensive trigger functions, the drive provides the possibility of triggering at different signals and events in the drive.

Features The oscilloscope function is characterized by the following features:

- **Measured value recording**
  - 8 channels, each with a maximum of 8192 measured values (the total number of values must not exceed 32768).
  - Freely selectable time resolution in the base time of the position controller clock cycle
  - In expert mode, shorter time resolutions possible with up to 4 channels
  - Signal selection by indicating the IDN of the respective parameter
- **Configuration (basic settings)**
  - Multiple-channel display in "IndraWorks Ds/D/MLD"
  - More than 100 different measuring and trigger signals (cf. P-0-0149)
  - Expanded oscilloscope function using 2 patch functions
  - Expanded oscilloscope function using 2 average value filters for display
- **Trigger function**
  - Trigger signal selection by indicating parameter IDN
  - Internal trigger or external trigger
  - External trigger with trigger offset determination for synchronizing multiple-axis measurements
  - Unit of trigger level adjusting to trigger signal selection

– Possibility of triggering at internal memory contents with patch signal
– Time stamp for trigger time is mapped in parameter

9.4.2 General information on the oscilloscope function

Sequence of a measurement (state diagram)

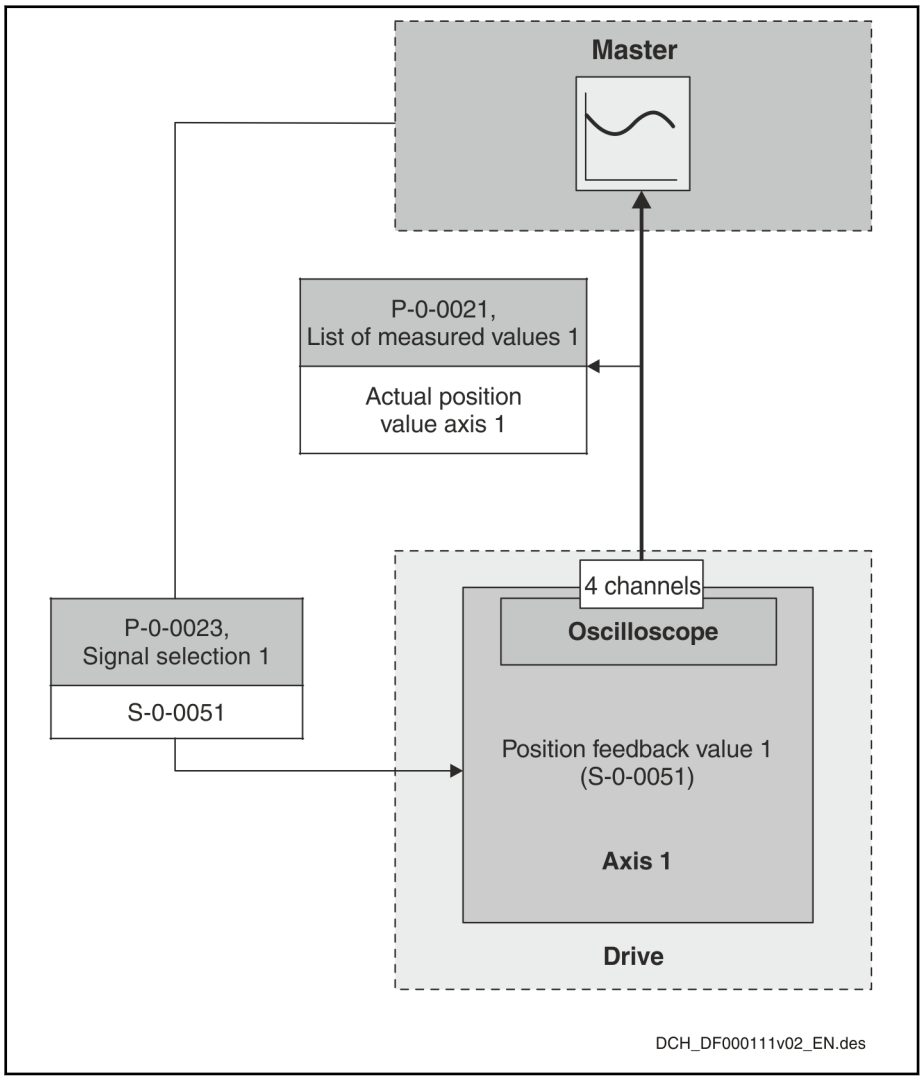


Fig. 9-21: State diagram of oscilloscope function

Configuring the measured value channels

A measured value channel can be configured by entering the IDN of the desired parameter in the respective signal selection parameter:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7

- P-0-0273, Oscilloscope: Signal selection 8

Signal selection list (P-0-0149)

All IDNs contained in parameter "P-0-0149, Oscilloscope: Signal selection list" can be entered.

P-0-0149 contains all parameters that are suitable as trigger signal (P-0-0026) or as measuring signal (P-0-0023, P-0-0024, P-0-0147, P-0-0148, P-0-0270, P-0-0271, P-0-0272, P-0-0273). By reading P-0-0149 the master recognizes, which signals can be recorded in the drive.

☞ At present, all cyclically configurable parameters (> 100) are contained in the list!

Example of signal selection

Example of signal selection of the oscilloscope function:

- "S-0-0051, Position feedback value of encoder 1" is selected as signal to be recorded
- The position feedback value of encoder 1 (S-0-0051) is written to parameter "P-0-0023, Oscilloscope: Signal selection 1"

→ When the limiting conditions occur, the position feedback value of axis 1 is recorded in the oscilloscope and transmitted to the master.

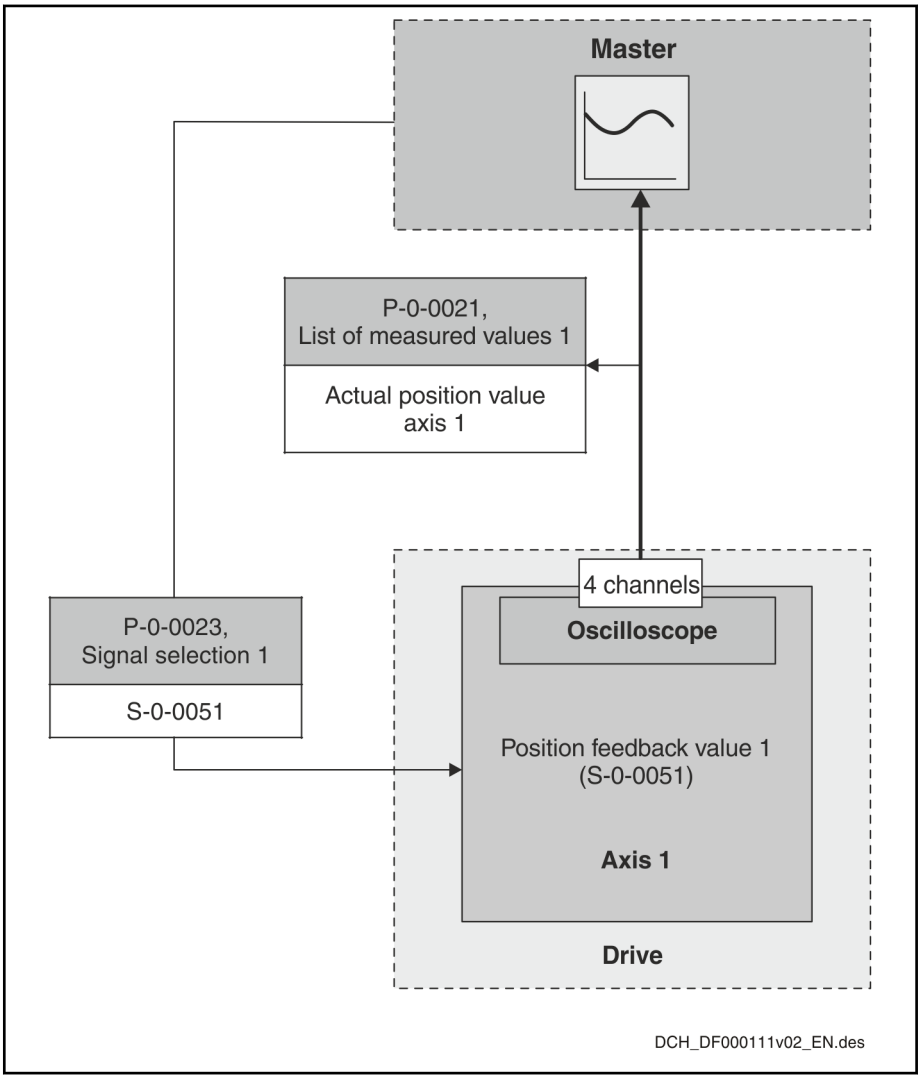


Fig. 9-22: Example of signal selection

Expanded oscilloscope function (patch function)

Besides recording parameter contents via the oscilloscope function, the drive provides the possibility of recording any internal signal, i.e. memory address (patch function).

☞ Using the patch function is only possible with information about the structure of the internal data memory; therefore, this function can be used effectively only by the developers of the IndraDrive firmware.

In order to record internal signals (memory address contents), "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" have to be configured in one of the signal selection parameters (P-0-0023, P-0-0024, P-0-0147, P-0-0148, P-0-0270, P-0-0271, P-0-0272, P-0-0273).

☞ The patch function has to be parameterized before the assignment as trigger or measuring signal. After the assignment to the signal selection, the address is copied from the patch function. This means that subsequent changing of the address works only, if it is newly assigned to the signal parameter.

Expanded oscilloscope function (PLC patch function)

Besides the recording of parameter contents via the oscilloscope function, the drive provides the possibility of recording any symbol-based PLC variables (PLC patch function).

☞ The patch function has to be parameterized before the assignment as trigger or measuring signal. After the assignment to the signal selection, the address is copied from the patch function. This means that subsequent changing of the address works only, if it is newly assigned to the signal parameter.

Activating the oscilloscope function

The oscilloscope function is activated/deactivated via parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, bit 0:

- Bit 0 = 1 → starts a measurement
- Bit 0 = 0 → stops a measurement

Setting bit 0 in P-0-0028 activates the oscilloscope function, i.e. recording of measured values of the selected signal starts. The oscilloscope function waits for the selected trigger edge or threshold to occur. Upon detection of a valid edge, the measured values keep being written to the measured value memory until the number of measured values defined in parameter "P-0-0033, Oscilloscope: Number of measured values after trigger event" has been reached (delay function).

☞ With Sercos master communication, the start of signal recording and of trigger evaluation are delayed until the next feedback acquisition starting time T4 (S-0-0007 and S-0-1007).

This causes the recording data and the data in the AT telegram to be identical and several drives at one Sercos bus to simultaneously start recording within one Sercos cycle.

After the defined number of measured values has been recorded, the bit "delay function completed" (bit 4) is set in parameter "P-0-0029, Oscilloscope: Status word". Recording is thus complete and automatically terminated. Bit 0 in parameter P-0-0028 is reset and the list of measured values can be read.



Depending on the parameterization of the memory depth, the time resolution, the number of measured values after the trigger event and the point in time the trigger event occurs, the measured value memory for the current measurement is not always written completely.

This means that there may still be old measured values in the memory that are not valid for the current measurement!

9.4.3 Trigger function

Trigger signal selection

The drive provides extensive and flexible possibilities of triggering.

Triggering at standard signals

The trigger signal is selected in parameter "P-0-0026, Oscilloscope: Trigger signal selection" by directly inputting parameter IDNs. Here, only IDNs are allowed which are contained in list "P-0-0149, Oscilloscope: Signal selection list".



If, when the oscilloscope function is activated, no valid trigger signal is available, bit 7 for "trigger error" is set in parameter "P-0-0029, Oscilloscope: Status word".

"P-0-0026, Oscilloscope: Trigger signal selection" determines which signal is monitored with regard to the parameterized edge reversal or threshold value.

Triggering at any signal

Besides triggering of parameter contents, the drive provides the possibility of recording any internal signal, i.e. memory address (patch function).



Using the patch function is only possible with information about the structure of the internal data memory; therefore, this function can be used effectively only by the developers of the IndraDrive firmware.

Patch function

In order to trigger at internal signals (memory address contents), parameters "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" have to be configured in P-0-0026.

Internal or external trigger

The kind of trigger can be selected in parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, bit 1:

- Bit 1 = 0 → internal trigger without offset measurement
- Bit 1 = 1 → external trigger with offset measurement

Trigger event

The trigger event is the point in time at which trigger signal (P-0-0026) and trigger threshold (P-0-0027) are matching, taking the determined trigger edge into account (P-0-0030). When the trigger event occurs, the internal trigger is enabled.

Internal trigger (without offset measurement)

When "internal trigger" (P-0-0028; bit 1 = 0) is selected, the external trigger source (P-0-0036 bit 0) is ignored. Until the trigger event has been reached, the current state of the comparison "signal/trigger threshold" is displayed in "P-0-0029, Oscilloscope: Status word".

As the trigger event is reached, bit "internal trigger event" in parameter "P-0-0029, Oscilloscope: Status word" is set and recording is continued until the determined number of measured values after the trigger event (P-0-0033) is reached. Only then is the bit "delay function completed" set (P-0-0029; bit 4). Setting this bit terminates the complete recording. The bit signals the end of recording irrespective of the trigger source.

When internal trigger source has been selected, the status bit "trigger function completed" (P-0-0029 bit 3) is set simultaneously with the bit for "internal trigger event" (P-0-0029 bit 2) (see state diagram).

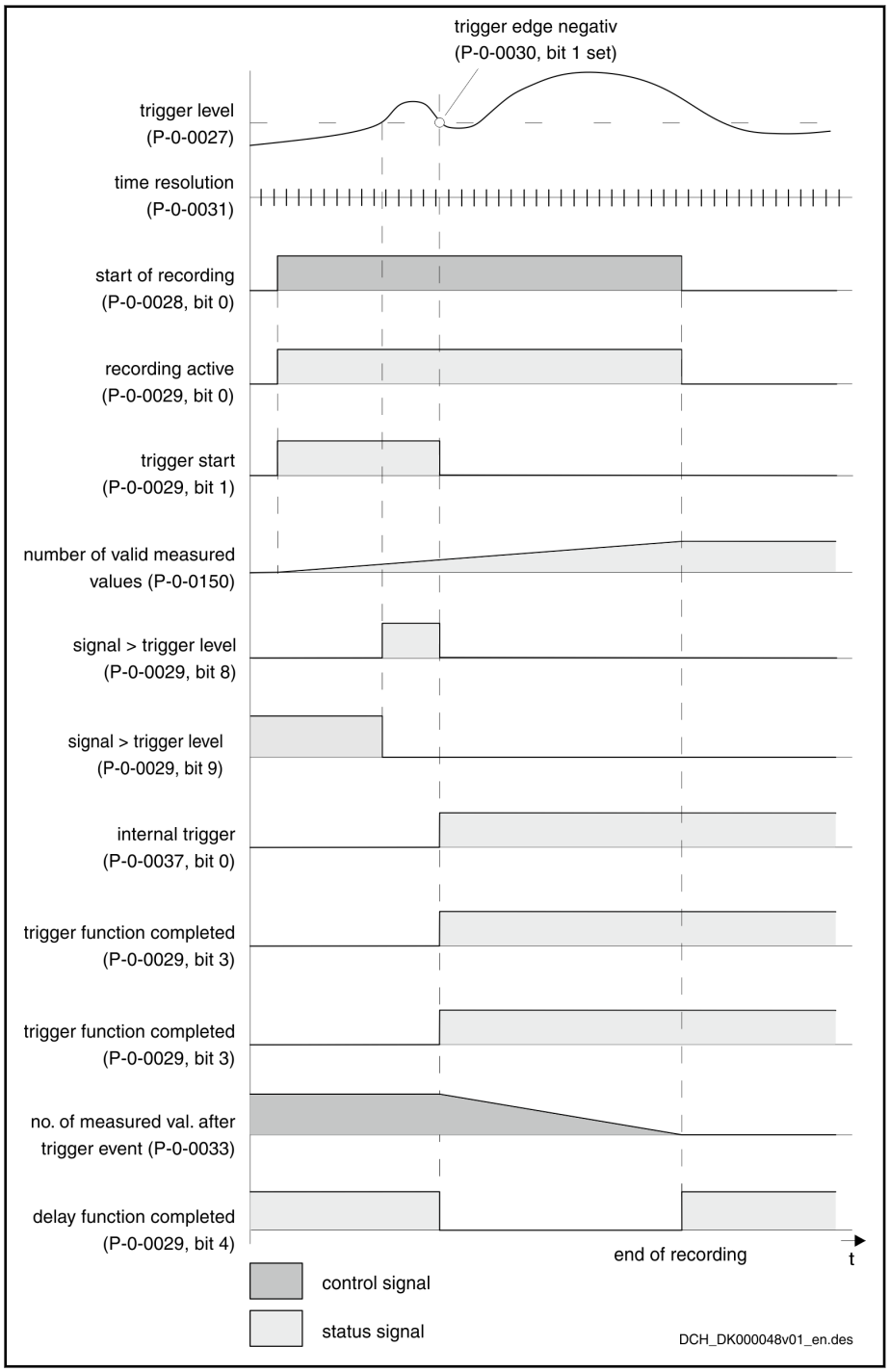


Fig. 9-23: Internal trigger without offset measurement (P-0-0028; bit 1 = 0)



By parameterizing P-0-0036 (external trigger signal) in "P-0-0026, Oscilloscope: Trigger signal selection" it is possible to enable the internal trigger function by the external trigger input.

External trigger with offset measurement

When the kind of trigger "external trigger with offset measurement" (P-0-0028; bit 1 = 1) has been selected, the internal and external trigger are used for the master axis.

When "external trigger" has been selected, the behavior until the internal trigger event has been reached, corresponds to the behavior for the case when trigger source "internal trigger" has been selected. Until the external trigger signal occurs (P-0-0036; bit 0) the trigger offset between both trigger events is determined and displayed in parameter P-0-0035. Afterwards, bit "trigger function completed" is set in the status word of (P-0-0029; bit 3). The rest of the sequence is the same as in the case of internal trigger source without offset measurement.

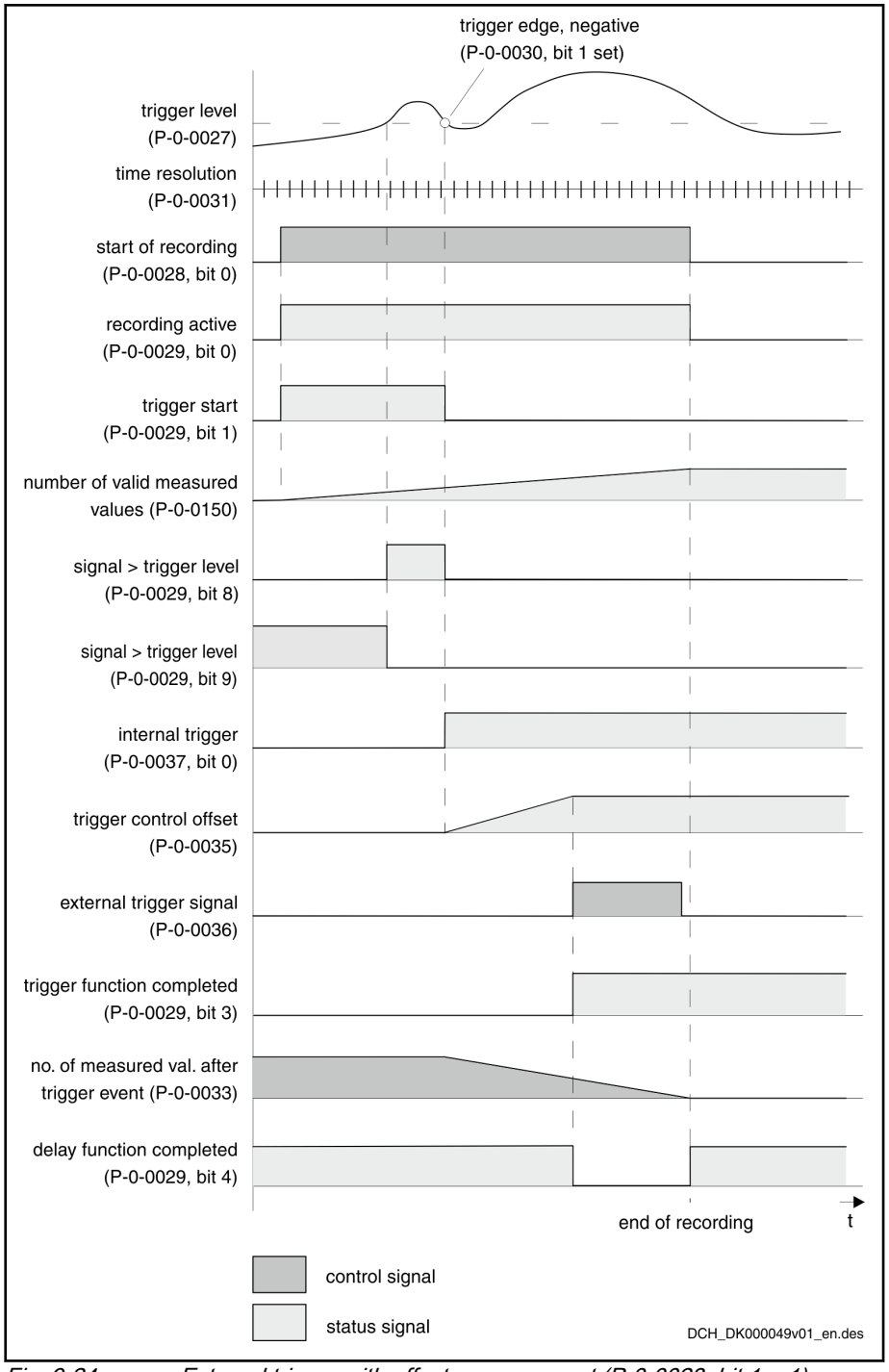


Fig. 9-24: External trigger with offset measurement (P-0-0028; bit 1 = 1)

The use of the external trigger source with trigger offset determination is described in section "Synchronizing the measuring signals of several axes" (see below).

Selection of trigger edges

Trigger edge (P-0-0030)

In parameter "P-0-0030, Oscilloscope: Trigger edge", you can set at which edge of the trigger signal the internal trigger is released. The following options are available:

- Triggering at the **positive** edge

  Triggering is based on the transition “less than or equal to → greater than"
- Triggering at the **negative** edge

  Triggering at the transition “greater than or equal to → less than"
- Triggering at **both** edges

  Triggering at the transition "less than or equal to → greater than" and "greater than or equal to → less than"
- Triggering when trigger signal **equals** trigger threshold

---

☞ Even if both edges are activated, the trigger is only enabled when the value falls below or exceeds the set value. In the case of equal values, the trigger is not enabled.

 See parameter description "P-0-0030, Oscilloscope: Trigger edge"

Setting the trigger delay

Trigger delay function

Via "P-0-0033, Oscilloscope: Number of measured values after trigger event" it is possible to reach a trigger delay independently of the preset trigger source (external/internal). For this purpose, the number of measured values that are to be recorded following the respective trigger event is set in parameter P-0-0033.

☞ It is also possible to record measured values before the trigger event occurs (trigger delay functions of an oscilloscope).

If "0" is entered in P-0-0033, no data are recorded after the trigger event. The trigger event is the last value in the list of measured values. If the value of parameter P-0-0032 is entered, only data available before the trigger event will be recorded. The trigger event is the first value in the list of measured values. The trigger event is therefore also counted. If P-0-0033 consequently takes the value "0" or "1", the trigger result is the last value in the list of measured values.

If the time until the trigger event occurs is too short, it may happen that the lists of measured values are not complete. If P-0-0033 has the value "0", the list of measured values contains only one value.

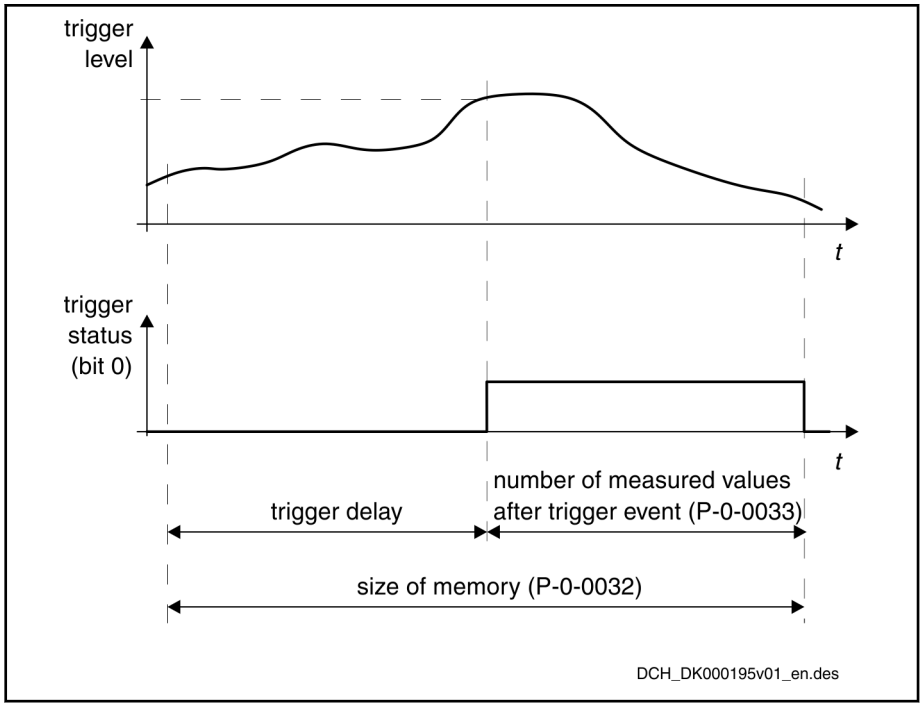


Fig. 9-25: Trigger delay: Number of measured values after trigger event

Expanded trigger functions

Trigger mask (P-0-0025)

With parameter "P-0-0025, Oscilloscope: Trigger mask", it is possible to trigger at certain events. For trigger signals with the display formats "Bin" and "Hex", it is possible to mask the trigger signal and the trigger threshold.

See parameter description "P-0-0025, Oscilloscope: Trigger mask"

Trigger threshold (P-0-0027)

The trigger threshold can be freely set via parameter "P-0-0027, Oscilloscope: Trigger level", with the attribute, unit, etc. being adjusted to the selected trigger signal.

See parameter description "P-0-0027, Oscilloscope: Trigger level"

9.4.4 Manual trigger

As manual trigger, parameter P-0-0136 should be selected, since P-0-0036 is also used for multiple-device measurement. To this end, it is cyclically configured and can no longer be written by the user. It must be noted that, depending on the edge configuration, exceeding / falling below the value signals the trigger threshold (not that the trigger level has been reached).

9.4.5 Trigger time

When the system time is set, P-0-0035.0.1 can be used to read the system time at the time of triggering. In this way, it is possible to determine the time of trigger also at a later point in time. This can be a useful function, if a monitor was configured and the user wishes to see, at which point in time the trigger event occurred.

The system time is given in Sercos time format (UNIX format) Since not all field buses support 8-byte parameters, the time is transmitted in an array with 2*32 bits. Since data are generally transmitted in the Little Endian, the first element contains the system time (fine), and the second element the system

time (coarse) according to the parameters "S-0-1305.0.2, System fine time" and "S-0-1305.0.3, System coarse time".

Parameter attributes			
Type	**Value**	**Type_**	**Value_**
IDN	P-0-0035.0.1	Name	Oscilloscope: Trigger time
Parameter class	Parameter	Editability	No
Display format	DEC_OV	Data length	4-byte var.
Decimal places	0	Scaling dependence	
Unit		Cyclically configurable	No
Extreme value check	No	Combination check	No
Min/max value	../..	Default value	
Axis-specific	Yes		

Tab. 9-10:

9.4.6 Synchronizing the measuring signals of several axes

Parameter "P-0-0035, Oscilloscope: Trigger control offset" contains the number of measured values between the occurrence of the internal trigger event (P-0-0029; bit 2) and the external trigger event (P-0-0036; bit 0).

Trigger control offset (P-0-0035)

The transmission of the trigger event via the master causes a delay between the detection of the trigger event and the release of the trigger. This delay is measured by drive 1 (master drive) and stored in parameter "P-0-0035, Oscilloscope: Trigger control offset". In the visualization of measured values, this parameter helps to ensure the representation of signals of several drives with the correct time.



In principle, a slave drive may also be used as triggering axis. It will then behave like the master axis.

See also "Trigger function"

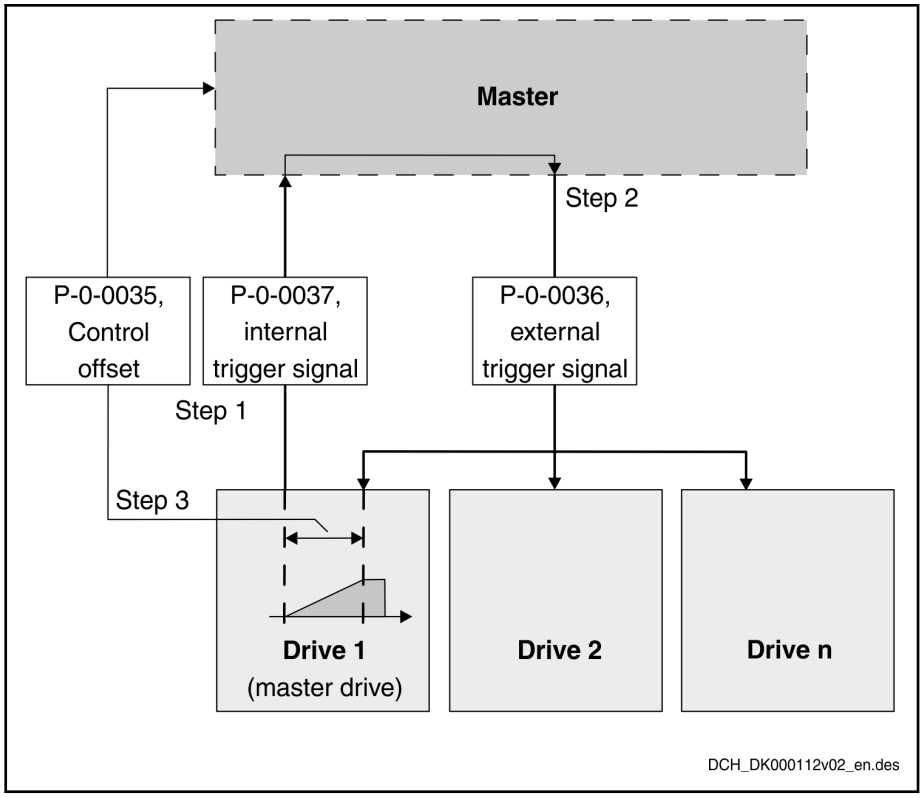


Fig. 9-26: Application for trigger source "External" with determination of trigger offset

☞ The value in parameter P-0-0035 can be used by the master for synchronizing the measuring signals of several axes with the internal trigger event of the master axis.

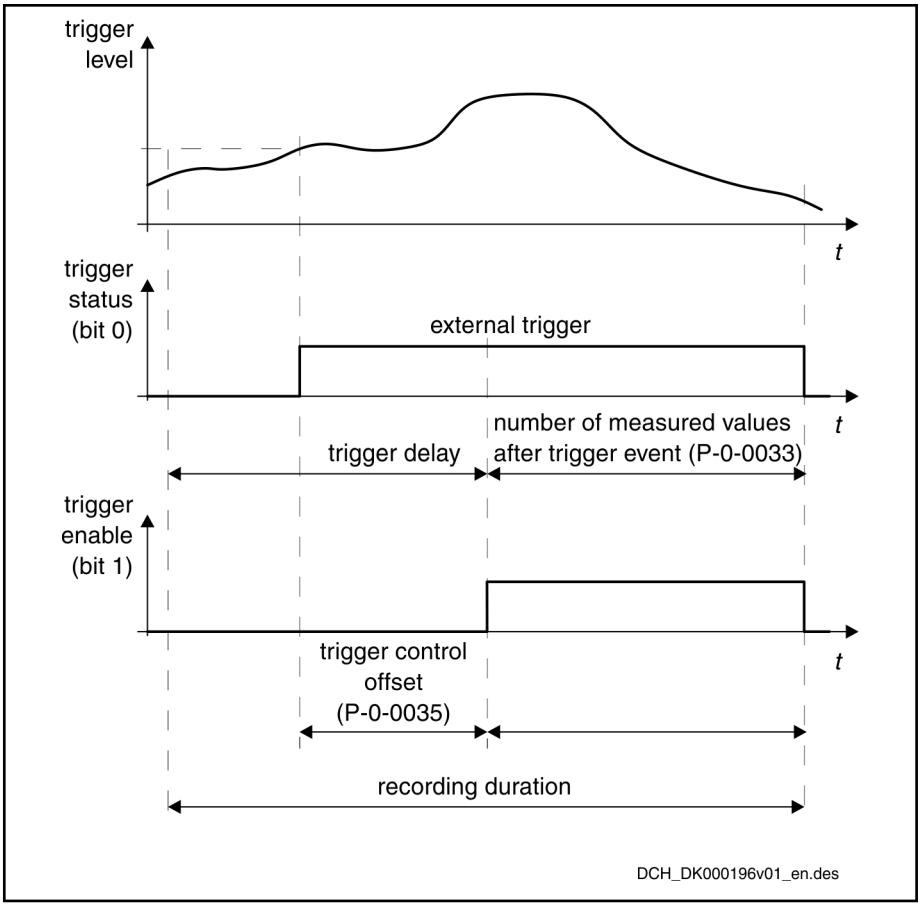


Fig. 9-27: Trigger control offset

Status of internal trigger (P-0-0037)

Upon successful comparison of trigger signal and trigger condition, bit 0 is set in parameter "P-0-0037, Oscilloscope: Internal trigger signal" (trigger status), but the trigger is not released. This enables the master to signal the trigger event via the real-time status bits and real-time control bits simultaneously to several drives and to release the trigger.

External trigger signal (P-0-0036)

"P-0-0036, Oscilloscope: External trigger signal" can be parameterized as real-time control information, both in the real-time channel of the interface and as hardware input. This allows triggering at external signals that are preset via

- master communication of the master

- or -

- an analog or digital input.

9.4.7 Parameterizing the oscilloscope function

Recording duration

The recording duration is determined according to the following relationship:

$$t_A = (P\text{-}0\text{-}0031) \times (P\text{-}0\text{-}0032)$$

t_A	Recording duration (in µs)
P-0-0031	Oscilloscope: Time resolution
P-0-0032	Oscilloscope: Memory depth

Fig. 9-28: Determining the recording duration

Parameterizing the selection of measured values

For the oscilloscope function, it is possible to select 4 signals that are defined by the IDNs of their respective parameters and assigned to the following parameters:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Only such parameter IDNs are allowed that are contained in the list parameter "P-0-0149, Oscilloscope: Signal selection list".

☞ The selected signal (parameter IDN) defines the unit of the data stored in the list of measured values.

Parameterizing the trigger function

See above "Trigger function"

Parameterizing the time resolution and the memory depth

The recording range or the recording duration can be adjusted to suit the measurement requirements via the following parameters:

- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory

Memory depth of oscilloscope function

The number of measured values is determined via "P-0-0032, Oscilloscope: Size of memory". A maximum of 8192 measured values per channel can be recorded.

Time resolution of oscilloscope function

Parameter "P-0-0031, Oscilloscope: Time resolution" determines the time intervals at which measured values are recorded (sampling rate). It is possible to select the time resolution on the time base of the position controller clock cycle (T_{Osci} = N x $T_{A_position}$; N = 1, 2, 3, 4, …).

The position controller clock cycle depends on the selected control performance. The control performance in turn depends on the hardware design of the controller and the setting in parameter P-0-0556.

In the expert mode, the minimum time resolution can be set to the current control clock cycle.

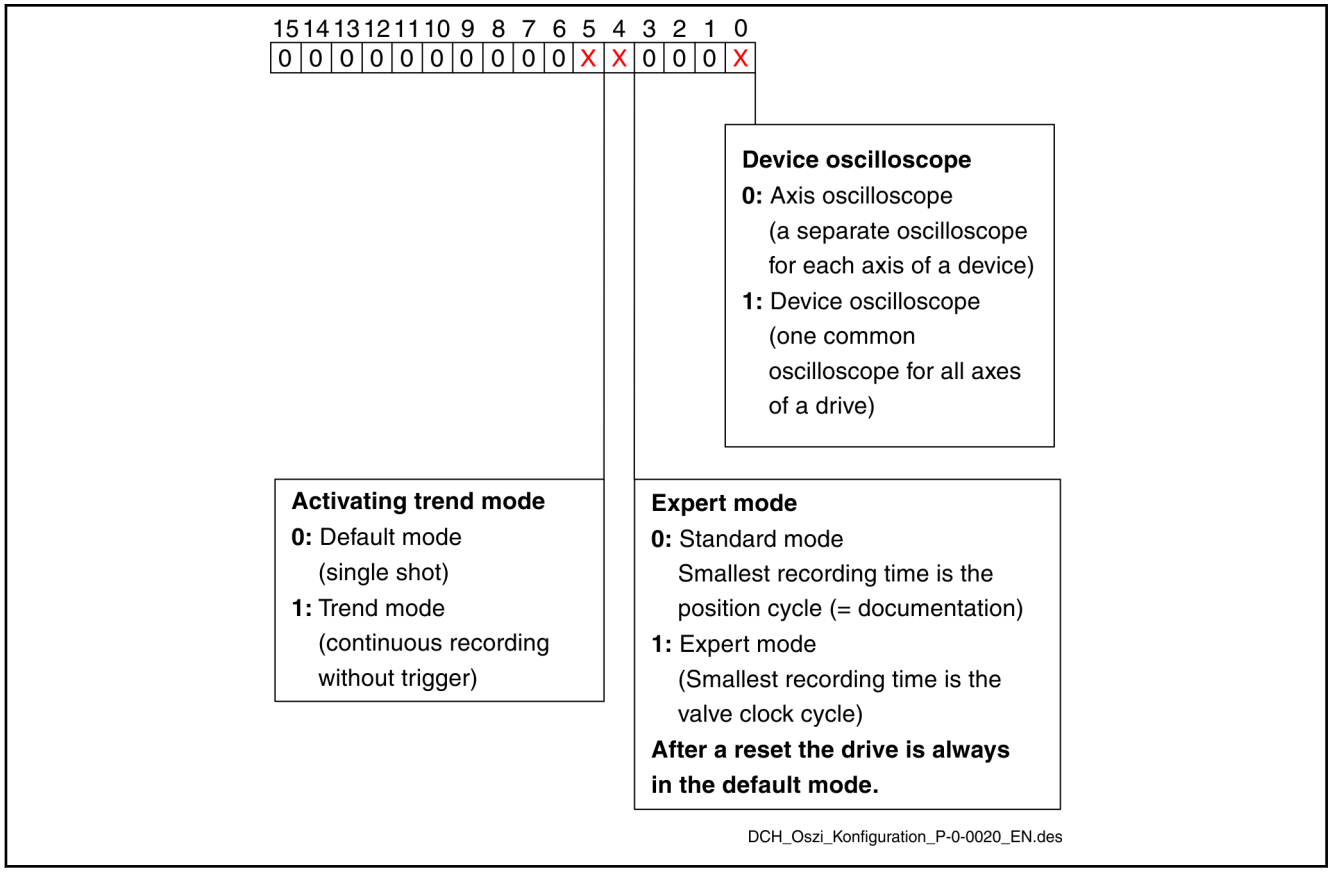


Fig. 9-29: Configuration of P-0-0020

The times that can be achieved can be found in the "Performance data". It must be noted that in the expert mode the trigger is evaluated only in the position controller clock cycle. This means that a trigger event, which is not existent in the position controller clock cycle, cannot be evaluated.

☞ Updating of the parameter values is not adapted to the time resolution of recording, i.e. a parameter, which is generated in the firmware in the position controller clock cycle (e.g. S-0-0051), will only change within the time window of the position controller, even if it is measured within, for example, the valve controller clock cycle.

When the time resolution is set to a value of less than the position controller clock cycle and unequal to the velocity or valve controller clock cycle, the time resolution is automatically set to the next smaller controller clock cycle (velocity or valve controller). The time resolution entered is rounded. The expert mode allows time resolutions, which are greater than or equal to the position controller clock cycle.

☞ After a reset the drive is always in the standard mode.

Depending on the control section's loading (performance setting, active options, functional packages, MLD program) it may happen that the computing time is not sufficient to call the oscilloscope function in every valve controller clock cycle or velocity controller clock cycle. The measurement is not completed before the configured number of measuring points has been recorded. It

can therefore not be guaranteed that the time resolution shown in the oscilloscope is correct.

Example: The measurement is configured with 100 measuring points in the valve controller (125 µs), and during the measurement the oscilloscope function is active in only every second valve controller clock cycle. In the oscilloscope a measurement over 12.5 ms is shown on a time base of 125 µs. The measured values were actually recorded over 25 ms on a time base of 250 µs.

Parameterizing the number of channels

The number of channels can be set using parameter P-0-0269. For reasons of compatibility, the minimum number of 4 channels must be adhered to. The maximum number can be set to 8 channels. In this case, the maximum recording depth is reduced. The sum of all channels must not exceed 32768. This means that the following combinations are possible:

Number of channels	Recording depth
1-4	8192
5	6553
6	5461
7	4681
8	4096

Tab. 9-11: Recording depth dependent on number of channels



This parameter is only effective after a restart. Then, the respective parameters become available and the respective recording depth is set.

Depending on the number of channels set, the relevant parameters for signal selection or list of measured values are made available.

9.4.8 Diagnostic and status messages

Status of oscilloscope function

Parameter "P-0-0029, Oscilloscope: Status word" indicates the current state of the oscilloscope function.

P-0-0029 contains, for example, status information on:

- Start/end of recording
- Trigger function
- Status of trigger signal
- Delay function



See also parameter description "P-0-0029, Oscilloscope: Status word"

Via parameter "P-0-0037, Oscilloscope: Internal trigger signal" the master is informed about the status of the internal trigger. This parameter can be parameterized as real-time status information, both in the real-time channel of the interface and as hardware output.

Displaying the number of valid measured values

After a measurement, the parameter "P-0-0150, Oscilloscope: Number of valid measured values" displays the number of measured values in the ring

buffer. If the ring buffer has been completely filled with the length determined in parameter "P-0-0032, Oscilloscope: Size of memory", the memory depth is displayed in this parameter.

See also parameter description "P-0-0150, Oscilloscope: Number of valid measured values"

9.4.9 Trend mode

The trend mode allows up to 8 channels to be recorded in a cyclical mode. The values are administrated in a buffer memory and called cyclically. IndraWorks can read out and continuingly show this memory. Since the measurement is not necessarily equidistant, it may happen that measured values are missing due to, for example, a slow connection. These values are shown accordingly in the graphic display.

In order that trend mode can be used, the system time must be activated. This time base serves to clearly assign the respective measuring points to a point in time.

The time resolution and the signal selection can only be set while trend mode is switched off. As time resolutions, only times are permitted that are a multiple of 2 ms. If another value is entered, it is rounded down to the next possible value. The signal selection is made using the parameters set before.

The trend mode is activated by setting P-0-0020, bit 5. The mode of the "classic" oscilloscope cannot be used in parallel. Trend recording is then activated via P-0-0028, bit 0. The trend signals its activity also in P-0-0029, bit 0.

After trend mode was activated, the values are recorded in the set time resolution. These values are stored in two double buffers, which means that while one buffer is read, the other can be refilled. Every reading of the parameter (P-0-0280) results in a changeover of the double buffer. This means also that the data can only be read once. If the parameter is not read and the maximum number of elements has been saved, trend comes to a stop until the parameter is read again. Until reading out, data can no longer be saved and are therefore lost. Considering the current size of the buffers and a number of 8 channels, it can be assumed that with a minimum time resolution of 2 ms it is possible to record for ca. 400 ms before data are lost. Because these data are to be represented continuously, the request intervals should be issued at significantly shorter time intervals.

Recording always starts with 4-byte information. It always contains the version in the least significant byte. Depending on the version, the other data may be adapted.

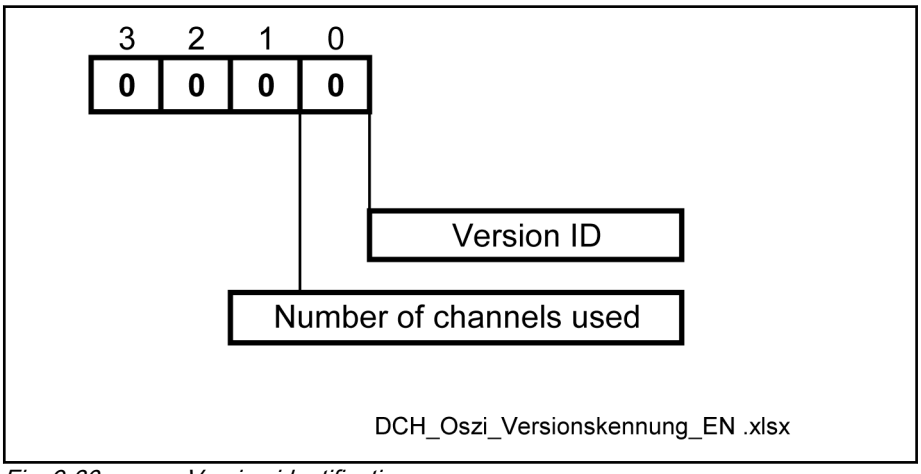


Fig. 9-30: Version identification

Currently, only version 1 is used. This means that the 2nd byte shows the number of channels. The subsequent data are always composed of 2 entries for time (P-0-0197). The high word precedes the low word. They are followed, depending on the number of channels, by the payload data - always in the 4-byte format. 2-byte values are expanded with the correct sign. Payload data are interpreted with the same conversion as the selected signals.

9.4.10 Pertinent parameters and diagnostic messages

Parameters

- P-0-0020, Oscilloscope: Operation mode
- P-0-0021, Oscilloscope: List of measured values 1
- P-0-0022, Oscilloscope: List of measured values 2
- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0025, Oscilloscope: Trigger mask
- P-0-0026, Oscilloscope: Trigger signal selection
- P-0-0027, Oscilloscope: Trigger level
- P-0-0028, Oscilloscope: Control word
- P-0-0029, Oscilloscope: Status word
- P-0-0030, Oscilloscope: Trigger edge
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory
- P-0-0033, Oscilloscope: Number of measured values after trigger event
- P-0-0035, Oscilloscope: Trigger control offset
- P-0-0036, Oscilloscope: External trigger signal
- P-0-0037, Oscilloscope: Internal trigger signal
- P-0-0145, Oscilloscope: List of measured values 3
- P-0-0146, Oscilloscope: List of measured values 4
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0149, Oscilloscope: Signal selection list
- P-0-0150, Oscilloscope: Number of valid measured values
- P-0-0269, Oscilloscope: Channel number setting
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8
- P-0-0274, Oscilloscope: List of measured values 5
- P-0-0275, Oscilloscope: List of measured values 6
- P-0-0276, Oscilloscope: List of measured values 7
- P-0-0277, Oscilloscope: List of measured values 8
- P-0-0279, Oscilloscope: Trend mode, time resolution
- P-0-0280, Oscilloscope: Trend mode, list of measured values

P-0-0035.0.1, Oscilloscope: Trigger time

Parameter "P-0-0035.0.1" contains the current system time (see S-0-1305.0.1, System time) at the time, when the drive's oscilloscope function was triggered. The parameter contains the trigger time with a resolution

of 1 ns. When triggering of the drive oscilloscope is released this parameter is filled with the content of parameter "S-0-1305.0.1" at the time when the related control cycle is started.

Parameter "P-0-0035.0.1" is a 64-bit value, which is structured as list with two 4-byte long elements.

Element	Content
1	Trigger time (fine) (according to S-0-1305.0.2)
2	Trigger time (coarse) (according to S-0-1305.0.3)

Tab. 9-12: Points of time of triggering

Parameter “P-0-0035.0.1” serves to synchronize measurements like

- the simultaneous measurement on the PC and in the drive. To this end, the system time of the drive must have been synchronized with the system time of the PC connected via IndraWorks,
- the simultaneous measurement on several drives. Synchronization via a bus master,
- the synchronization of Diagnostic Trace (event recording via S-0-1303.0.x, see "Error and diagnostic memory" and oscilloscope recordings)

9.5 Condition monitoring

9.5.1 Pump control

Functional description

Condition monitoring functions are provided for the pump control to be able to make a statement about the condition of the pump system. Over the time in operation, wear and tear or aging of the system may occur in dependence on various boundary conditions.

The condition monitoring functions are designed to detect this process of aging or wear. They are available in the HydraulicDrive firmware as of HDx20V20. To enable condition monitoring, the system has to be brought to a defined state. This creates a comparable condition, in which certain characteristic values can be determined. To obtain a comparative value, after initial commissioning the system has to be set to a defined state and a reference point has to be set for condition monitoring. In normal operation of the system, the condition monitoring functions can be called at defined intervals (e.g. once a week). During this call-up, the pump controller system is operated using internal command values and follows a defined sequence. When the CM functions are completed, the characteristic values are internally evaluated and a general statement on the condition of the system is made:

- **GREEN:** No indication of serious wear/aging of the pump system
- **YELLOW:** Wear/aging detected;

  At present, the machine function is not yet compromised;

  Inspection/replacement of the pump system recommended for the next maintenance interval
- **RED:** Clear signs of wear/aging;

  Machine function is affected;

  Servicing/replacement required

Controlling the condition monitoring functions

The command function "C9000, Condition monitoring" is provided for controlling condition monitoring. The command function is controlled via "P-0-2887, C90xx Condition Monitoring command parameter". Further information on calling and the sequence of a command function of the drive can be found in chapter "chapter 9.1.6 "Command processing" on page 546".

The individual functions can be selected by means of parameter "P-0-2888, Condition monitoring control word". The following selection options are offered:

Number	Description / selection of condition monitoring functions
1	Determination of the current condition of the system
2	Merely evaluating the condition monitoring data (no determination of values)
10	Setting the reference point for the condition monitoring pump
30	Clearing the memory range for condition monitoring data
...	...

Tab. 9-13: Controlling the condition monitoring functions

Setting the reference point for the condition monitoring pump

The condition monitoring function of the pump requires a reference point to be set. This reference point serves as comparative value for condition monitoring of the pump. The reference point has to be set once after successful commissioning at operating temperature of the system. To be able to set the reference point, start the command function C9000. For condition monitoring, the value 10 has to be selected in selection parameter P-0-2888. The following requirements have to be met in order that the reference point can be set:

- Pump drive motor ON
- All actuators disconnected from the pump (i.e. no oil flow and no oil consumption)
- Controller enable active (otherwise, command error C9001)



While the command function is being called up, the control switches to internal command values for the controller. The command values preset by the machine control are not influenced by the command. However, they are not used while the command is running. Before the command is started, the system must therefore be brought to a safe state for the monitoring function.

Determining of the current condition of the system

To be able to determine the current condition of the system, the command function C9000 has to be started. For condition monitoring, the value 1 has to be selected in selection parameter P-0-2888. The following conditions have to be fulfilled for this:

- Pump drive motor ON
- All actuators disconnected from the pump (i.e. no oil flow and no oil consumption)
- Controller enable active (otherwise, command error C9001)

☞ While the command function is being called up, the control switches to internal command values for the controller. The command values preset by the machine control are not influenced by the command. However, they are not used while the command is running. Before the command is started, the system must therefore be brought to a safe state for the monitoring function.

After the command was successfully completed, the current condition of the system is shown as follows in "P-0-2891, Condition monitoring status word":

Bit	Designation/function
0-2	001: System status GREEN 002 System status YELLOW 003 System status RED

Tab. 9-14: Current condition monitoring sate

Pertinent parameters and diagnostic messages

Pertinent parameters

- P-0-2887, C90xx Condition Monitoring command parameter
- P-0-2888, Condition monitoring control word
- P-0-2889.0.x, Reference values of CM function
- P-0-2890.0.1, Process values of CM function
- P-0-2891, Condition monitoring status word
- P-0-2885.0.12, Oil temperature

Pertinent diagnostic messages

- C9000 Execute Condition Monitoring command
- C9001 No drive enable
- C9002 Error message present during Condition Monitoring
- C9003 Condition Monitoring error, other command active
- C9004 Error in pump Condition Monitoring, see detailed diagnostics
- C9005 Abort Condition Monitoring, incorrect memory access
- C9006 CM control word contains invalid selection

Description of detailed diagnostics "C9004 Error in pump Condition Monitoring, see detailed diagnostics"

Detailed diagnostic message	Remedy
Swivel angle feedback value of the condition monitoring pump too large	• Disconnect all consumers from the pump • Repeat calibration function, if necessary
Pressure control difference too large during condition monitoring function	• Check setting for pressure controller • Repeat calibration function, if necessary
Valve calibration value too large during condition monitoring function	• Check setting for pressure controller • Repeat calibration function, if necessary

Detailed diagnostic message	Remedy
Leakage calibration value too large during condition monitoring function	• Disconnect all consumers from the pump • Repeat calibration function, if necessary
Swivel angle offset too large during condition monitoring function	• Disconnect all consumers from the pump • Repeat calibration function, if necessary

Tab. 9-15: Description of detailed diagnostics C9004

9.6 Average value filter

Functional description

If highly dynamic or actual values generated with high frequency such as currents, torques, accelerations, velocities, etc. are to be processed further for visualization purposes, it is often useful to direct these actual values via a smoothing filter. To this end, the function of the average value filter is used.

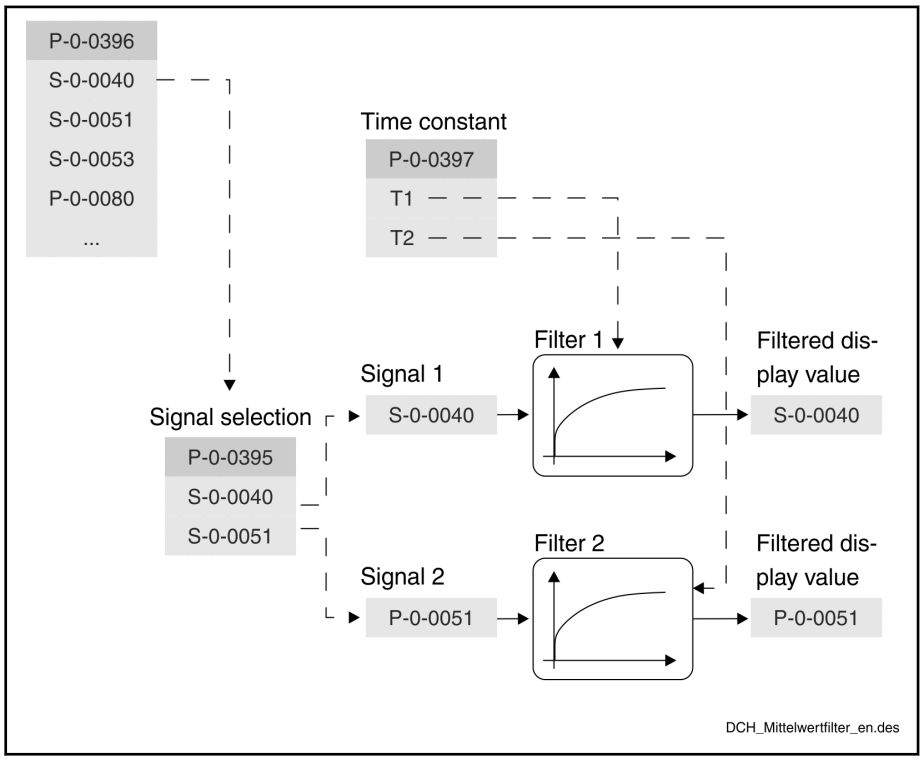


Fig. 9-31: Average value filter

When selecting the signals, the following points have to be observed:

- Only signals from parameter "P-0-0396, Average value filter for display: Signal selection list" can be selected.
- The filter function is deactivated, when "S-0-000" is selected as signal.

Oscilloscope function and average value filter

The order of parameterization must be observed!

- If first the signal for the average value filter for display is set and then the same signal is selected as measuring signal in the oscilloscope, the filtered value is recorded in the oscilloscope.
- If the order is inverse, the non-filtered value is recorded.

If the signal for the average value for display is changed or cleared, automatic switching does not take place with the oscilloscope function. The signal has to be selected again as measuring signal.

Pertinent parameters

- P-0-0395, Average value filter for display: Signal selection
- P-0-0396, Average value filter for display: Signal selection list
- P-0-0397, Average value filter for display: Time constant

9.7 Firmware replacement

9.7.1 Brief description

Basic principles

Explanation of terms

The following cases are distinguished for firmware replacement:

- **Release update**

  An old firmware release (e.g. HDB-17**V12**) contained in the device is replaced by a new firmware release (e.g. HDB-17**V14**).

- **Version upgrade**

  The older firmware version contained in the device is replaced by a new firmware version (example: HDB-**17**V14 is replaced by HDB-**18**V10).

Replacement

Firmware can be replaced using the following hardware and software:

- Computer with software "IndraWorks" or
- Computer with TFTP client

☞ The "IndraWorks" commissioning software can be ordered from Rexroth.

The scope of supply of "IndraWorks" contains documentation which describes the operation of the program.

To be noticed

After every firmware replacement (release update and version upgrade), check the following parameters for validity:

- P-0-2003, Selection of functional packages
- P-0-4089.0.1, Master communication: Protocol

It might be necessary that you set them valid manually during the first run-up after the firmware replacement.

Preparations and boundary conditions for firmware replacement

Preparations for replacing firmware

You have to make the following preparations for firmware replacement:

1. Drive controller must be on (24 V supply).
2. The drive controller **must not** be in operating mode (communication phase 4) (cf. P-0-0115).
3. It is recommended that you save the required parameters before replacing the firmware.

General notes on how to carry out firmware replacement

You have to observe the following points when carrying out the firmware replacement:

- For the firmware replacement via IndraWorks, Ethernet communication to the drive has to be possible.
- Do not switch off the 24 V control voltage while replacing the firmware.
- The firmware has always to be replaced completely.

Communication types

The engineering communication works in different ways, depending on the activated bus system (cf. P-0-4089.0.1). Make the settings and comply with the requirements in accordance with the bus system used. For further information, see chapter "TCP/IP communication".

☞ After you have changed the IP settings, the device has to be restarted for activating the settings. If several devices have been connected via the master communication bus, you have to make sure that an unequivocal IP address is assigned to each node.

IP settings on the computer

See Microsoft help, keyword "LAN connection"

9.7.2 Firmware release update

General information

Before you update the firmware release, it is recommended that you save the backup parameters of the drive!

Firmware release update with computer

1. Connect the drive to the computer (recommended: Cat5e Ethernet cable)
2. Load firmware

   There are two possibilities of performing a firmware release update using a computer:

   - By means of IndraWorks or
   - with a TFTP client

   1. *Firmware release update with IndraWorks*

      1.1 Open "IndraWorks Suite or IndraWorks Ds".

      1.2 IndraWorks Suite: Load project for relevant axis or create new project; to do this, address axis over Ethernet.

      1.3 IndraWorks Suite: Switch project "online".

      IndraWorks Ds: Establish connection with the controller via the dialog "Connection Selection".

      1.4 IndraWorks Suite: Select/highlight controller and call "Firmware Management" in context menu.

      IndraWorks Ds: Call menu item **Diagnosis/Service ▸ Firmware Management...**.

      A new window opens and drive firmware currently available in the drive is displayed.

      1.5 Highlight new firmware (*.ibf file) in upper part of dialog and start firmware download by clicking "Download" button.

      The firmware download runs automatically and all required firmware components are loaded to the drive.

      1.6 After the firmware download has been completed, close the "Firmware Management" window.

   2. *Firmware release update using a TFTP client*

      2.1 Firmware update service is made available via a TFTP server. Command for sending the firmware is "put" command.

☞ It is possible with any TFTP client supporting this command (e.g. Windows command line program "tftp.exe") to carry out a firmware release update **without IndraWorks**.

Example (with "Microsoft Windows consoles TFTP client"):

To carry out a firmware release update, only a "put" request is transmitted. Do not use an optional alternative name for the file on the target system. For the host, the IP address of the device is to be specified (standard is 192.168.0.1): `tftp -i 192.168.0.1 put FWA-HYDRV_-HDB-18V10-D5.ibf`

See also functional description: "Firmware download via TFTP server"

3. Restart drive
4. Put machine into ready-for-operation status again according to the machine manufacturer's instructions.
5. Check functions of drive.

9.7.3 Firmware version upgrade

General information

When firmware in a drive controller is replaced by firmware of a **more recent version**, this is called firmware version upgrade (e.g., FWA-HYDRV*-HDB-**17**V12-D5 replaced by FWA-HYDRV*-HDB-**18**V10-D5).

☞ **Before** carrying out the firmware version upgrade, you have to save all parameters (e.g., with "IndraWorks"). **After** firmware replacement, the parameters need to be restored, because the command "C07_1 Load defaults procedure command (factory settings)" is carried out automatically. After the desired parameter file was loaded, the drive controller is ready for operation again.

Saving parameter values

Before the firmware upgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out by means of:

- **"IndraWorks" commissioning software**

  → Saving parameter values to external data carrier

- or -

- **Control master**

  → Saving parameter values on master-side data carrier

Version upgrade with "IndraWorks"

Requirements The following requirements should have been met in order that a firmware version upgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and drive controller
- Current parameter setting of axis was saved.

When upgrading from HDB-17VRS to HDB-18VRS, the error F8100 is sometimes generated during the drive controller's initial start-up. This error can be cleared via the display and will not occur again during the next booting process.

Firmware upgrade with "IndraWorks"

Carrying out the firmware version upgrade with "IndraWorks" requires the following steps:

1. **Load firmware**
   - 1.1 Open "IndraWorks Suite or IndraWorks Ds".
   - 1.2 IndraWorks Suite: Load project for relevant axis or create new project; to do this, address axis over Ethernet.
   - 1.3 IndraWorks Suite: Switch project "online".

     IndraWorks Ds: Establish connection with the controller via the dialog "Connection Selection".
   - 1.4 IndraWorks Suite: Select/highlight controller and call "Firmware Management" in context menu.

     IndraWorks Ds: Call menu item **Diagnosis/Service ▸ Firmware Management...**.

     A new window opens and drive firmware currently available in the drive is displayed.
   - 1.5 Highlight new firmware (*.ibf file) in upper part of dialog and start firmware download by clicking "Download" button.

     The firmware download runs automatically and all required firmware components are loaded to the drive.
   - 1.6 After the firmware download has been completed, close the "Firmware Management" window.
   - 1.7 Reboot drive controller
2. **Put drive into ready-for-operation state**

   ⇒ Switch project "online"!

   After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to drive via Ethernet interface, as drive-internal settings for Ethernet communication were reset.

   ⇒ In this case, reconfigure communication via button "Search for devices"!

   ⇒ As the firmware in the drive no longer complies with the version stored in the project, a corresponding message is displayed. Select desired option in the dialog to make the drive available in the project again and allow reestablishing communication with the device.

   ⇒ Set functional package and master communication protocol manually via corresponding parameters.

   ⇒ Activate command "C07_1 Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.
3. **Load parameter values**

   ⇒ Load saved parameter file!

   ⇒ Switch off drive and re-start so that the parameterization becomes active.
4. **Put machine into ready-for-operation state**

   ⇒ Put machine into ready-for-operation status again according to the machine manufacturer's instructions.

   ⇒ Check functions of drive.

9.7.4 Upgrade to HDB-18V08

As of version HDB-18V08, the firmware download is carried out exclusively via the TFTP protocol. With the predecessor versions HDB18V06 and HDB17V16 the SIS protocol is active.

For the upgrade, an intermediate step is necessary, i.e. the FWA file (version HDB18V08) is loaded twice. In a first step, the TFTP loader is activated. In a second step, the respective, complete FWA version is loaded via the activated loader.

The description refers to the IndraWorks Ds 13V10 operator interface used.

9.7.5 Upgrade From HDB-17/18 (SSI) to 18V08 (TFTP)

Upgrading must be carried out in the following sequence:

1. Call →Service→Firmware administration in IndraWorks
2. Select file name **FWA-HDB-18V08.ibf**
3. Start download

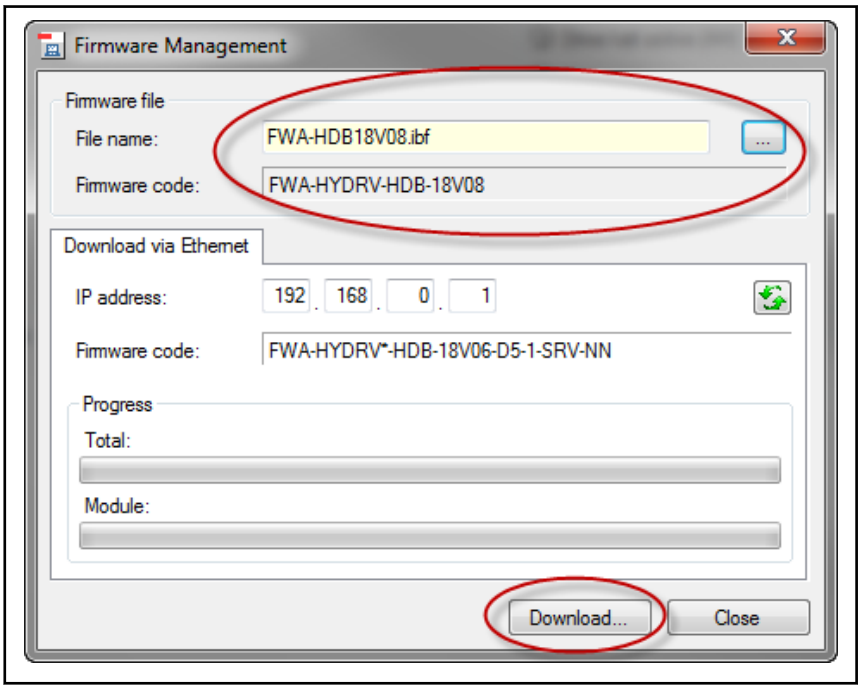


Fig. 9-32: Upgrade to HDB-18V08

4. The following safety warning must be observed and, if necessary, confirmed by clicking **Yes**.

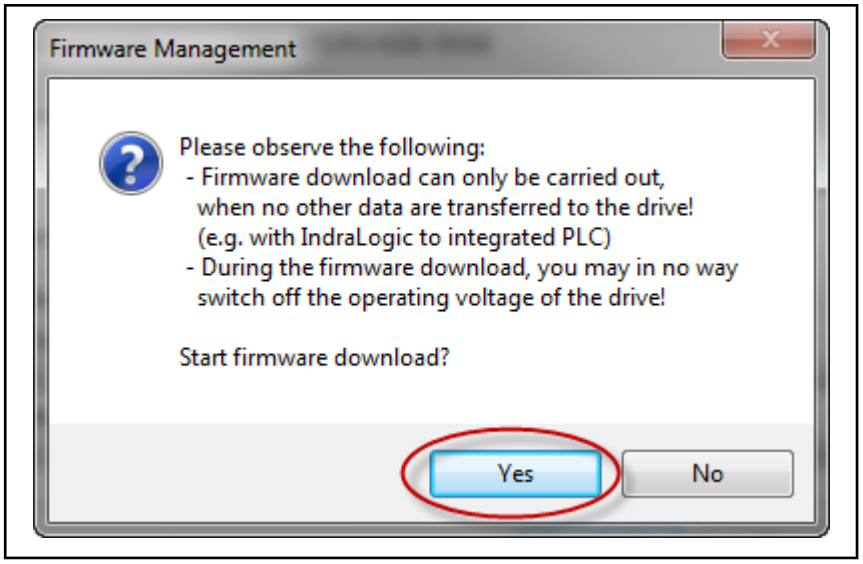


Fig. 9-33: Upgrade to HDB-18V08

The download is started now.

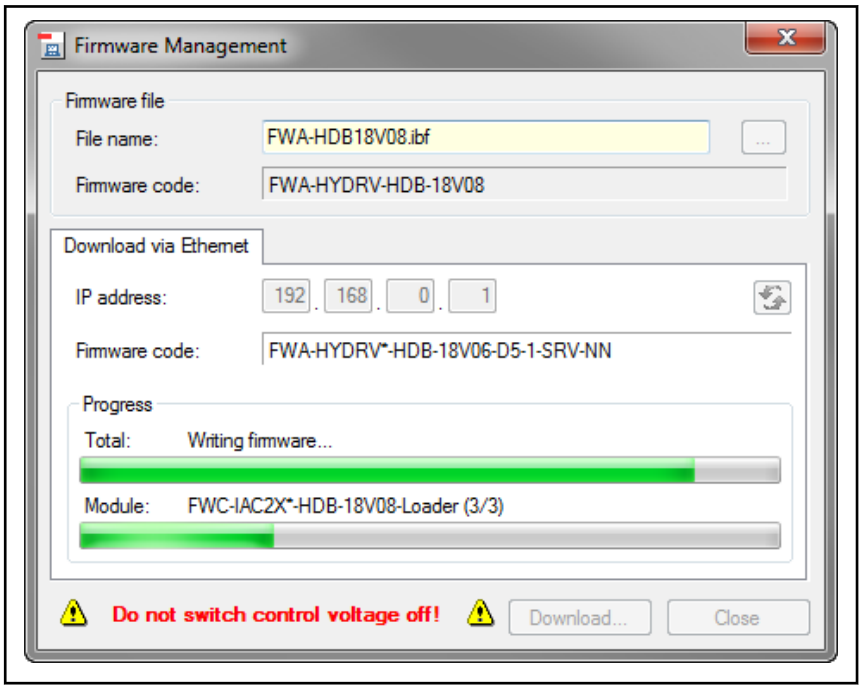


Fig. 9-34: Upgrade to HDB-18V08

A successful download is confirmed by the subsequent information window.

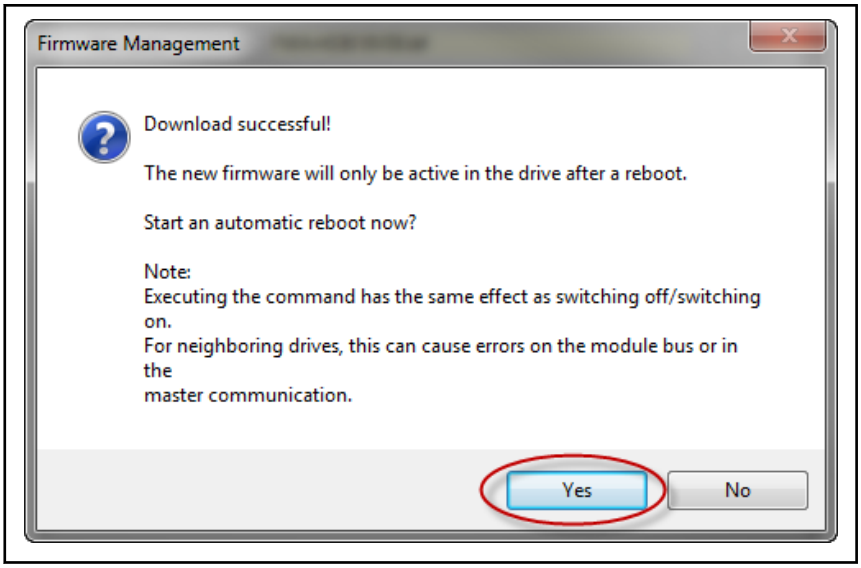


Fig. 9-35: Upgrade to HDB-18V08

5. A restart is required. It is executed after clicking **YES**. The device can also be booted manually.

☞ Following the restart, the TFTP loader is now active.

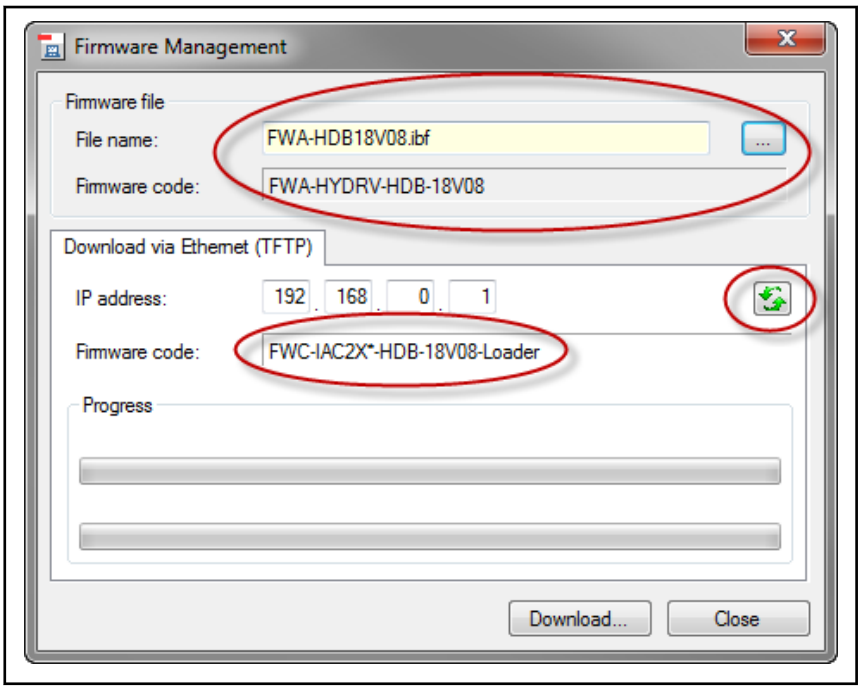


Fig. 9-36: Upgrade to HDB-18V08

6. The download must be started again.

☞ The IP address was reset to 192.168.0.1. Otherwise, the address has to be entered later.

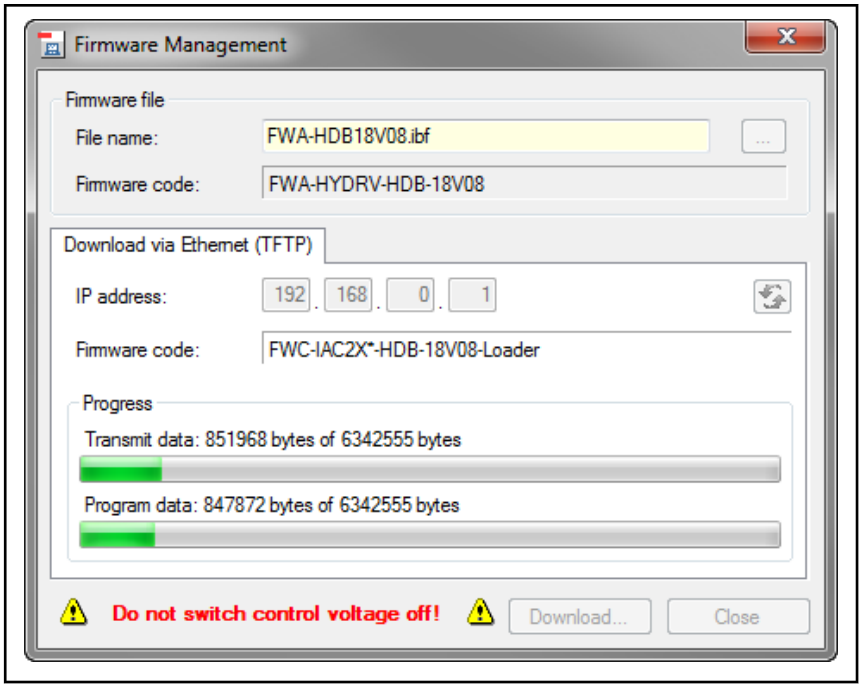


Fig. 9-37: Upgrade to HDB-18V08

☞ A successful download is confirmed by an information window.

7. A restart is required. It is executed after clicking **YES**. The device can also be booted manually.

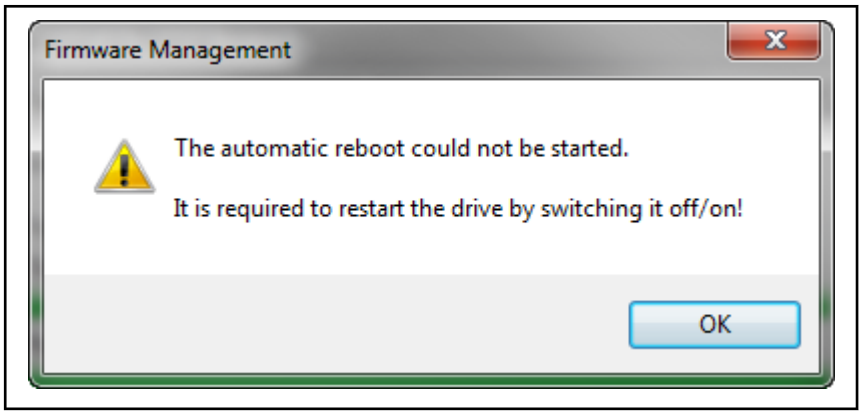


Fig. 9-38: Upgrade to HDB-18V08

☞ After a restart was carried out, re-copying processes take place, which are signaled by red/green flashing of the ModulStateLED. Then, the new version (HDB-18V08) is active.

9.7.6 Possible problems arising during firmware replacement

General information

After an incomplete firmware update, the drive controller might no longer be operable.

Firmware replacement is carried out incompletely, if one of the following situations occurs during the sequence of firmware replacement:

- 24 V supply of control section is switched off

- Connection to drive is interrupted (e.g. defective interface cable)
- Crash of update software / of computer

If there is no valid firmware available in the control section, the loader is started. With the loader, it is possible to replace the firmware of the control section.

☞ Upon successful firmware replacement in the control section, a restart has to be carried out.

Firmware replacement in the control section in the event of an error

The following steps are required for loading the firmware to the control section in the case of error:

1. Open "IndraWorks Suite or IndraWorks Ds".
2. IndraWorks Suite: In the menu, call firmware management under **Tools ▸ Drive ▸ Firmware Management**.

   IndraWorks Ds: In the menu, call firmware management under **Diagnosis/Service ▸ Firmware Management**.

   A new window opens in which the firmware file last used is displayed on the PC.
3. Select "Download via Ethernet" tab.
4. Set IP address "192.168.0.1".
5. Highlight desired firmware (*.ibf file) and start firmware download via **Download** button.
6. The firmware download runs automatically and all required firmware components are loaded to the drive.
7. After the firmware download has been completed, close the "Firmware Management" window.
8. Restart drive.

9.7.7 Reboot command

Functional description

Various, fundamental changes in the configuration of the drive will not become effective before the system is rebooted such as

- Loading of new firmware to firmware
- Changeover of functional package
- Changeover of Multi-Ethernet protocol

To avoid that the control voltage of the device concerned and possibly other devices that may be supplied with the same control voltage need to be switched off and on completely, the "S-0-1350, C6400 reboot command" is implemented.

Sequence of the reboot command

Upon the start of the command, retain data are saved. Then, a fixed delay time of 2 sec has to elapse before the reboot process is initiated. The delay time allows starting of the command at several drives of a system in parallel without resulting in a breakdown of the Sercos communication immediately after the start of the command due to the drive boot process. During the delay time, the command signals "in process".

For safety reasons, the command can only be started in the parameter mode (PM).

9.8 Replacing the controller

9.8.1 Overview

The paragraphs below describe how to replace the complete drive controller as regards the parameter backup.

The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

A device intended for replacement that has already been in operation (and thus is not in the new condition as supplied), has to be brought again to the condition as supplied ["load d""efaults procedure (factory settings)", command C0750] before it is used.

The figure below illustrates the basically required individual steps.

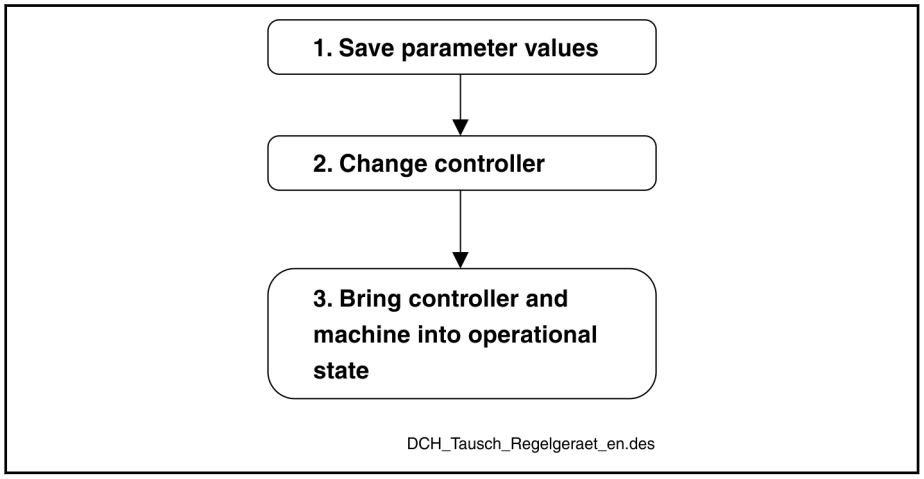


Fig. 9-39: Sequence of drive controller replacement

9.8.2 How to proceed when replacing drive controllers

Saving parameter values

Before demounting the defective device, save the drive parameter values, if possible.

If saving the parameter values before replacing the device is impossible due to a total breakdown of the device, only the parameter values backed up after initial commissioning can be loaded when the parameter values are loaded later on!

1. Switch to parameter mode (PM or P2).
2. Save parameter values of defective device using the "IndraWorks Ds/D/MLD" commissioning tool or the control master:
   - "IndraWorks" commissioning tool
     1. In IndraWorks, open context menu of device.
     2. In context menu, select menu item “Saving...” under “Parameters”.

        ⇒ The "Save Parameters" dialog opens.

3. Enter a file path in “Save Parameters” dialog (“D:\Axis_2.par” in the example) and select the axis to be replaced (axis at address 2 in the example).

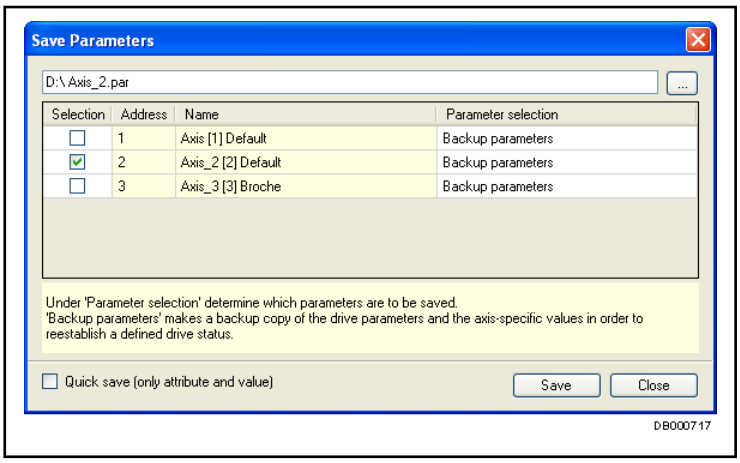


Fig. 9-40: Saving parameters

4. Click **Save** button to save the parameters.

- Control master:

  Using the control master, save parameter values of parameters listed in "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)" to a master-side data carrier.

Replacing the drive controller

1. Open main switch
2. Make sure the main switch cannot be switched on again.
3. Make sure drive controller is completely de-energized.
4. Disconnect connection lines from the controller and demount it.
5. Mount new controller.



The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

6. Set address of master communication.
7. Connect device according to machine circuit diagram.

Putting drive controller and machine into ready-for-operation state

1. Restore control voltage.
2. Put machine into ready-for-operation state again according to the machine manufacturer's instructions.
3. Check functions of drive.

9.8.3 Possible problems during controller replacement

The paragraphs below give a brief description of critical problems and their recommended handling.

If it was impossible to save the parameter values according to list parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)" directly before the device was to be replaced, reload the parameter values saved after initial startup.

NOTICE

The parameter values saved after initial start-up are not generally suited for reestablishing the operability of the drive after a device has been replaced!

Check actual position values and active target position before setting drive enable!

When firmware and drive parameters are to be transmitted to the replacement controller, the required firmware and a parameter backup of the respective axis must be available.

1. Reestablish the control voltage supply of the controller.
2. Carry out firmware update, see also chapter "Firmware replacement"
3. Load parameter file to controller via the "IndraWorks" commissioning tool or the control master:
   - "IndraWorks" commissioning tool

     Load operating data saved under item "1. Save parameter values" to the controller.
   - Control master

     Load axis-specific parameter values [according to list parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"] saved before the device had been replaced.

☞ In the case of drives with absolute value encoder and modulo format, the position data reference has to be established again after having loaded the parameter values saved after initial commissioning, even if parameter "S-0-0403, Position feedback value status" signals that the actual position values are valid!

10 Engineering/diagnostic interfaces

10.1 Web server

10.1.1 Brief description

Activating/deactivating the web server

The web server can be activated or deactivated via parameter "P-0-1535, Setting of IP communication", bit 13. In the minimum extension stage, this means that at least the WebSocket interface is available.

The web server is made available at port 80 of the device IP address, e.g. http://192.168.2.1.

Overview of web server

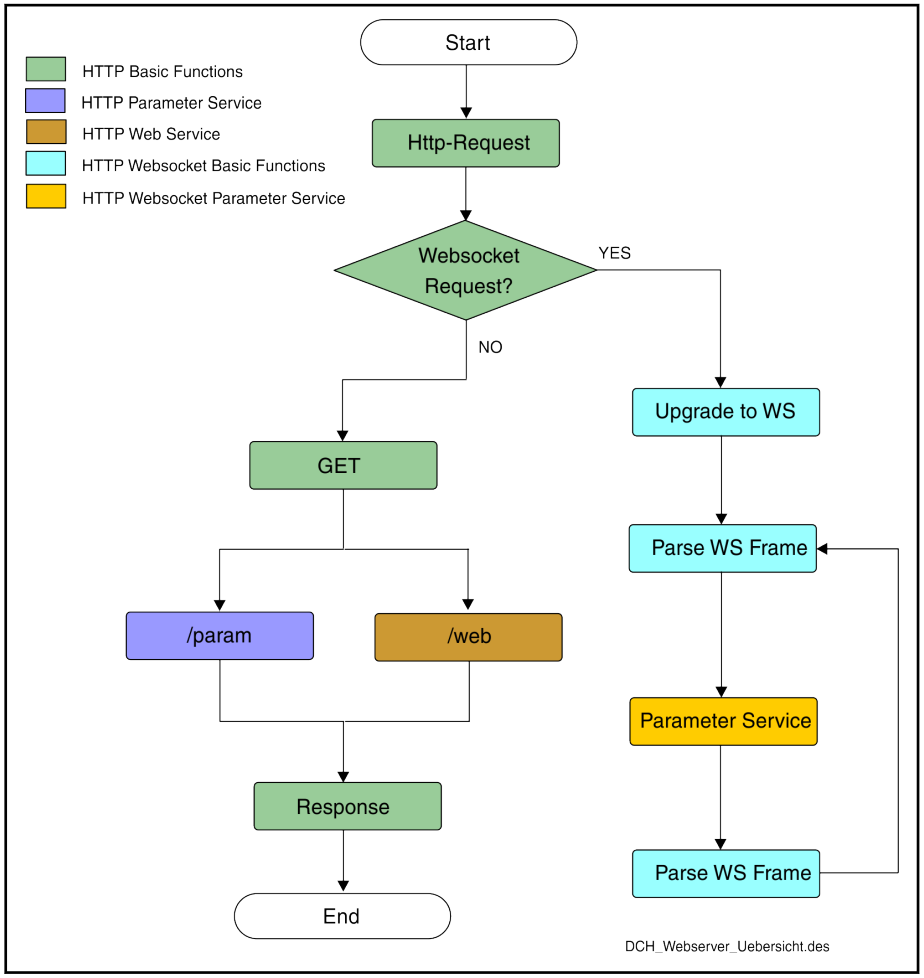


Fig. 10-1: Overview of web server

At present, the web server provides 3 services:

- HTTP parameter service
- HTTP web service
- WebSocket parameter service

The "HTTP parameter service" offers a simple interface for reading parameter data via an HTTP connection. Die interface is described in chapter 10.1.2 "WebSocket parameter service" on page 612.

The "HTTP web service" comes with a website stored in the HydraulicDrive in the factory. It contains (status) information about the connected device, see chapter 10.1.4 "HTTP web service" on page 613.

The "WebSocket parameter service" offers a high-performance connection to the parameter system of the drive. This service can be used to read and also edit parameters. Die interface is described in chapter 10.1.2 "WebSocket parameter service" on page 612.

Availability

	HDB	HDC	HDM	HDE	HDP
HTTP parameter service	X	X	X	X	--
HTTP web service	--	X (SD only)	X (SD only)	--	--
WebSocket parameter service	X	X	X	X	--

Tab. 10-1: Availability

10.1.2 WebSocket parameter service

WebSockets

WebSockets offer the possibility of a high-performance data connection of an HTML user interface to the parameter system of the hydraulic drives.

Interface

To be able to utilize the WebSocket interface, a WebSocket connection has to be established first:

```
var connection =
new WebSocket("ws://<IP-Adresse>:<Port>","<Protocol>");
```

As soon as a connection is established with the server, server data can be sent. For this, the `send()` method is used. For binary messages such as used by the parameter service, the `Blob` or the `ArrayBuffer` object may be used.

The server can send messages at any time. As soon as this is the case, the `onmessage` callback is triggered. The message can be accessed via the `data` property. Binary frames can be received in the `blob` or `ArrayBuffer` format.

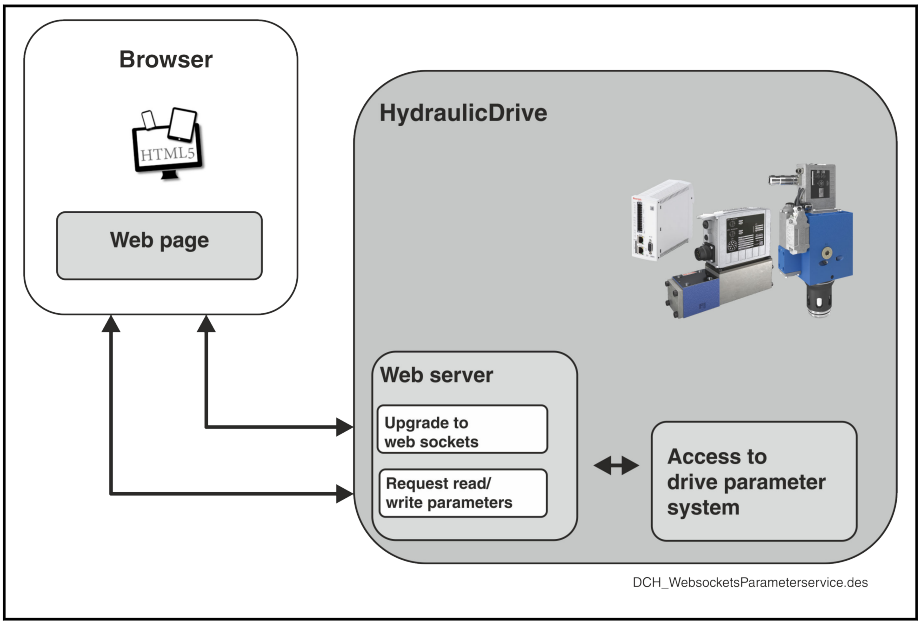


Fig. 10-2: Interface WebSockets/parameter service

Parameter service

The parameter service can be used for accessing parameter data.

In order that the parameter service can be employed, the protocol "param-v01.boschrexroth.com" is used at present.

For a simple implementation we recommend using the *Rexroth WebSocket library*. The library represents a simple interface for the parameter service.

The complete API description is contained in the library.

10.1.3 HTTP parameter service

The "HTTP parameter service" can also be used for reading any parameter of the HydraulicDrive.

The service is called by means of keyword "`/param`".

Then, the indication of an IDN or EIDN, followed by the number of the subdevice, is expected. After this you have to enter the element that you wish to read. This may be the value of the parameter, for example, or also a unit, the limit values or the name of the parameter. With the optional indication of "`plain`" or "`json`" you can determine the return format for the data. If you make no selection, "`plain`" is taken.

The structure of the parameter interface is shown in the following:

	Structure	Value range
	Keyword	/param
	/	/
	(E)IDN identifier	P, S
	-	-
	Parameter set	0-9
	-	-
	Number	0000-9999
Optional	.	.
	SI	000-999
	.	.
	SE	000-999
	/	/
	Subdevice	0-9
	/	/
	Element	value, unit, min.: max, last name, attribute
Optional	/	/
	Response type	plain (default), json

Tab. 10-2: Parameter interface structure

Example: The value of parameter "P-0-2845.0.1, Force controller P-gain" is to be read out as json object:

```
<IP address>/param/P-0-2845.000.001/0/value/json
```

10.1.4 HTTP web service

As of firmware release HDx20V20 it is possible to open a web project.

As only the SD card is currently available as storage medium for a web project, this is only possible with the control cabinet electronics VT-HMC and VT-HPC.

For storing the project, a web project must be in the "User/WEB" directory of the SD card. The start page should be named "index.html".

To open the web project enter the URL "<IP address>/SD" or "<IP address>/SD/index.html" in the address bar of the browser.

10.2 TCP/IP communication

10.2.1 Brief description

☞ The chapter "TCP/IP communication" describes all information required for standard Ethernet communication. In addition to TCP/IP communication, communication via UDP/IP is also possible.

To avoid any confusion with the master communication "EtherNet/IP™ interface" we will not use the term "Ethernet communication". Instead, we use the term "IP communication".

It is possible to communicate with a controller via standard Ethernet telegrams. These Ethernet telegrams contain TCP/IP or UDP/IP telegrams for application-side connection. For communication with the device, the CSMA/CD access method is used. Connection possibilities are interfaces that allow for TCP/IP communication. This may be a free port (e.g. Sercos or EtherNet/IP™) or a separate engineering port (if available).

Example of master communication

For Sercos, in addition to the time-controlled transmission of Sercos-type Ethernet telegrams (MDT and AT), an NRT channel (NonRealTime or IP channel) exists, where telegrams are sent in a specially reserved time slot.

Therefore, in addition to the existing service channel, a further option for asynchronous data transmission is available for Sercos that is very well suitable for large data volumes due to the maximum lengths of payload data of approx. 1500 bytes.

Possible applications

With TCP/IP communication in the drive, different application options become available, which are summarized in the following table.

Connection	Server application	Example client applications
SIP protocol	Parameter access	IndraWorks parameter application
TFTP	Firmware update service	Updating the firmware
FTP	File server	File access to the optional memory card (only available if the optional memory card is connected during the booting process)

Tab. 10-3: Overview of the possible applications

Pertinent parameters

- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- P-0-1044, Master comm. engineering over IP: Status IP communication
- P-0-1530, Engineering: MAC address
- P-0-1531, Engineering: IP address

- P-0-1532, Engineering: Network mask
- P-0-1533, Engineering: Gateway address
- P-0-1534, C6100 Command Activate IP settings
- P-0-1544, Engineering: Status IP communication

Pertinent diagnostic messages

- C6101, Incorrect IP settings
- F2190, Incorrect Ethernet configuration

10.2.2 Functional description

General information on the function

Components for TCP/IP communication

Every device has an interface for Multi-Ethernet master communication. This interface enables direct IP communication. Depending on the existing hardware or the enabled master communication, this interface is called "Engineering via IP" or "Engineering Port".

The interface is called "Engineering via IP" in the case of:

- Sercos
- EtherNet/IP™
- PROFINET® RT
- EtherCAT®

  With IndraWorks and TwinCAT, connection establishment is possible via the ADS interface or the EoE profile.
- VARAN

  With IndraWorks, connection establishment is possible via the EoV profile.

The interface is called "Engineering Port" with:

- PROFIBUS DP

  For PROFIBUS DP, an additional interface option is required.

Configuration

For IP communication, at least the IP address and network mask have to be set in each drive.

In addition, a gateway address can be set.

Interface	IP address	Network mask	Gateway address
Engineering over IP	S-0-1020	S-0-1021	S-0-1022
Engineering port	P-0-1531	P-0-1532	P-0-1533

Tab. 10-4: Parameters for IP configuration setting

Changes become effective when the drive is restarted or the drive command "C6100 Command Activate IP settings" is executed.

Structure of the IP address

The IP address of a communication node always comprises a network address (network ID) and a host address (host ID).

In a class C network (network mask 255.255.255.0), the network ID corresponds to the first three bytes of the IP address. The host ID is the fourth byte of the IP address.

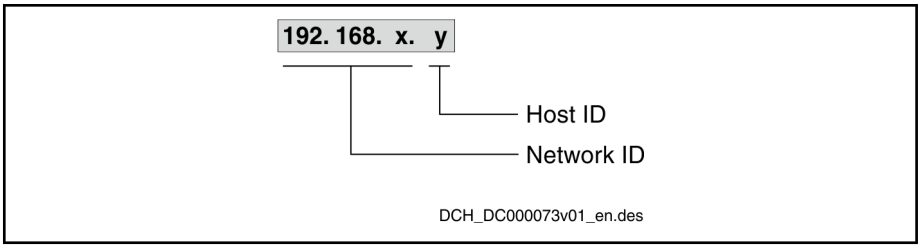


Fig. 10-3: Structure of the IP address

Always use a "private" area as address range of the IP communication with the drive. The defined areas of the following networks are available

- Class A networks (10.x.x.x),
- Class B networks (172.16.x.x) or
- Class C networks (192.168.x.x).

As IP address range, the area of private class C networks (192.168.x.x) is recommended or used as default setting.

Interface	IP address	Network mask	Gateway address
Engineering over IP	192.168.0.<Master communication address>	255.255.255.0	192.168.0.254
Engineering port	192.168.1.<Master communication address>	255.255.255.0	No default value

Tab. 10-5: Default values of the IP configuration

☞ Use "Load basic parameters (factory settings)" to restore the default values of the IP configuration; see tab. 10-5 "Default values of the IP configuration" on page 616.

The IP communication configuration can be maintained by selecting this in "Load basic parameters".

Select the option "without Engineering interface" to maintain the Engineering port settings unchanged. Select the option "without master communication parameters" to maintain the "Engineering via IP" settings unchanged.

Automatic settings

IP address of the master communication interface

This IP configuration is pre-set automatically:

- **IP address:** 192.168.0.<master communication address>
- **Network mask:** 255.255.255.0
- **Gateway address:** 192.168.0.254

IP configuration for Ethernet engineering interface

Automatically set IP configuration for the engineering port:

- **IP address:** 192.168.1.<master communication address>
- **Network mask:** 255.255.255.0
- **Gateway address:** 192.168.1.254

If required, change the settings as needed. This may be done using the control via an active connection to the drive.

General behavior of IP communication

Apart from setting the IP configuration, it has to be determined how the device is to behave with regard to the IP communication, when:

- the network settings are changed.

- the connection to the device is resumed/established (LINK status changed).

This general behavior of IP communication can be set using the configuration parameter "P-0-1535, Setting of IP communication".

In detail, the following can be set:

- ARP test (according to RFC 5227) active yes / no

Behavior when connection was established or IP address changed

If two devices with the same network configuration are connected to one IP network, this will inevitably result in communication problems within this network.

For this reason, a device should check whether the IP address is already used in the network, when:

- the device switched on,
- it is newly connected to the network (Ethernet cable plugged) and the LINK status consequently changes,
- the network configuration (IP address) of the device is changed.

In case that the own network configuration is already available, this configuration must not be used for communication.

To be able to carry this check out, the ARP test mechanism (according to RFC 5227) is integrated in the device. However, with the "default setting" the function remains switched off in the device, since, when devices are configured in the machine environment, IP addresses are typically not assigned more than once. If you whish to activate this additional check you can switch the ARP test function on by means of control bit 2 in configuration parameter "P-0-1535, Setting of IP communication".

The ARP test mechanism is generally started in the above cases, with two special points in the device having to be noted:

The IP-capable interfaces in a device are partially provided with two RJ45 sockets in order to allow, for example, setting up a line topology of the devices. Therefore, two independent pieces of LINK information are available.

For the ARP test mechanism, these two pieces of LINK information are internally merged and the address check is carried out only when the first LINK was detected. This is required in order that an existing IP communication, e.g. between the drive and the control, is not interrupted when an engineering PC is connected to the last device in a line or when a new device is connected to the line via hot plug.

The second special feature is necessary, because the device is not provided with a mechanism that would continuingly check the network for IP address conflicts. Such conflicts may occur, if you interconnect two network segments, for example, and a device with identical IP configuration is available in both segments.

For this reason, a feature was provided in the device, which allows the ARP test mechanism to be started manually in order to detect such potential conflicts irrespective of the above cases. When command "S-0-1048, C6100 Command Activate IP settings" is executed, the ARP test mechanism is therefore always active, regardless of any change in the IP configuration. Thus, every device can be forced to check its set IP configuration within the network.

The sequence of the address check by the ARP test mechanism is as follows:

First, three ARP test telegrams are sent by the device at time intervals of 1 second in order to determine whether the own IP address already exists in the network.

After the last ARP test telegram, a wait time of 2 seconds must be allowed to elapse before the IP configuration may be used.

During the time of 5 seconds the mechanism continuously checks whether a response is received in reply to the ARP requests of the device or whether telegrams are received, which contain the relevant IP address as sender address. If this is not the case - that is, no other device in the network utilizes the IP configuration - the desired IP address is activated in the device.

When the ARP test function is switched off in the device, the IP address is not checked in the network, but the configuration is used directly.

When the IP configuration is activated in the device, two final gratuitous ARP telegrams are sent with a time interval of 1 second and in this way the use of the IP address made known to the network. With a valid configuration, the device sends these telegrams, irrespective of whether the ARP test mechanism was run.

IP port list

The following table provides an overview of the IP ports used in the drive and if they are configurable.

Communication	Port	Protocol	Port configurable?
IndraWorks drive programming	5002	TCP	No
IndraWorks drive programming	35021	TCP/UDP	No
IndraLogic MLD programming system	1200	TCP	No
IndraLogic network variables	1202	UDP	Yes
EtherNet/IP™	44.818	TCP/UDP	No
EtherNet/IP™	2222	UDP	No
TFTP	69	UDP	No
TFTP - other ports, dynamic	1023 ff	UDP	Yes
Telnet	23	TCP	No
FTP[1)]	20 and 21	TCP	No
Web server	80	TCP	No
ComServer	6042	TCP	No
Global port list "well known ports"	http://www.iana.org/assignments/port-numbers		

1) Only, if SD card is available in the device

Tab. 10-6: IP port list

Looking at the above-listed IP services from an IT security point of view, each of these ports presents a potential point of attack for manipulation.

To offer operators the possibility of reducing this manipulation risk, the individual IP services can be configured via the configuration parameter "P-0-1535, Setting of IP communication" so that they can be switched off. Switching off will, however, only take effect after the device has been restarted.

To provide for the security aspect on which the deactivation of IP services is based, the attribute "customer password-protected" is automatically assigned

to the configuration parameter "P-0-1535, Setting of IP communication". If the operator assigns a password (recommended), the configuration parameter P-0-1535 can only be written if the device was unlocked by entering a password. The parameter is automatically entered in the list of password-protected parameters ("S-0-0279, Oscilloscope: Trend mode, time resolution"), unless it was already entered by the user.

10.3 S/IP protocol

10.3.1 Brief description

Fields of application

S/IP allows for simple access to all drive parameters.

Typical fields of application are:

- Communication with the drive for engineering via IndraWorks
- Replacement for cyclic bus communication for the control of simple axis applications without real-time requirements, e.g. positioning block operation or with drive-controlled positioning

Overview of functions

Features

- TCP/IP-based protocol
- The protocol focuses on data exchange; only a very small administration overhead is required.
- User-defined busy timeout (time until the drive sends a defined answer)
- User-defined lease timeout (time when the connection is re-enabled if no new requests are received)
- Dedicated service for read-out of all parameter information in a request
- Up to 2 simultaneous connections possible

Pertinent diagnostic messages

The following error messages are defined and are returned directly in a dedicated service by the drive:

Name	Value in the telegram	Significance
CONNECTION_ERROR	1	Error during connection set-up
ABORTED	2	The process was aborted
UNKNOWN_MESSAGE_TYPE	3	Unknown MessageType in the header
SERVICE_SPECIFIC	4	Service-specific error, e.g. "datum is write-protected"

Tab. 10-7: S/IP error class

10.3.2 Functional description

General information

S/IP is short for Sercos internet protocol.

The following sections contain an overview of the services available in the S/IP protocol and explain the individual services. Example requests and responses are presented in the commissioning information.

A service always consists of a request and a response. The request is always sent by the client. The server (drive) can answer a request with various responses. If the request can be processed and replied to immediately, the drive directly sends the corresponding response to the request (usually: response service number = request service number +1). If the drive is processing another request, it may also send a busy response (service number: 68). If the telegram was improperly formatted, the service is not supported or if another error occurred, an exception response is sent (service number: 67).

Each telegram consists of a static and a service-specific part. In the static part, a package number can be assigned to allocate the request to the response. In addition, it states the service executed with this telegram.

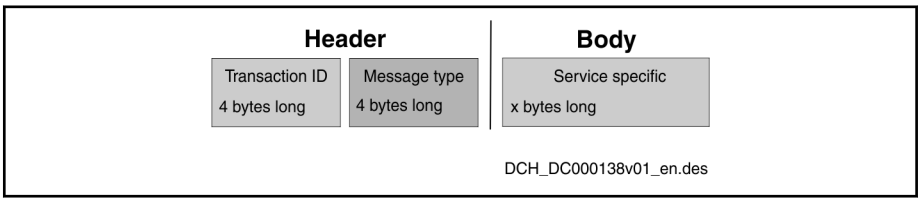


Fig. 10-4: Basic set-up of a S/IP telegram

The header consists of 8 bytes:

- Bytes 1 to 4 form the "TransactionID", an identification number, which defines this request. This number is stated in a response.
- Bytes 5 to 8 define the "MessageType". The MessageType is the service number (for a list of services supported by the drive, see below). As currently only services with 1 byte in length are used, the low byte is relevant.

Variable definitions

The services "ReadEverything response" and "ReadDescription response" send, in addition to data, a 2-byte value that states which elements are valid in the response. This value called "ValidElements" consists of the following:

Bit	Description
0x01	Data status is valid
0x02	The Description and DescriptionLength are valid
0x04	The attribute is valid
0x08	Unit and UnitLength are valid
0x10	The minimum value is valid
0x20	The maximum value is valid
0x40	The Value and ValueLength are valid

Tab. 10-8: Valid elements

For the services "ReadEverything request", "ReadOnlyData request", "ReadOnlyDescription request", "ReadDataStatus request", "WriteData request", and "WriteDataBits request" specify for which parameter the action is to be carried out.

For this purpose, a 4-byte value is passed to the drive. The following figure illustrates its set-up.

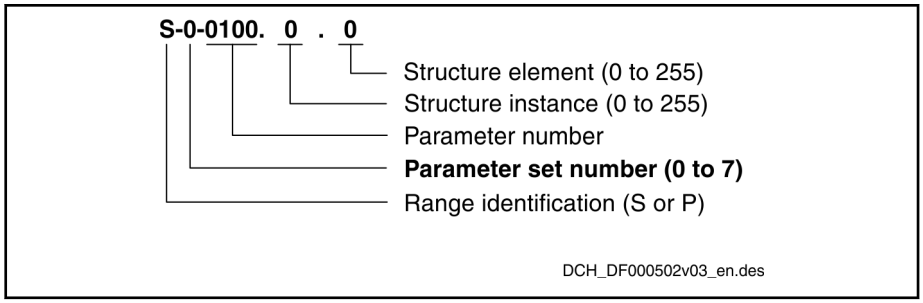


Fig. 10-5: Example of a 4-byte IDN

Bit. No.	Description		Range of values	Note
31-24	Parameter instance/structure instance (SI)		0-255	
23-16	Parameter element/ structure element (SE)	SE defined by Sercos	0-127	Determined by Sercos (bit 15 = 0)
		Product-specific SE	128-255	Not in use
15	Sercos-specified or product-specific IDN (S or P)	Standard IDN (S-0-nnnn)	0	SE (0-127), SI and parameter number are defined via Sercos
		Product-specific IDN (P-0-nnnn)	1	Product-specific parameter
14-12	Parameter set		0-7	See also "Parameter set switching"
11-0	Parameter number		0-4095	

Tab. 10-9: Structure of the 4-byte value

Supported services

The following table gives an overview of the services supported by the drive and the corresponding "MessageTypes" for the request and response.

Service name	Service number	
	Request	Response
Connect	63	64
Ping	65	66
Exception	-	67
Busy	-	68
ReadEverything	69	70
ReadOnlyData	71	72
ReadDescription	73	74
ReadDataStatus	87	88
WriteData	83	84
WriteDataBits	85	86
Nameplate	89	90

Tab. 10-10: Supported IndraDrive S/IP services

Connect

Request

Structure:

The client connects to the drive using the Connect service. For this purpose, MessageType "63" is sent. Furthermore, the client suggests the so-called busy timeout and the lease timeout times in this telegram.

- **Busy timeout:** States the time that may pass until a response telegram is received in reply to a request.
- **Lease timeout:** States the time until the drive terminates the connection automatically if there are no new requests.

In addition, the S/IP protocol version used for communication is stated. The drive supports specification 1.0. Accordingly, the "Version" field has to contain the value "1".

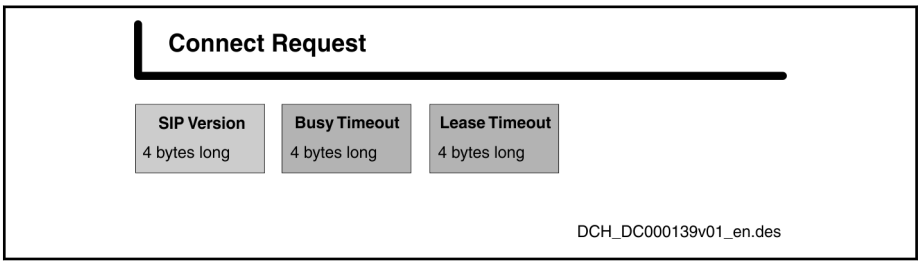


Fig. 10-6: Representation of a Connect request

Response

The Connect response is sent as a reply to a Connect request if the connection was established successfully. The service has service number "64" and provides information on the connection:

- What busy timeout is actually used
- What lease timeout is actually used
- What protocol version is actually used
- An array of all supported services (requests) of the drive

Byte offset	Length (in bytes)	Name	Significance	Example
0	4	Version	Drive protocol version used	1
4	4	BusyTimeout	Drive busy timeout used	500
8	4	LeaseTimeout	Drive lease timeout used	15.000
12	4	NumberMessageTypes	Number of services supported by the drive	12
16	NumberMessageTypes * 4	MessageTypes	Array consisting of 4-byte values that contain the available services of the drive	-

Tab. 10-11: Structure of Connect response

Ping

Ping request

The Ping request is identified by service number "65". This is an empty telegram, i.e. the telegram contains 0 bytes of payload data. The service can be used to:

- maintain the connection as the drive terminates the connection when the lease timeout has expired
- measure the minimum time required by a response of the drive

Ping response

The Ping response is sent as a reply to a Ping request. The telegram contains no payload data.

Busy & Exception

The services "Busy" and "Exception" are special services. They may be sent to reply to any request.

Busy response

The Busy response is sent if the response telegram cannot be sent when the Busy timeout expires. The Busy response contains no data. Set the Busy timeout to high values to virtually suppress this response. However, even high values do not guarantee that no Busy response is sent.

Exception response

The Exception response is sent if a general communication error occurred. There are several causes for an Exception response.

ReadEverything

ReadEverything request

With the ReadEverything request all data of a parameter can be requested collectively. The service is identified by service number "69". For this purpose, the SlaveIndex and SlaveExtension are required. Furthermore, the parameter to be read is transmitted.

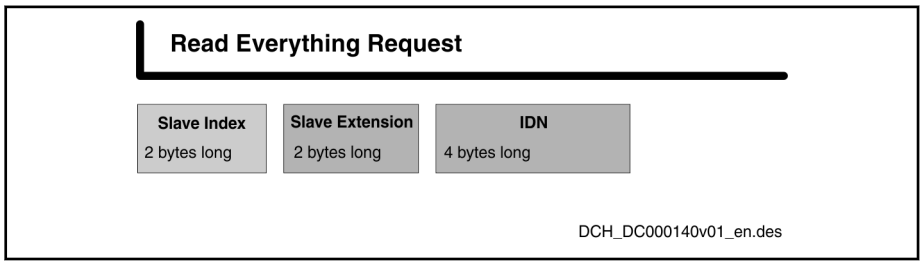


Fig. 10-7: Representation of a ReadEverything request

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	SlaveIndex	Only relevant with multi-axis devices (HCQ/HCT/CDB). 0: Access to 1st axis 1: Access to 2nd axis etc.	0
2	2	SlaveExtension	Reserved - always 0	0
4	4	IDN	Parameter to be read	0x30

Tab. 10-12: Structure of a ReadEverything request

ReadEverything response

The ReadEverything response contains the data for the "ReadEverything request". The service is identified by service number "70".

The following values are transmitted:

- Data status
- Attribute
- Minimum and maximum
- Maximum length of the list in bytes (if list parameter)
- Current length of the parameter data in bytes
- Current length of the parameter unit in bytes
- Current length of the name in bytes
- Parameter data in binary format
- Parameter unit as string
- Parameter name as string

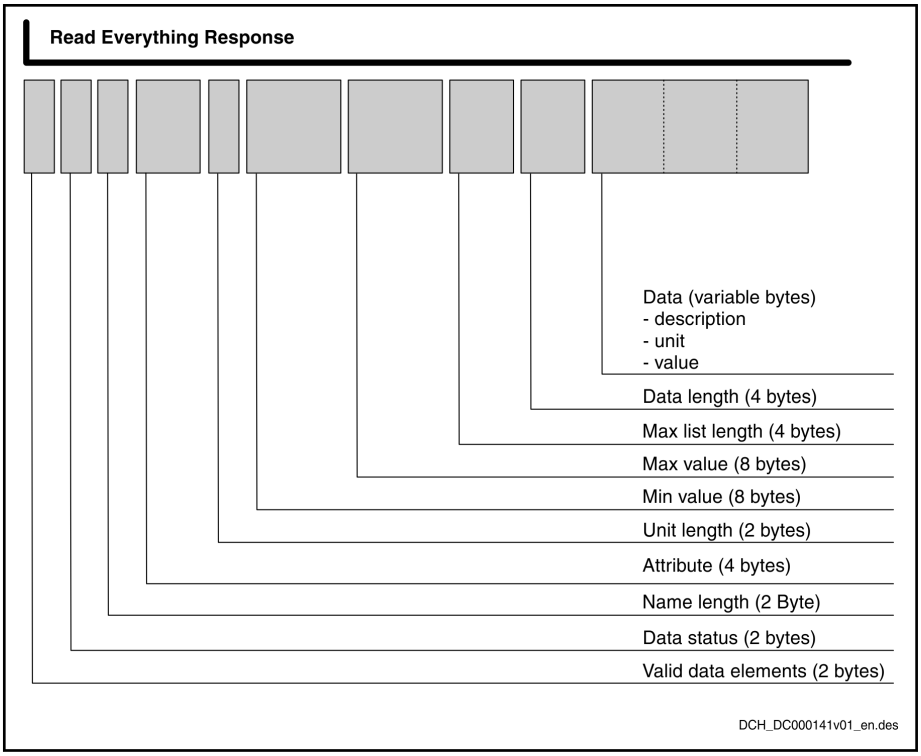


Fig. 10-8: Representation of the ReadEverything response

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	ValidElements	Bit string that encodes the valid elements	0b0000.0000.0100.1111
2	2	DataStatus	Data status of the parameter (valid/invalid) and/or command status of command parameters	1
4	2	NameLength	Length of the string that contains the parameter name in the language set in S-0-0265	0x20
6	4	Attributes	The attribute of the parameter contains information on decimal places, display format, maximum length, write protection and whether the parameter is a command parameter.	0x77560000
10	2	UnitLength	Length of the string that contains the parameter unit (scaling-dependent)	6
12	8	Min	Lower input limit of this parameter	-
20	8	Max	Upper input limit of this parameter	-
28	4	MaxListLength	Maximum length of the list parameter in byte (valid only for list parameters)	8196
32	4	DataLength	Current length of the parameter	38
36	Name-Length	Name	Name of the parameter	"Firmware version"

Byte offset	Length (in bytes)	Name	Significance	Example
36 + Name-Length	Uni-tLength	Unit	Unit of parameter	""
36 + Name-Length + Uni-tLength	Data-Length	Data	Value of the parameter	"FWA-INDRV****"

Tab. 10-13: Structure of ReadEverything response

ReadOnlyData

ReadOnlyData request

The "ReadOnlyData request" reads out the datum. The "ReadOnlyData" request is identical with the "ReadEverything request". Here, service number "71" is sent in the header.

ReadOnlyData response

The "ReadOnlyData response" is identified by service number "72". The following data are transmitted:

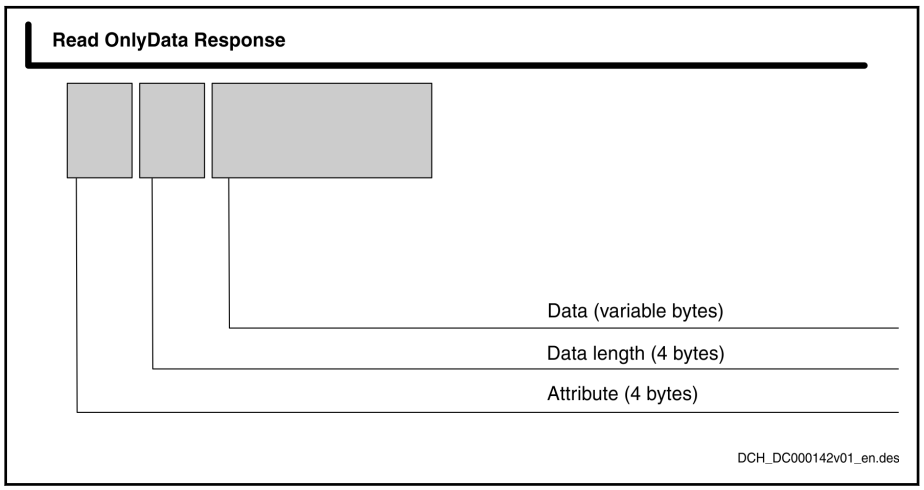


Fig. 10-9: Representation of the ReadOnlyData response

Byte offset	Length (in bytes)	Name	Significance	Example
0	4	Attributes	Attribute of parameter	0x77560000
4	4	Length	Length of the data array in bytes	2
4	Length	Data	Data of the parameter	0x1345

Tab. 10-14: Structure of a ReadOnlyData response

ReadDescription

ReadDescription request

The "ReadDescription request" queries all information on the parameter, excluding the operating datum. The "ReadDescription" request is completely identical with the "ReadEverything request". However, service number "73" is used.

ReadDescription response

The "ReadDescription response" is identified by service number "74". The following data are transmitted:

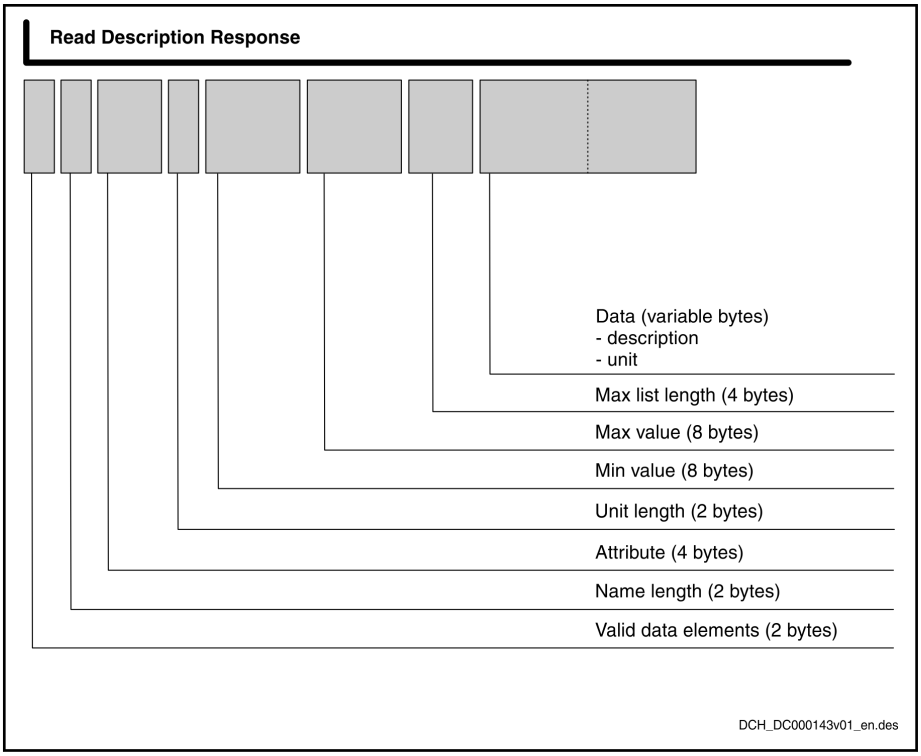


Fig. 10-10: Representation of the ReadDescription response

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	ValidElements	Bit string that encodes the valid elements	0b0000.0000.0100.1111
2	2	NameLength	Length of the string that contains the parameter name in the language set in S-0-0265	0x20
4	4	Attributes	The attribute of the parameter contains information on decimal places, display format, maximum length, write protection and whether the parameter is a command parameter.	0x77560000
8	2	UnitLength	Length of the string that contains the parameter unit (scaling-dependent)	6
10	8	Min	Lower input limit of this parameter	-
18	8	Max	Upper input limit of this parameter	-
22	4	MaxListLength	Maximum length of the list parameter in byte (valid only for list parameters)	8196
26	4	DataLength	Current length of the parameter	38
30	NameLength	Name	Name of the parameter	"Firmware version"
30 + Name-Length	UnitLength	Unit	Unit of parameter	""

Tab. 10-15: Structure of ReadDescription response

ReadDataStatus

ReadDataStatus request

Use the "ReadDataStatus request" to read out the data status directly. The "ReadDataStatus" request is identical with the "ReadEverything request". Here, service number "87" is used.

ReadDataStatus response

The "ReadDataStatus response" is identified by service number "88". The following data are transmitted:

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	DataStatus	Data status of the requested parameter	1

Tab. 10-16: Structure of ReadDataStatus response

WriteData

WriteData request

The datum is read via the "ReadOnlyData request". Here, service number "83" is used.

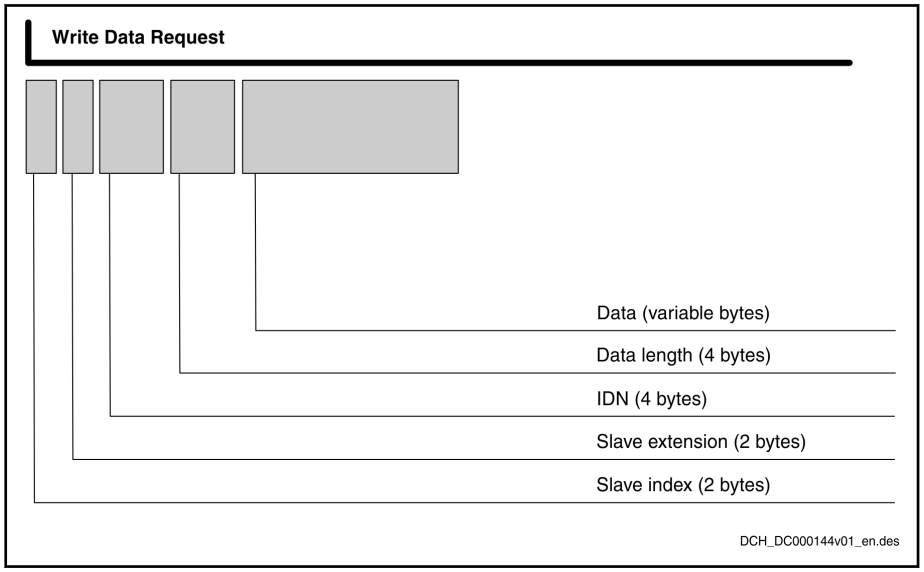


Fig. 10-11: Representation of the WriteData request

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	SlaveIndex	Reserved - always 0	0
2	2	SlaveExtension	Reserved - always 0	0
4	4	IDN	Parameter to be read	0x30
4	4	DataLength	Length of the data to be transmitted	2
8	DataLength	Data	The operating datum to be transmitted	0x1234

Tab. 10-17: Structure of a WriteData request

WriteData response

The "WriteData response"is identified by service number "84". No data are transmitted.

WriteDataBits

WriteDataBits request

Use the "WriteDataBits request" to write individual bits of a parameter. The "WriteDataBits" request is identified by service number "85".

Any number of bits of a parameter value can be written in a request. The DataMask, which is part of the request, determines which bits are written. It is therefore possible to change an individual bit in any place in the parameter or to write all bits. The bits to be written have to be selected in the "DataMask" in the respective position. If bit 7 is to be written, set bit 7 in the "DataMask" to 1.

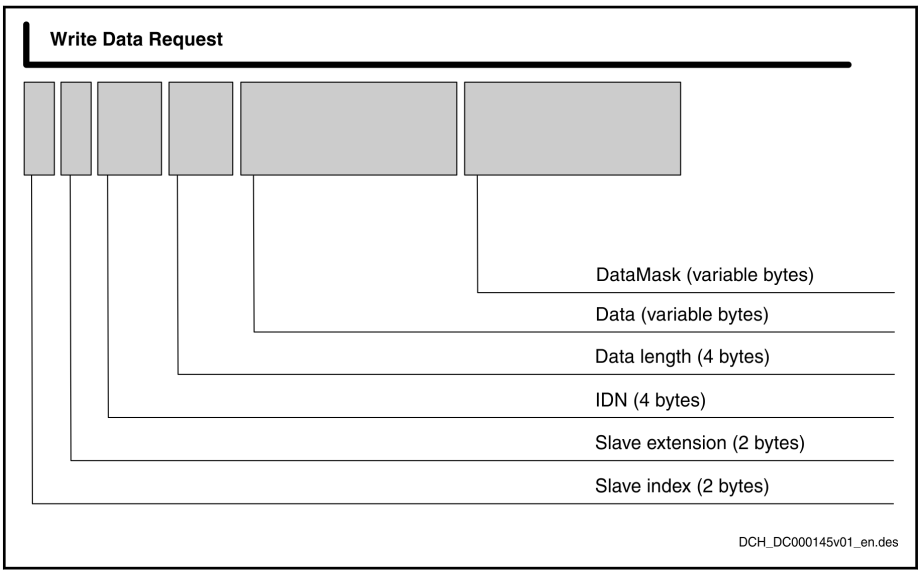


Fig. 10-12: Representation of the WriteDataBits request

Byte offset	Length (in bytes)	Name	Significance	Example
0	2	SlaveIndex	Reserved - always 0	0
2	2	SlaveExtension	Reserved - always 0	0
4	4	IDN	Parameter to be read	0x30
4	4	DataLength	Length of the data to be transmitted	2
8	DataLength	Data	The operating datum to be transmitted	0x1234
8 + DataLength	DataLength	DataMask	The bits to be updated	

Tab. 10-18: Structure of a WriteDataBits request

WriteDataBits response The "WriteDataBits response" is identified by service number "86". No payload data are transmitted. In case of error, an "Exception response" is returned instead of the WriteData response.

Nameplate

Nameplate request In preparation

Nameplate response In preparation

10.4 Firmware download via TFTP server

10.4.1 Brief description

Fields of application

A TFTP server is available for firmware downloads. It is possible to download new firmware to the device.

Overview of functions

Identifying firmware

Using a special "ReadRequest" the firmware installed in the device can be identified. For this purpose, the string "Firmware" is transmitted during "ReadRequest".

The response telegram contains a data package which contains the manufacturer version (see S-0-0030.0.0).

Firmware download

A WriteRequest starts the download process. For this purpose, the drive has to be in PM. Additionally, the "WriteRequest" also establishes a connection to the TFTP server.

Afterwards, the firmware is downloaded to the device via "DataRequests". The device carries out several checks:

- Can the new firmware file be used for the device (compatibility check)?
- Was the correct number of data transmitted (data integrity check)?
- Was the firmware file transmitted correctly and validly (validity check)?

Error diagnosis

All errors occurring in this process are sent back via ErrorFrame in TFTP. The error text is available as plain text.

Features

The TFTP server of an HydraulicDrive device has the following features:

- A TFTP connection does not know authentication
- There are the following 5 package types with a TFTP connection:
  - "ReadRequest" (starts reading files from the server/drive)
  - "WriteRequest" (starts writing files to the server/drive)
  - "Data" (data transmission)
  - "Acknowledge" (acknowledgement of data packages)
  - "Error" (any kind of error messages)
- Each data package has to be confirmed using "Acknowledge" before the next data package is sent.

Pertinent diagnostic messages

Any errors that occur are converted into plain text using "TFTP ErrorFrame"

11 Commissioning

11.1 General information

11.1.1 Safety instructions

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious personal injury or damage to property!**

- Do not stay in the range of motion of machines and machine parts.
- Prevent unauthorized access (e.g. by providing protective fence, safety guard, protective cover, light barrier).
- Before reaching into or accessing the danger zone, bring the drives safely to a standstill.
- Moreover, observe the safety notes "Protection against dangerous movements" in chapter “Safety instructions for electric and hydraulic drives and controls“

11.1.2 Introduction

This chapter describes the individual commissioning steps for the following types of control of a hydraulic drive:

- Commissioning of an axis control with a WRxD valve (high-response valve as axis controller) or with control cabinet electronics of type VT-HMC (digital axis controller)
- Commissioning of a pump control with an SYDFED control system (pressure and flow control system) or control cabinet electronics VT-HPC for pump control

In the following, the components WRxD valve, VT-HMC, SYDFED control system and VT-HPC are referred to as HydraulicDrive.

In these commissioning instructions, it is assumed that the HydraulicDrive is commissioned using the easy startup mode in conjunction with the commissioning tool IndraWorks Ds. The easy startup mode allows basic commissioning of the axis without involvement of a higher-level control unit (PLC) and thus without use of master communication (e.g. PROFINET).

However, it is always possible to carry out commissioning with a higher-level control or also to change back to the easy startup mode at any time.

11.1.3 Firmware on the Internet

The current firmware of the devices can be downloaded at the following links: The latest firmware can be found on the tab "Downloads".

- WRxD valve: http://www.boschrexroth.com/iac
- Control cabinet electronics VT-HMC: http://www.boschrexroth.com/hmc
- SYDFED control system: http://www.boschrexroth.com/sydfe
- Control cabinet electronics VT-HPC: http://www.boschrexroth.com/hmc
- HS5E pump system: http://www.boschrexroth.com/hs5e

11.1.4 Commissioning tool IndraWorks Ds

The commissioning IndraWorks Ds can be downloaded free of charge at http://www.boschrexroth.com/IndraWorks. When installing Install IndraWorks

Ds on your PC, please follow the instructions given by the installation program.

11.1.5 Establish Ethernet connection

Connect the HydraulicDrive to your PC using an Ethernet cable. Switch on the voltage supply and wait until the device has booted. Then open IndraWorks Ds.

The following window appears:

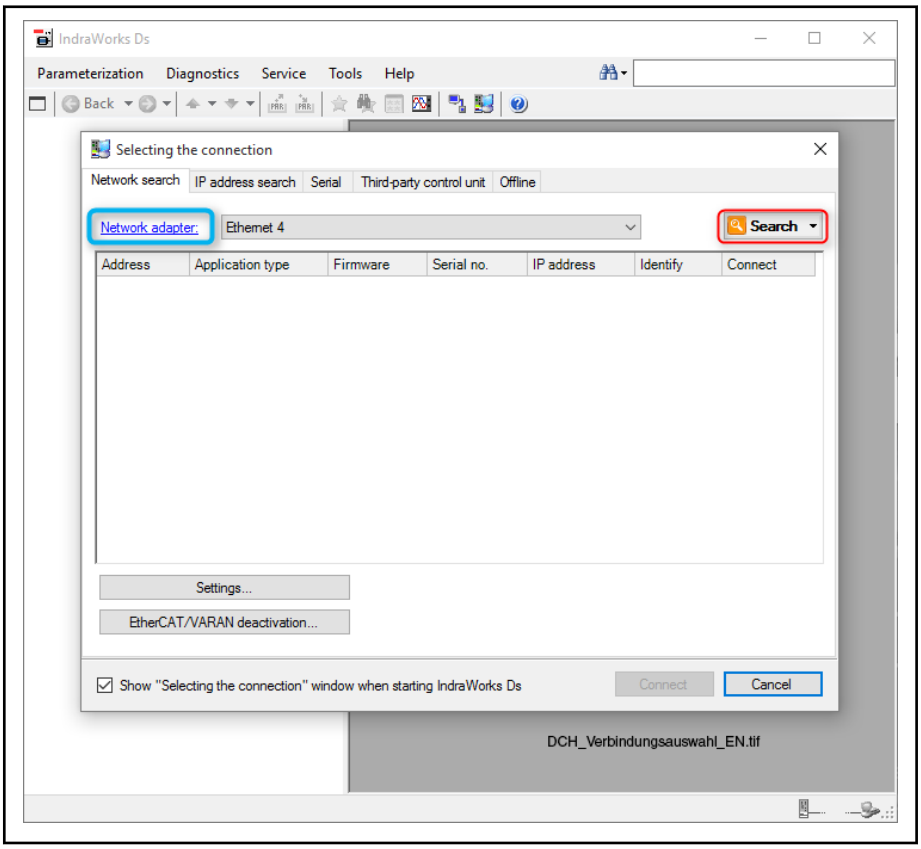


Fig. 11-1: Selection of connection when starting IndraWorks Ds

Before using the "Search" function, make sure that your PC does not automatically receive the IP address for the Ethernet interface to which the HydraulicDrive is connected. Therefore, click network adapter (blue rectangle on the image above). A dialog window opens with the available network connections.

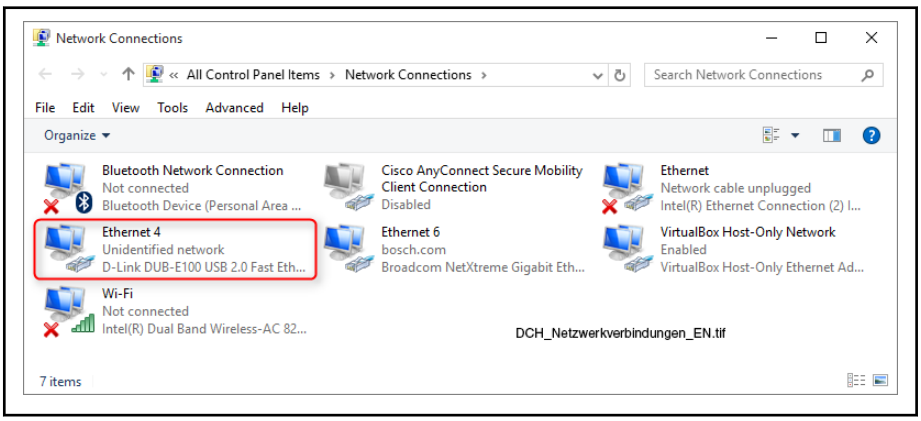


Fig. 11-2: Network connection

Use the right mouse button to select the network to which the drive is connected and click on "Properties" in the pop-up context menu. In the window that opens now, select "Internet Protocol Version 4" (red border in the figure below) and then click the on the "Properties" button (blue border).

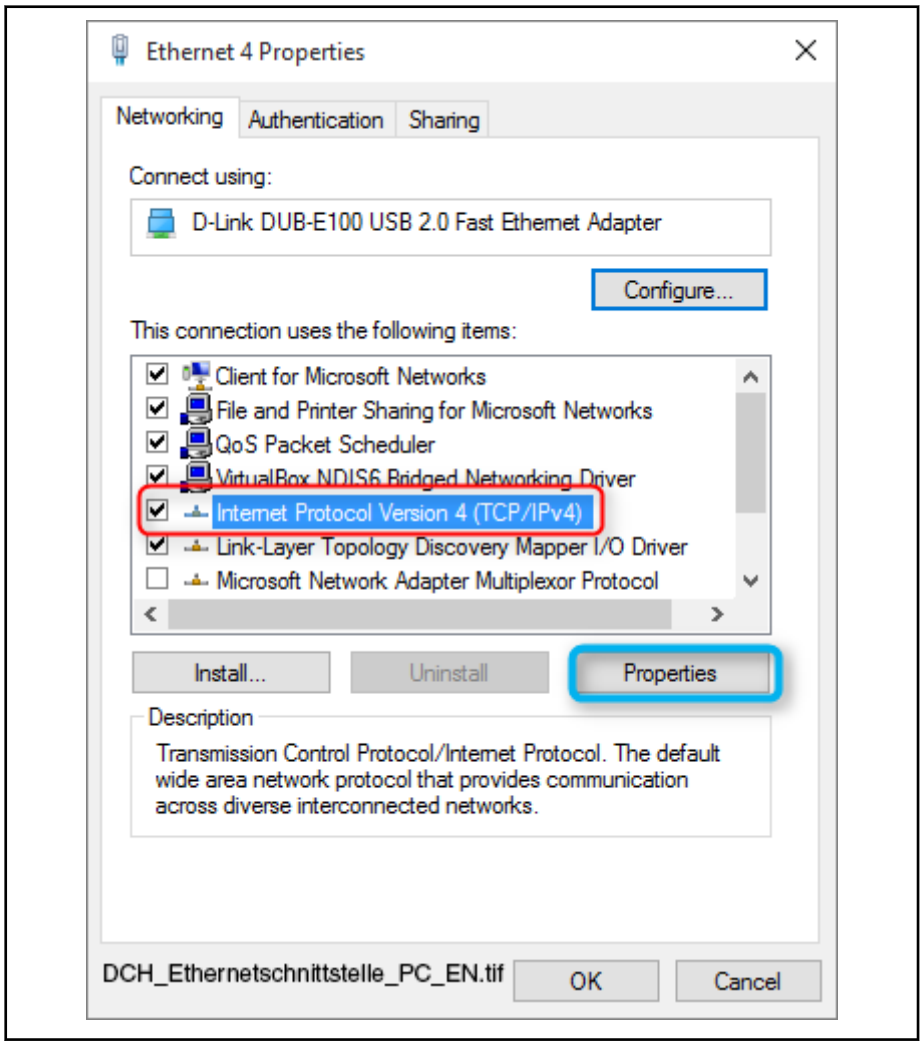


Fig. 11-3: Properties of the Ethernet interface of the PC

Make sure that “Obtain an IP address automatically” (red rectangle) is **not** selected. If it is selected, configure the window with the blue border similarly to the following figure.

It is important that no IP address is assigned that belongs to another device, e.g. a VT-HMC in the Ethernet network. This is not necessary, if it is already configured. Confirm the dialog by clicking OK.

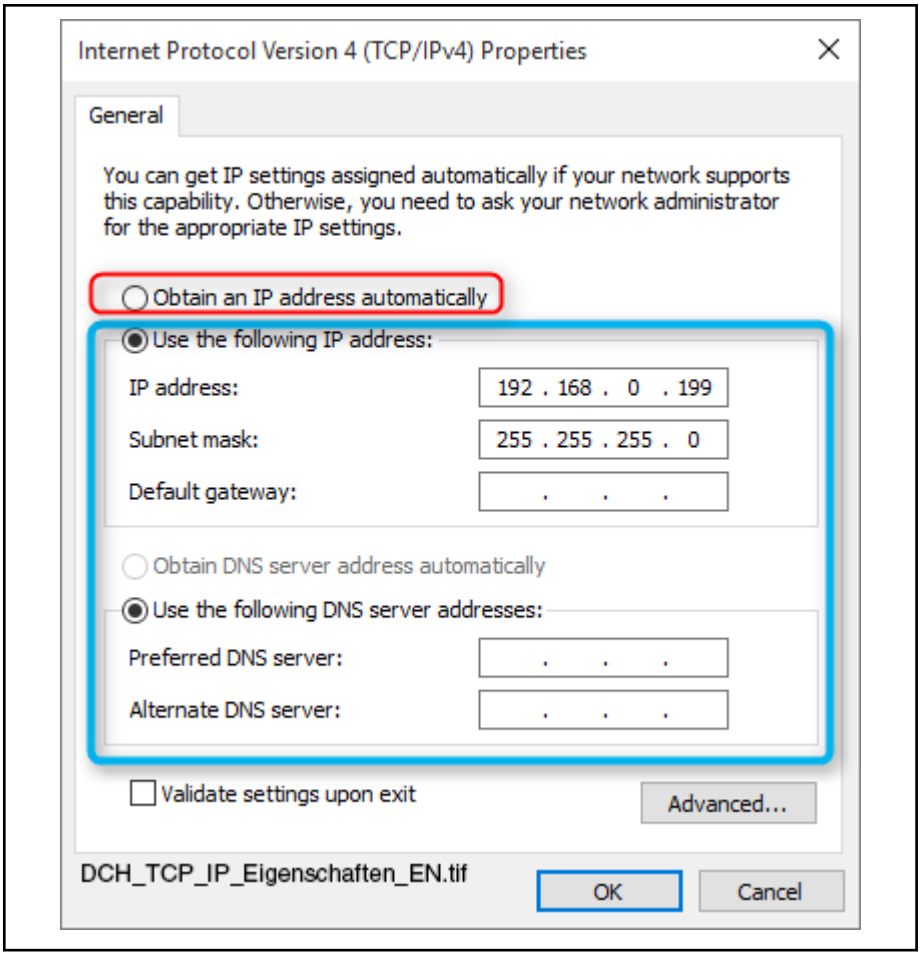


Fig. 11-4: TCP/IP properties

When the network settings are adjusted, click "Search" in the connection selection dialog (red rectangle). Then, all HydraulicDrive devices that are connected are displayed. Now select the device that you wish to hook up in the "Connect" column. Then confirm by clicking OK.

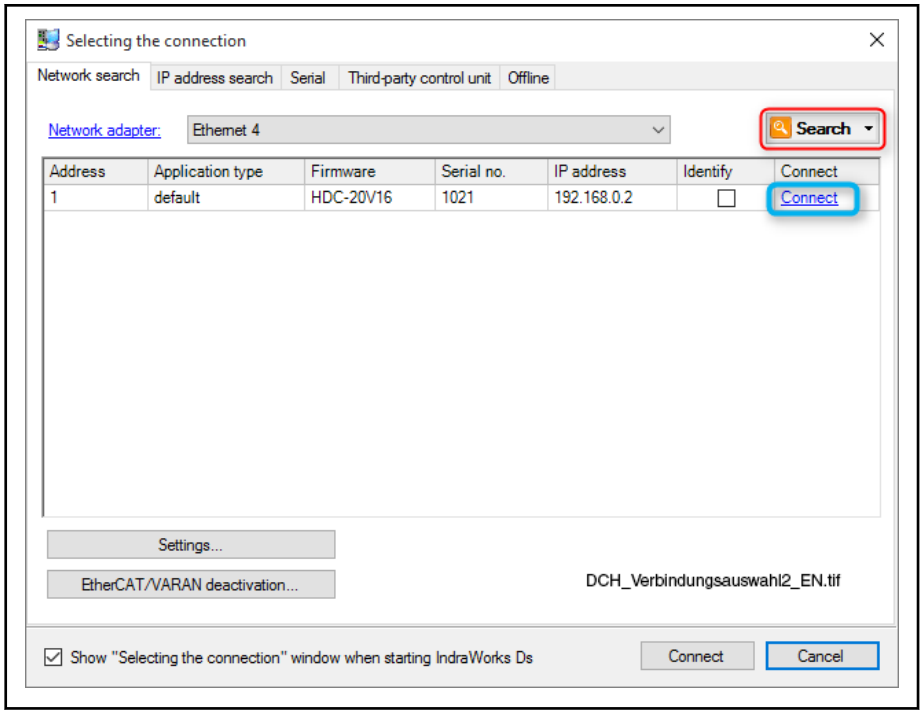


Fig. 11-5: Connection selection

If the current IP address settings of your PC and the HydraulicDrive does not match (e.g. different networks), they can be adjusted as follows: The IP addresses searched for are shown in red if the settings do not match. By clicking the button "Extend IP address settings now" the IP configuration is adjusted accordingly.

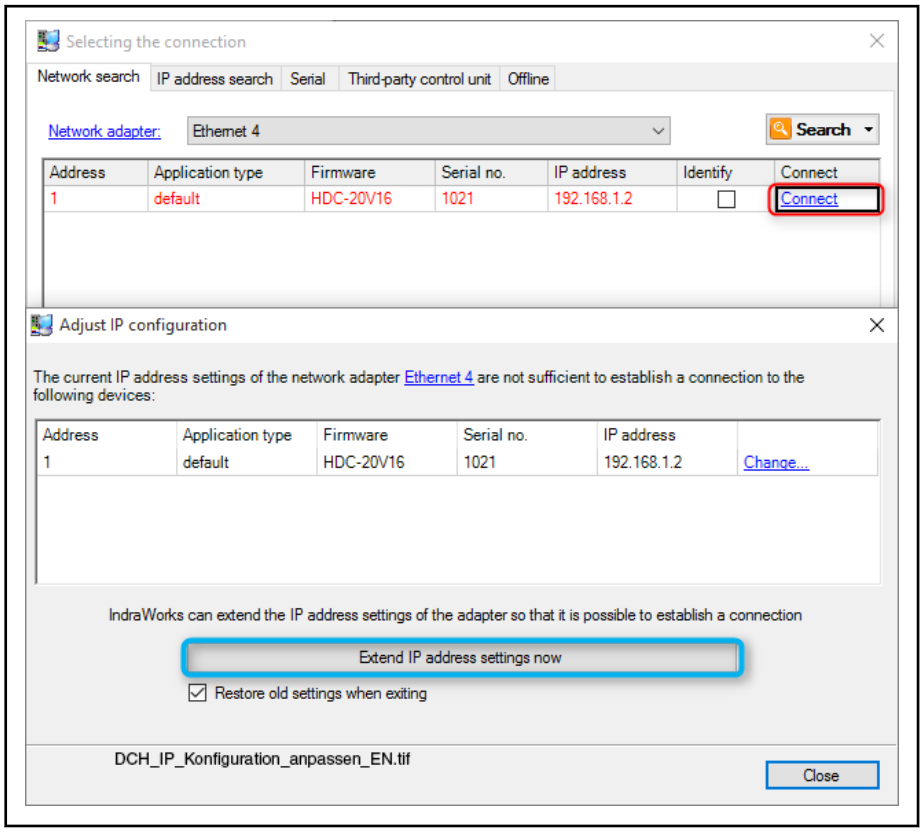


Fig. 11-6: Automatic adjustment of IP configuration

A dialog window opens which confirms the process "Adjust IP configuration". Close dialog window by clicking OK.

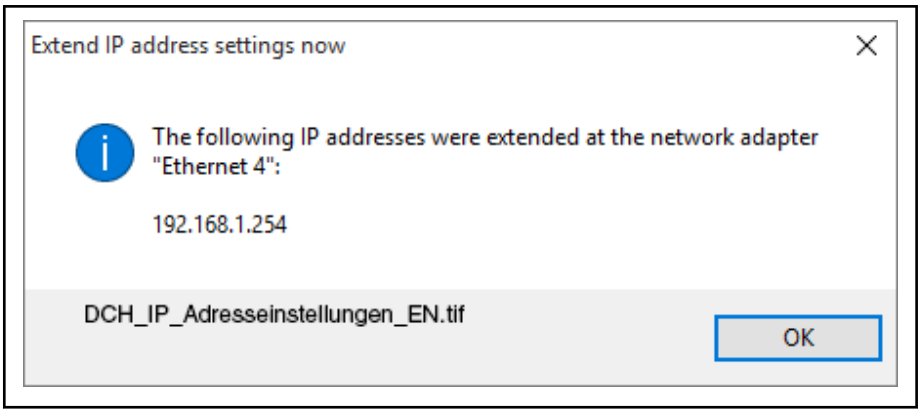


Fig. 11-7: Confirmation of IP address settings

11.1.6 Firmware update

If a firmware update is required, because the HydraulicDrive is not provided with the latest firmware, this update can be executed via Service -> Firmware management... in the menu bar. In the dialog window that opens select the new firmware from the hard disk of your PC. To start this click the button shown with the blue border in the figure. The IP address must be identical with that of the device. To finalize this process click the "Download…" button.

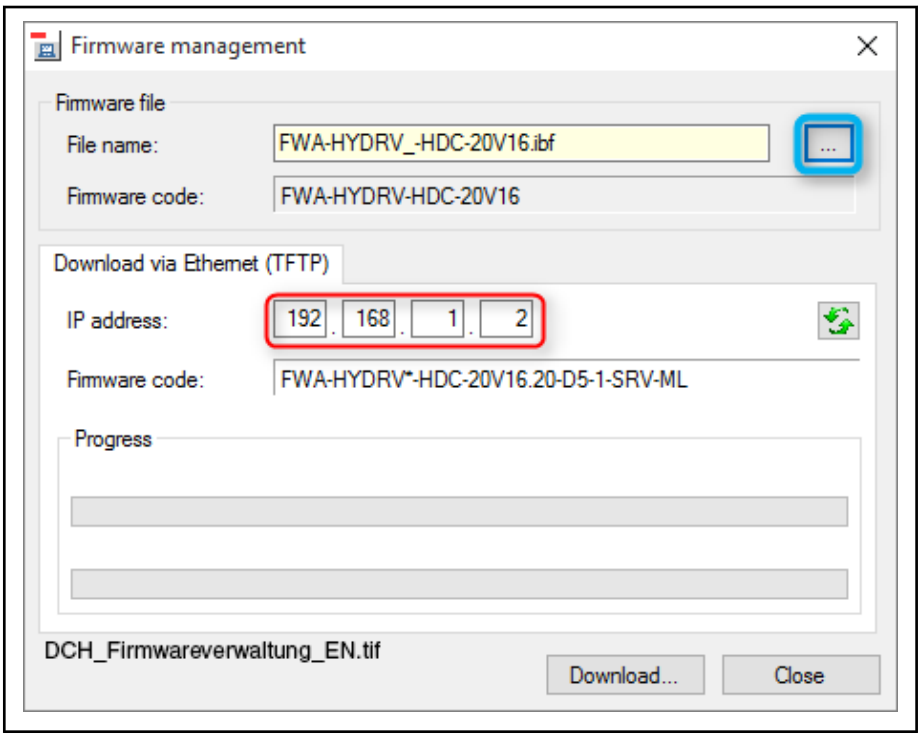


Fig. 11-8: Firmware management

11.2 Commissioning an axis control

11.2.1 Initial parameterization of axis control

Introduction

Before a hydraulic axis can be operated, the Wizard for initial parameterizing has to be executed for the HydraulicDrive. The Wizard is started in the following dialog:

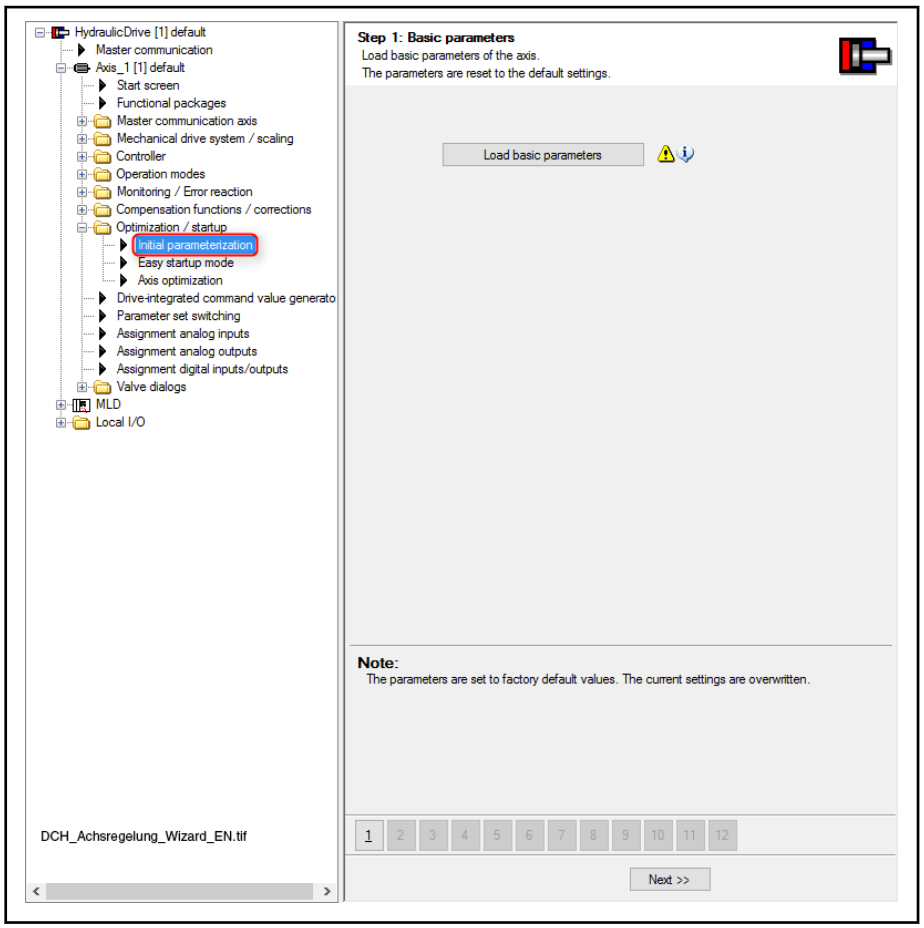


Fig. 11-9: Wizard for initial parameterization

In the following, not every dialog window of the Wizard for initial parameterization is explained in detail. The lower section of the initial parameterization window shows notes on the current menu item.

By clicking the info button you will get information about the possible parameter settings.

The warning triangle indicates that input is required in the Wizard.

Loading basic parameters

In a first step of initial parameterization, basic parameters are loaded. If a part of it was already parameterized, it can be excluded from being cleared or this step can be skipped completely.

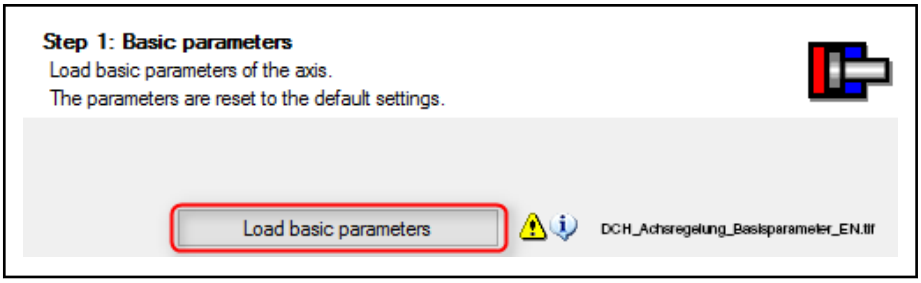


Fig. 11-10: Basic parameters

Basic configuration

Click “Next” to get to the next dialog box. In this window you can select or deselect “pressure/force sensing” and “pressure/force control” depending on the application. When “Parameter suggestion based on system data” is selected, controller parameters and limit values are suggested in the course of initial parameterization.

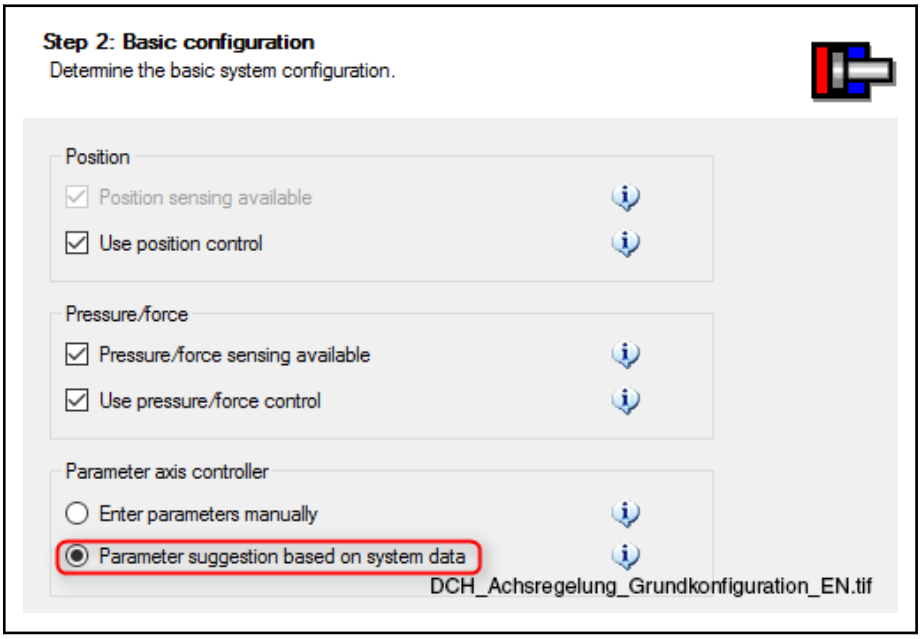


Fig. 11-11: Basic configuration

Mechanical axis system/scaling

In the next dialog the actuator and the type of scaling have to be selected according to the relevant application.

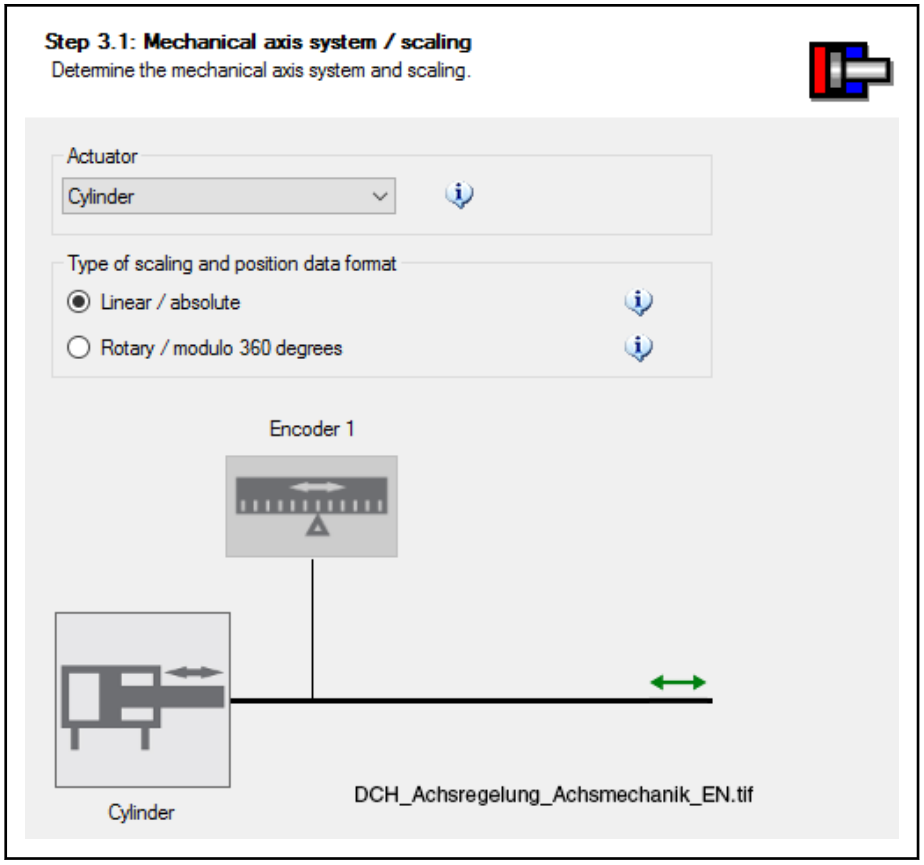


Fig. 11-12: Mechanical axis system/scaling

Scaling/units

At this point the unit can be selected. You can select either “metric” or “imperial”.

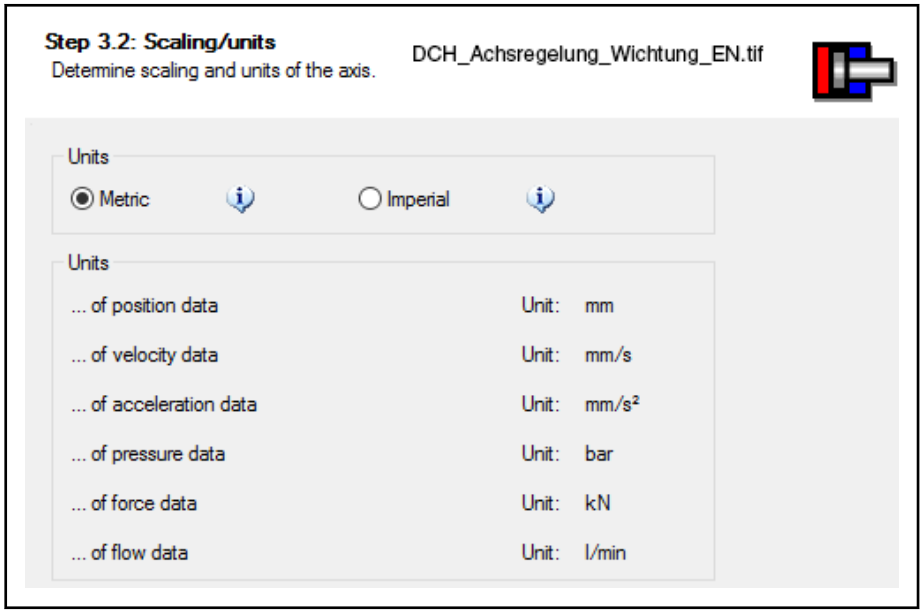


Fig. 11-13: Scaling /units

Scaling/polarity

Initially, the dialog for setting the polarity can be skipped.

System data

In the next step, system data have to be entered; cylinder dimensions can be found on the nameplate. The areas are then automatically calculated.

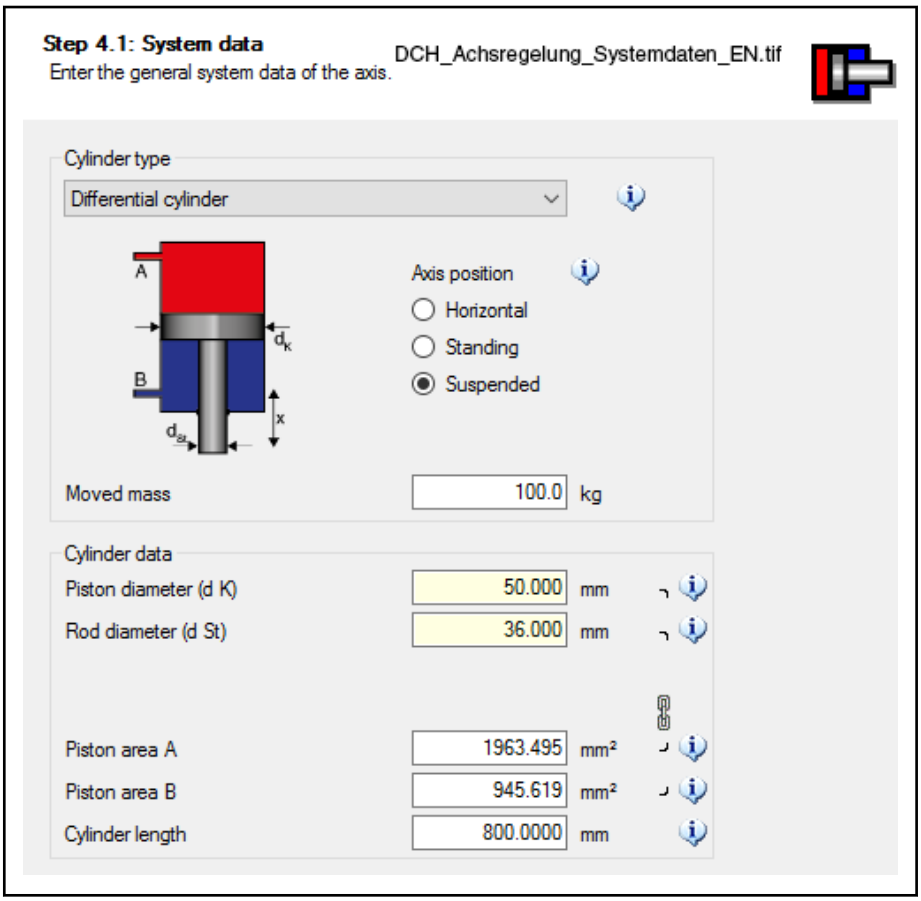


Fig. 11-14: System data

Following this, valve data are to be set. They can be found on the relevant nameplate or data sheet. The system pressure has to be known. Establishing the dead volume in the next step is only useful for large line lengths. The projected parameters are less exact if the volume is not known. Therefore, the controller parameters have to be checked again and, if required, adjusted.

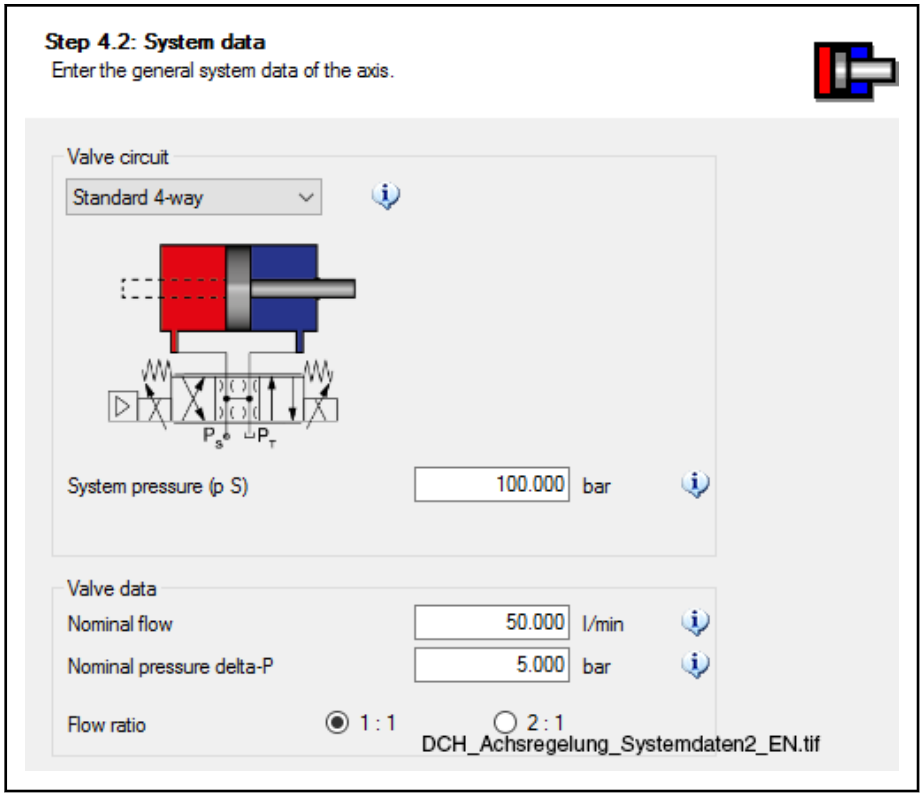


Fig. 11-15: System data 2

After this step the calculated system are shown - merely for display purposes.

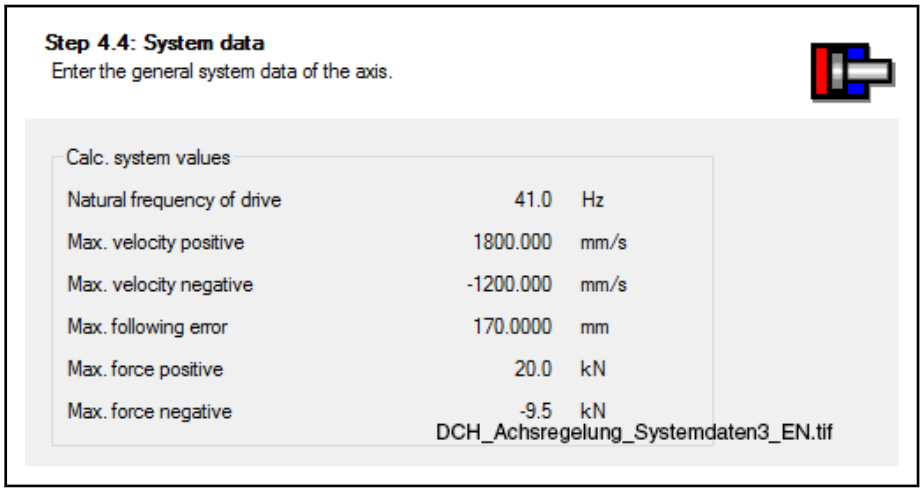


Fig. 11-16: System data 3

Position acquisition

If closed-loop position control is desired, then enter the sensor key data in the following dialog.

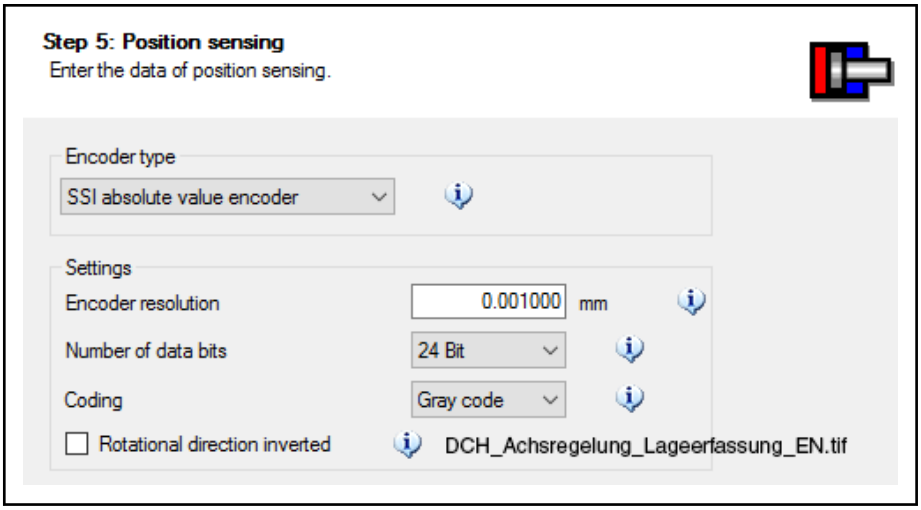


Fig. 11-17: Position acquisition

Force acquisition

If “pressure/force acquisition" was selected at the beginning of parameterizing, the pressure sensors as well as the kind of force sensing have to be configured in the display. The characteristic values of the pressure sensor are provided on the device or in the data sheet.

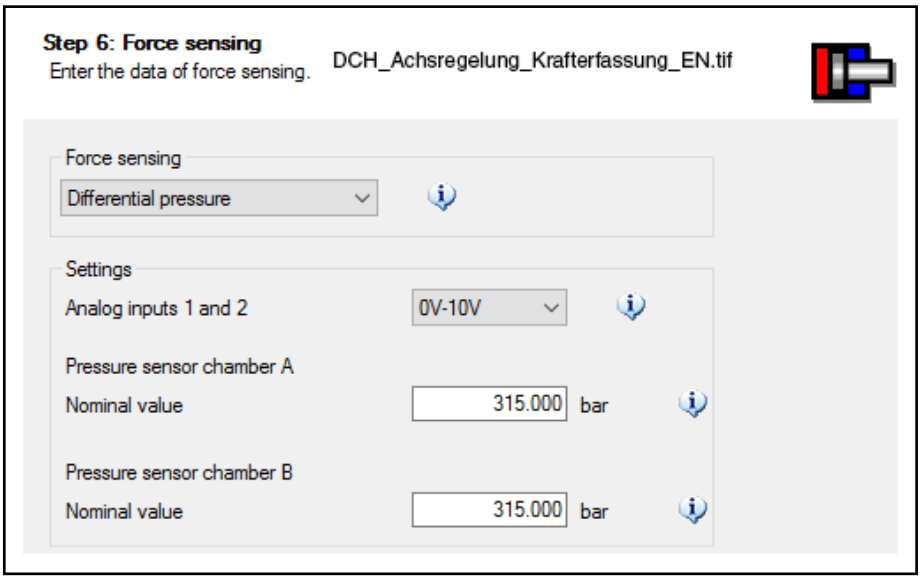


Fig. 11-18: Force acquisition

Limit values

In the next step, the limit values can be determined. They are deactivated by default. The suggested values can be accepted by clicking “SET”. Typically, for hydraulic axes velocity and acceleration limit value monitoring is not activated, but merely following error monitoring. It can be set in step "position controller" as monitoring window.

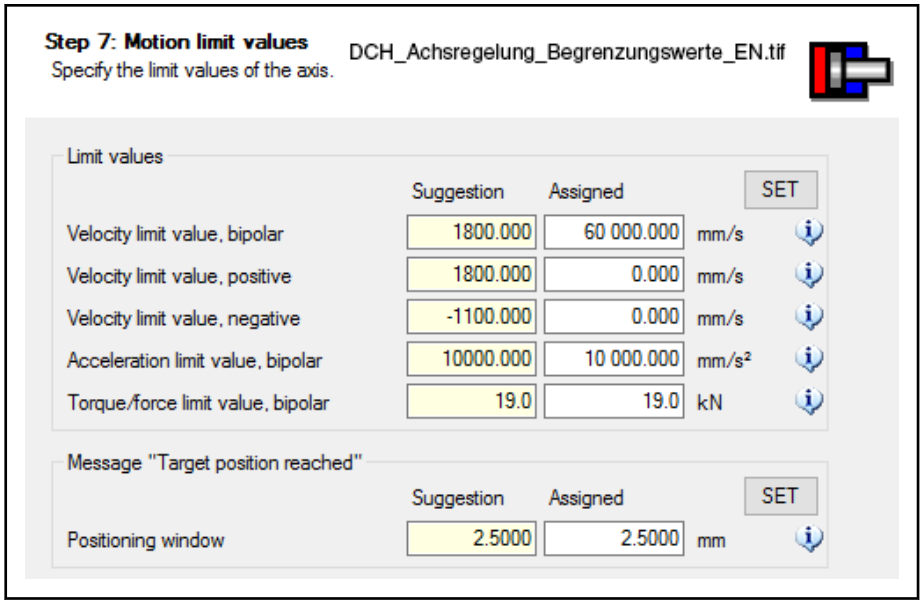


Fig. 11-19: Limit values

Output adjustment

The suggested values can be accepted by clicking “SET”. The valve standard velocity indicates at which velocity the actuator moves when the valve is 100 % opened. It also has any influence on the control. Direction-dependent gain serves to compensate for the smaller volume of single-rod cylinders on the annular side. In the section “output”, the type of output signal with which the valve is actuated is determined for the control cabinet electronics VT-HMC. It may be -10 V...10 V or 4 mA...20 mA. Switch to the next step.

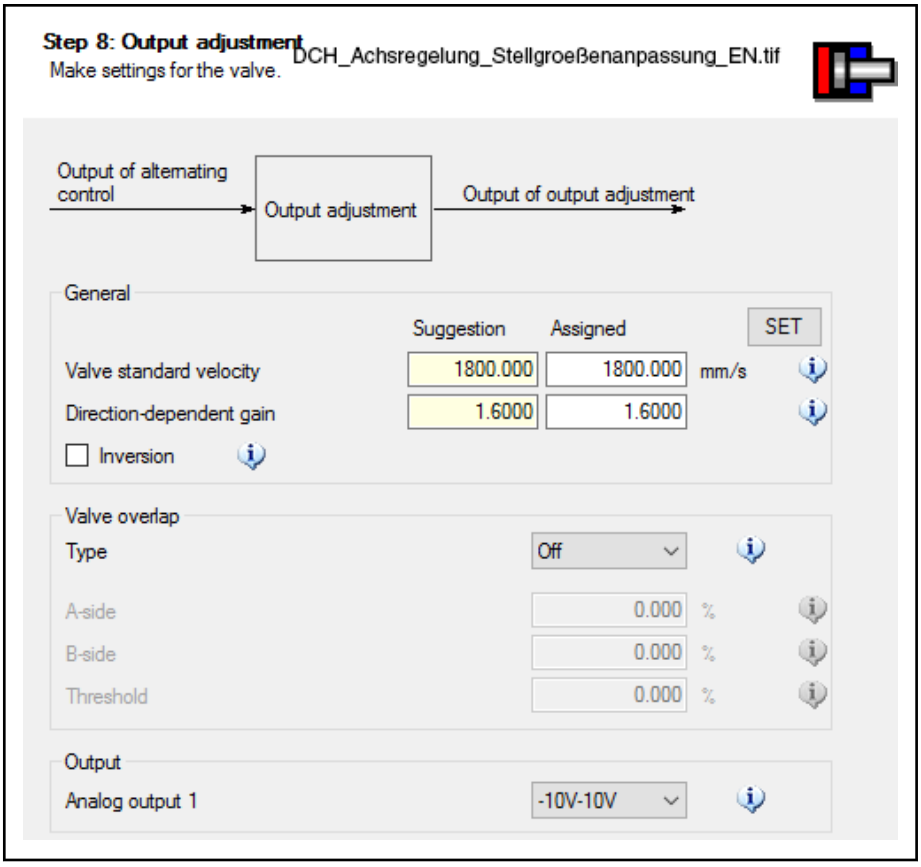


Fig. 11-20: Output adjustment

Position controller

In this step, the position controller is set. The pre-parameterization can be accepted by clicking “SET”. Fine positioning can be activated later after the P-component was optimized. Following initial parameterization, optimizations may be carried out with the help of the easy startup mode.

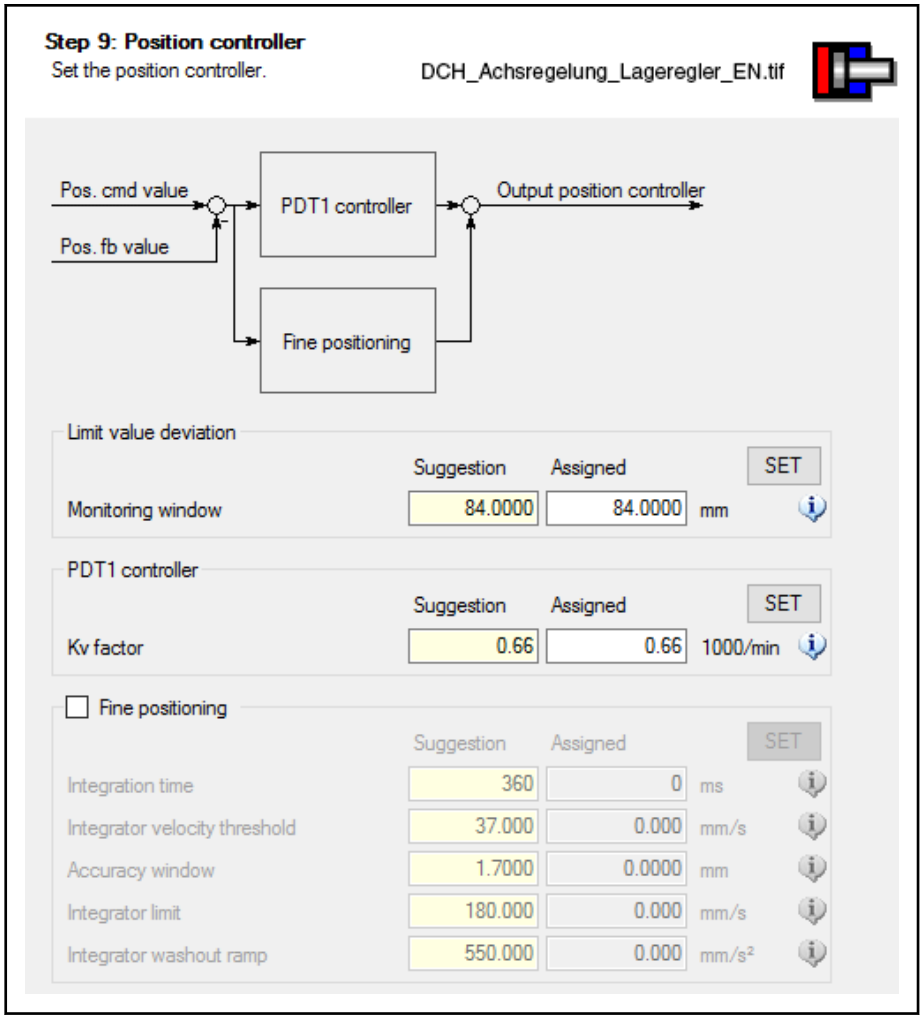


Fig. 11-21: Position controller

Force controller

If “force controller” was selected at the beginning of basic parameterization, the P-gain can be accepted for the force controller in a next step.

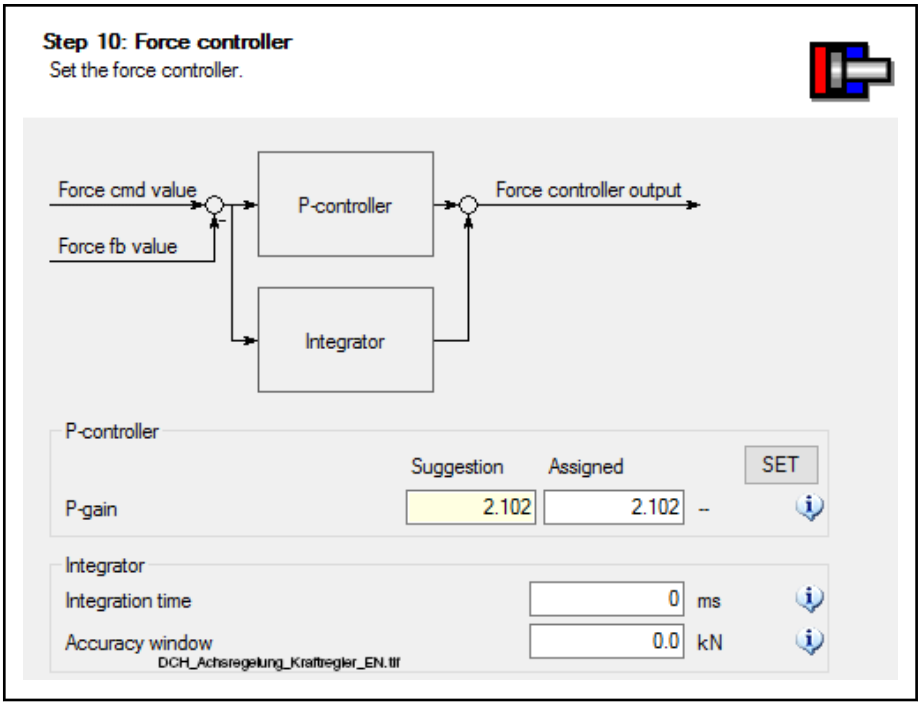


Fig. 11-22: Force controller

Alternating control

The dialog for activating alternating control appears only, if force control was selected. Alternating control should only be activated, when the position controller, integrator included, was set.

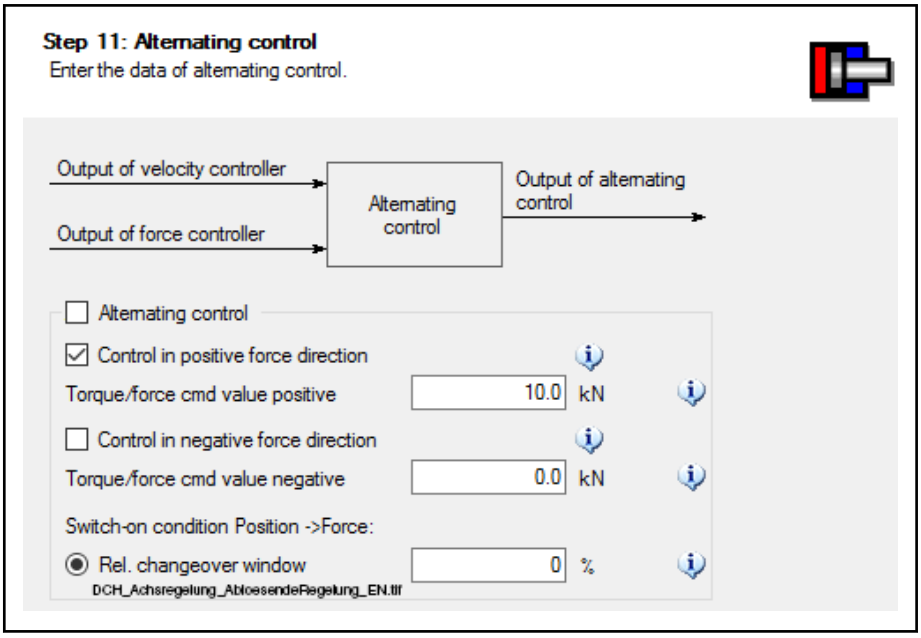


Fig. 11-23: Alternating control

The Wizard is now completed.

11.2.2 Easy startup mode

After the easy startup mode was activated, the HydraulicDrive is in direct valve control and in OM.

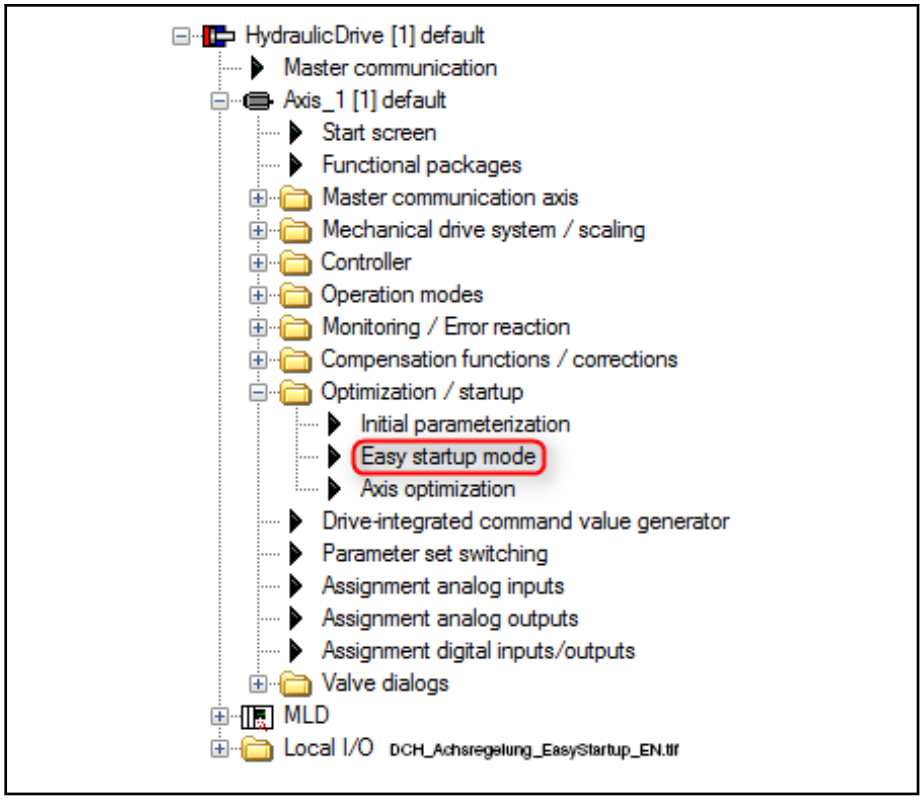


Fig. 11-24: Easy startup mode dialog

To be able to set the controller enable, the hardware input "Enable" has to be set in the HydraulicDrive. For the control cabinet electronics VT-HMC this is not required, since this enabling is not provided. After the software enable was activated the hydraulic axis can be traversed. In addition, the position, pressures and forces can be read out, if parameterized.

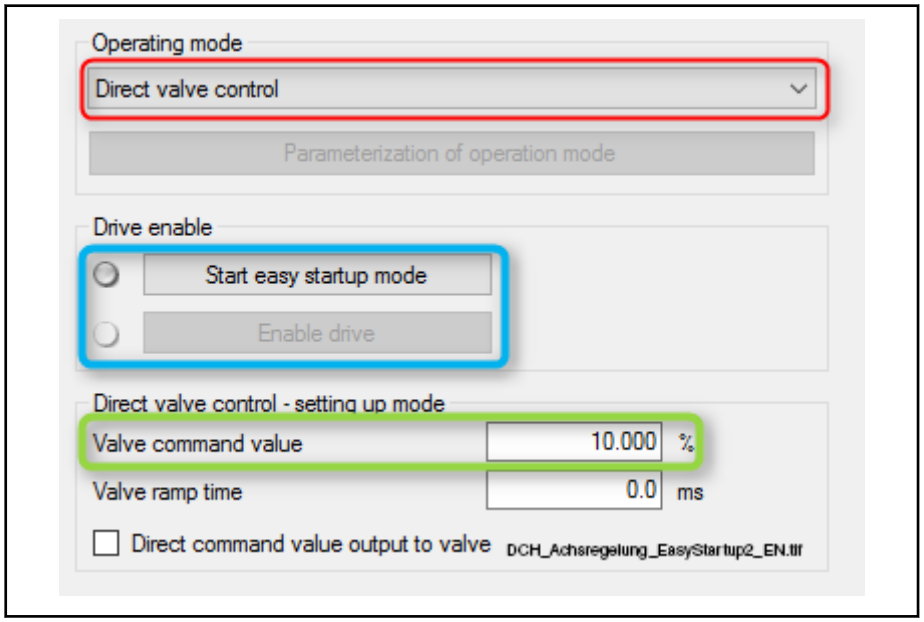


Fig. 11-25: Easy startup mode dialog with operation mode “direct valve control“

As operation mode, select “Direct valve control", red marking. Direct valve control is selected to allow first testing of the hydraulic system in open-loop controlled operation. It allows you to make sure that the system is properly piped, the position measuring system counts correctly and pressure sensors,

if fitted, work correctly. As valve command value, a value of 10 % is to be assumed, see green circle. In this case, 10 % means that the valve is 10 % opened. Before the values are transmitted to the drive, any errors have to be cleared by means of the button.

To send the values to the drive, easy startup mode has to be activated first. Before activating the enable, wait a moment until "A0012, Drive ready" appears under the process data. Following enabling, the button “Drive OFF” appears. It provides an emergency stop function. If it is actuated the movement is stopped.

Changes of the command and the actual value can be traced in the process data section. The actuator is moving. If the system is incorrectly piped, i.e. with a positive command value the cylinder retracts, this may be corrected by inverting the actuating variable or correcting the piping, see figure below. Select “Output adjustment” in the tree on the left. To invert the variables tick the box highlighted in blue. Before the inversions are made check on the electrical and hydraulic circuit diagram whether the connections and ports were properly connected to cables or pipes, respectively.

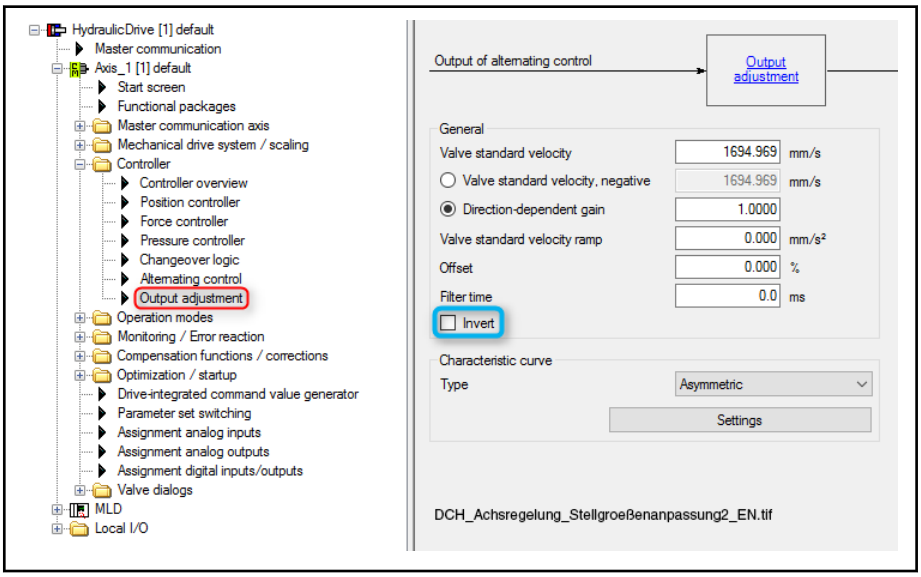


Fig. 11-26: “Output adjustment" dialog

A further error might occur if the position measuring system counts in the negative direction while the cylinder is extending. To correct this fault, proceed as follows:

Select “Position setting” in the tree. Tick the box “Direction of movement inverted" in the right window. In addition, with completely extended cylinder, a positive force has to be indicated. If this is not the case, the sensors have to be turned around by means of software.

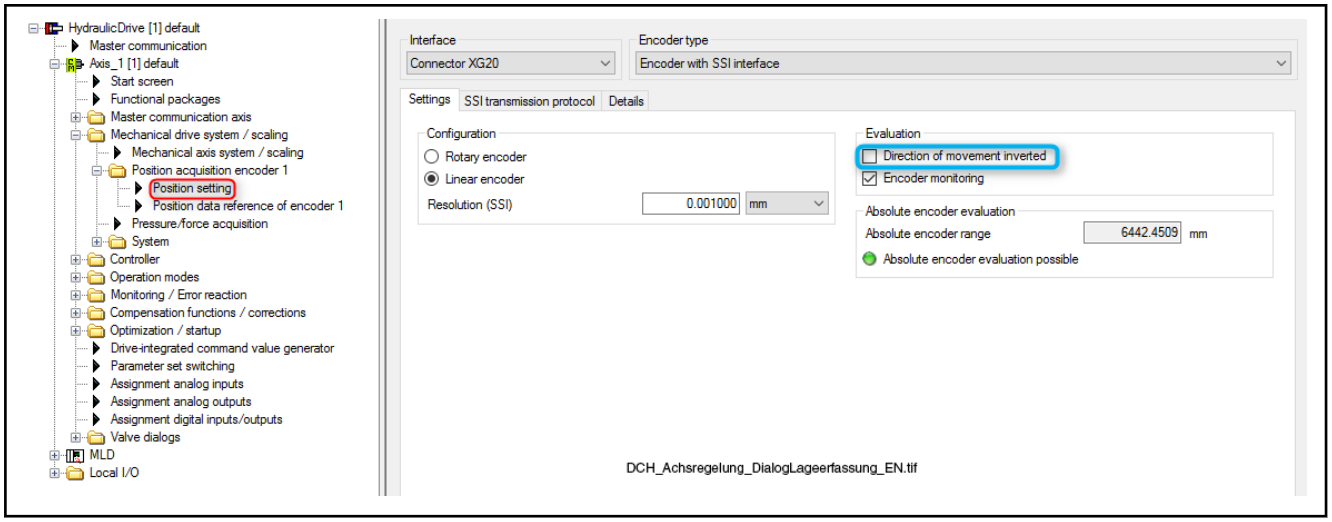


Fig. 11-27: "Position setting" dialog

In the easy startup mode “direct valve control" the correct valve standard velocity can be determined (velocity with 100 % opened valve).

In the case of a valve with linear characteristic curve, proceed as follows:

Set the valve command value to 10 %, for example, determine the velocity and multiply it by 10. Then enter the result in “valve standard velocity" in the dialog "output adjustment". The velocity can be determined by means of various methods. For a start, by reading "S-0-0535, Active velocity feedback value". However, the accuracy of this value strongly depends on the encoder resolution. It is also possible to derive the recorded actual position in the oscilloscope, which mostly provides a more accurate velocity. Moreover, two points can be selected on the signal of the actual position. Based on the time elapsed between the points the velocity can be calculated. To this end, recording with a long constant travel is useful.

A further operation mode is “drive-controlled positioning" in closed-loop controlled operation. To activate it, select operation mode “drive-controlled positioning" (with red frame on the following image). In the green bordered area you have to enter the configuration for the motion profile. To start the movement you have first to activate the easy startup mode (the lamp to the of the left of the button is green) and then activate the enable (the lamp to the left of the button has to be permanently lit green).

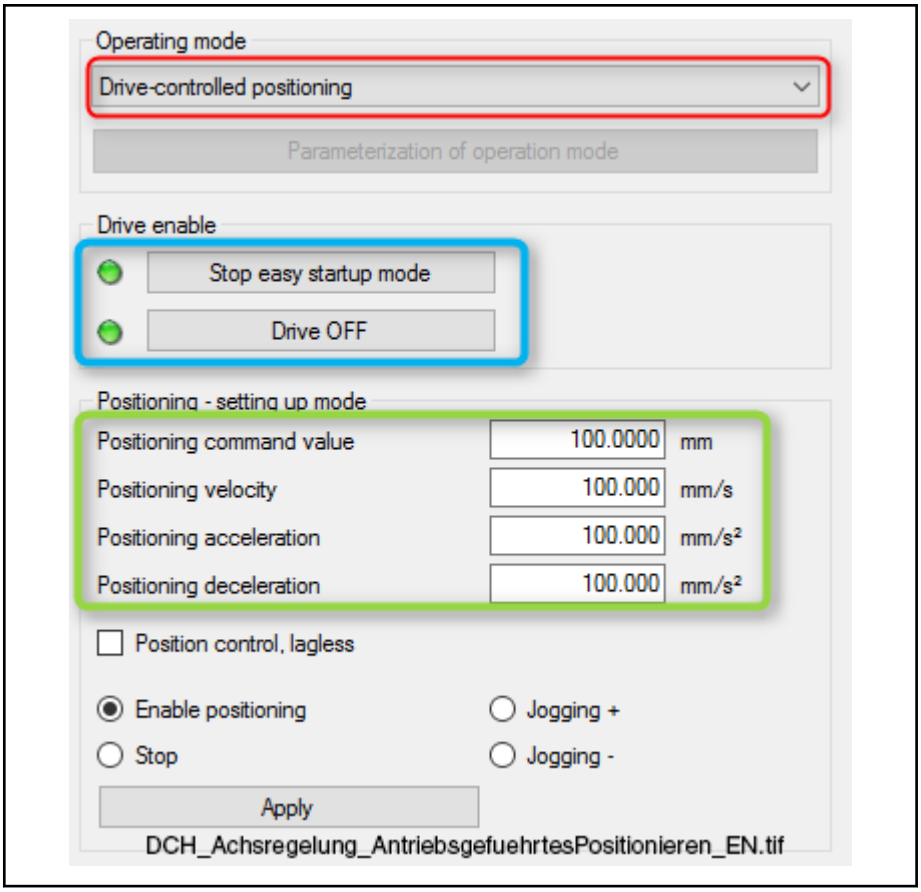


Fig. 11-28: Easy startup mode dialog with operation mode "drive-controlled positioning"

If the measuring system has not yet been homed, since, for example, an incremental measuring system is to be used, it has to be homed. For this, click "Position data reference of encoder 1" (in red rectangle on the figure below) in the tree, then button "Drive-controlled homing" (blue border).

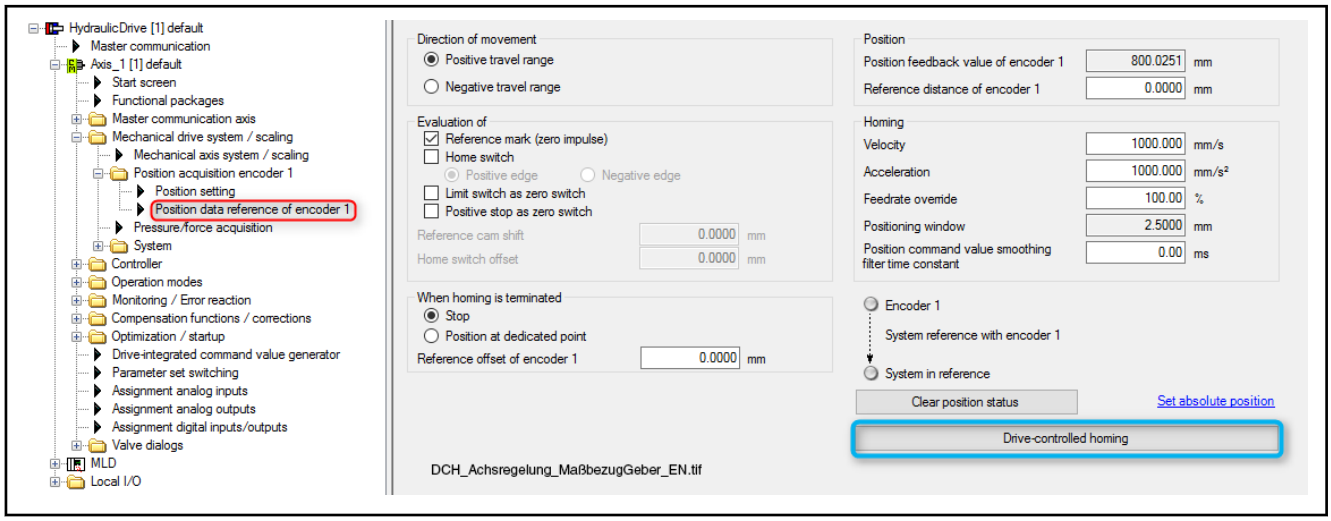


Fig. 11-29: Dialog "Position data reference of encoder"

After this, return to the easy startup mode. Then, "Enable positioning" has be to be activated as shown within the red frame below. To confirm your setting click the button "Apply" (shown in blue border). The drive will then move to the desired position.

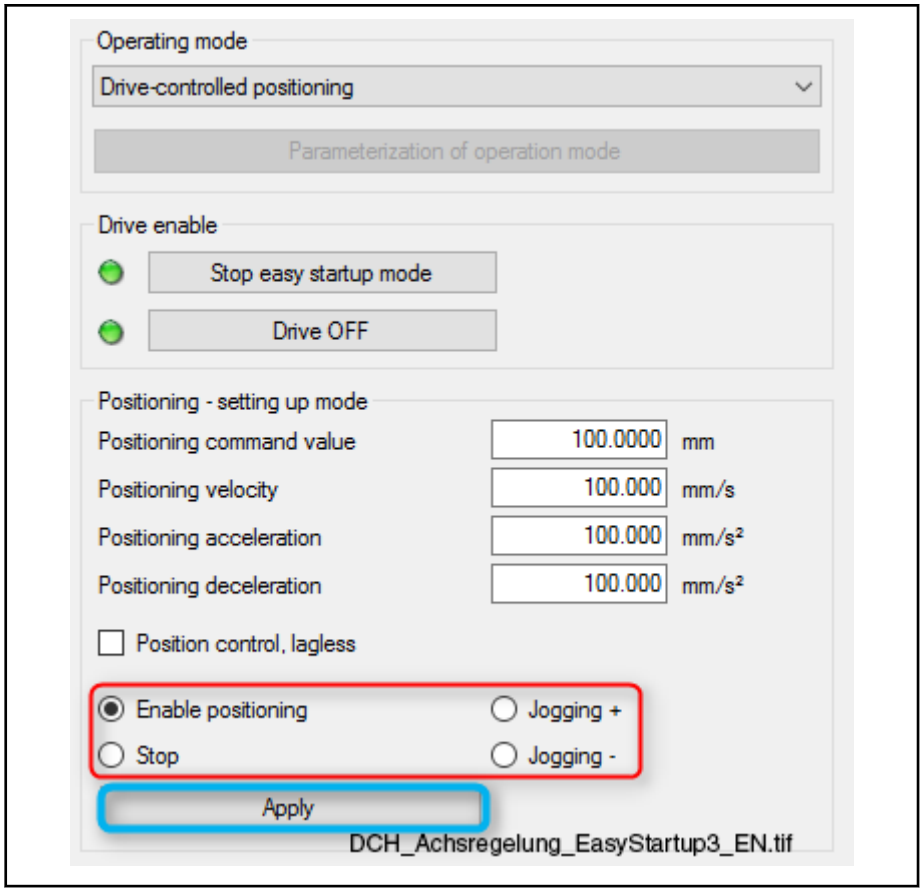


Fig. 11-30: Easy startup mode dialog with operation mode “drive-controlled positioning”

To stop the movement, select "Stop". "Apply" needs not to be clicked afterwards.

In the jog mode the axis can be moved in the positive direction by selecting “Jogging +" and in the negative direction by selecting “Jogging -". The jog command remains active until “stop” is selected.

11.2.3 Axis optimization

Before the cylinder can be operated for axis optimization, the drive enable must have been set. This can be done in the easy startup mode, for example. Axis optimization determines the standard velocity and the valve characteristic curve.

☞ Observe the information notes on the parameters to be entered.

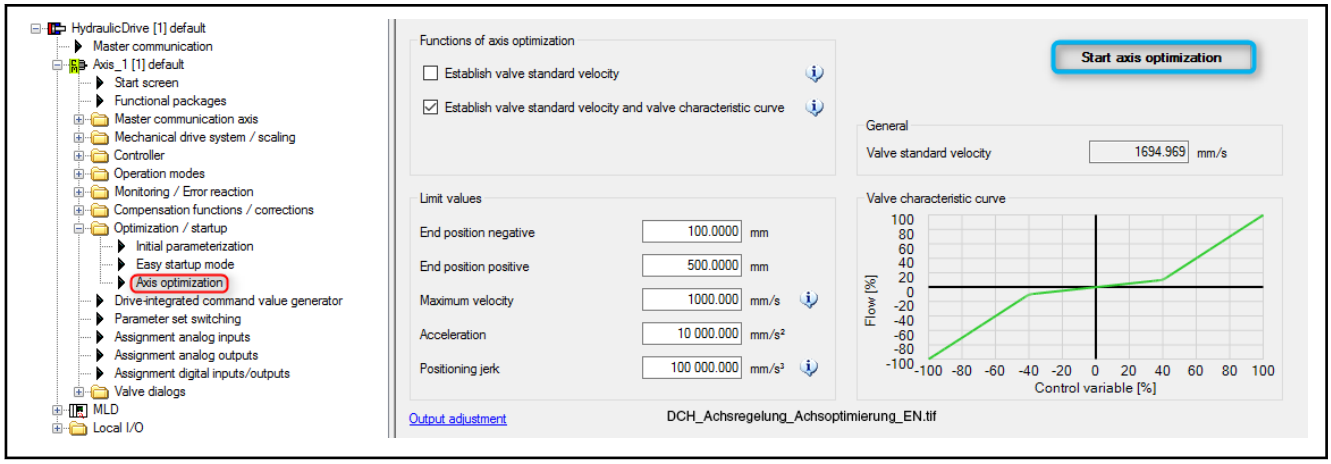


Fig. 11-31: “Axis optimization” dialog

11.2.4 Position control

For setting the controller parameters, it is useful to extend and retract the cylinder periodically. For this, it is helpful to use the positioning block mode, which can be selected in the easy startup mode. Click the button “Parameterization of operation mode” to set the positioning block mode.

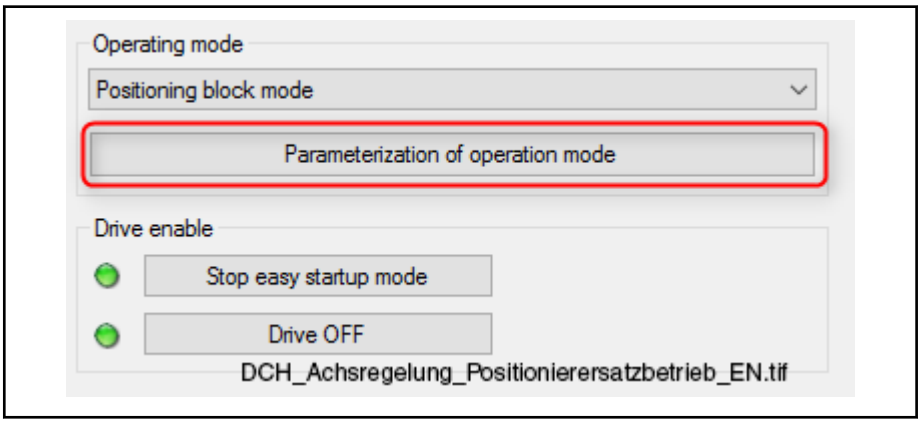


Fig. 11-32: Easy startup mode dialog with operation mode “Positioning block mode“

For commissioning, two blocks are sufficient, which contain the desired positions with the related velocities and accelerations. Select realistic values for these movements in order that the axis can actually perform them.

☞ It is important for the setting of the controller that the system corresponds to the pressure at which the system will be operated in the end. Moreover, take into account that the controller parameters depend on the weight.

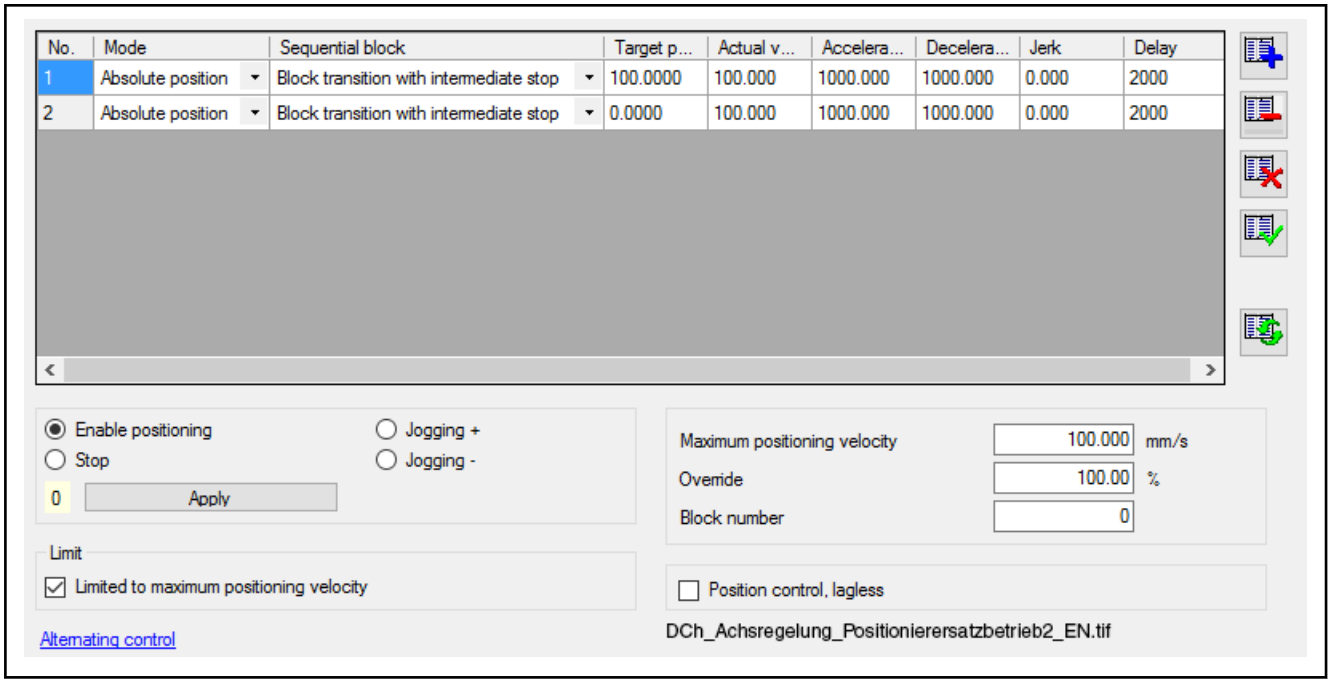


Fig. 11-33: "Positioning block mode" dialog

The following section describes how to determine the P-gain for an axis. First, fine positioning is to be switched off and “velocity feedforward” has to be set to “0” (shown in red border on the following figure).

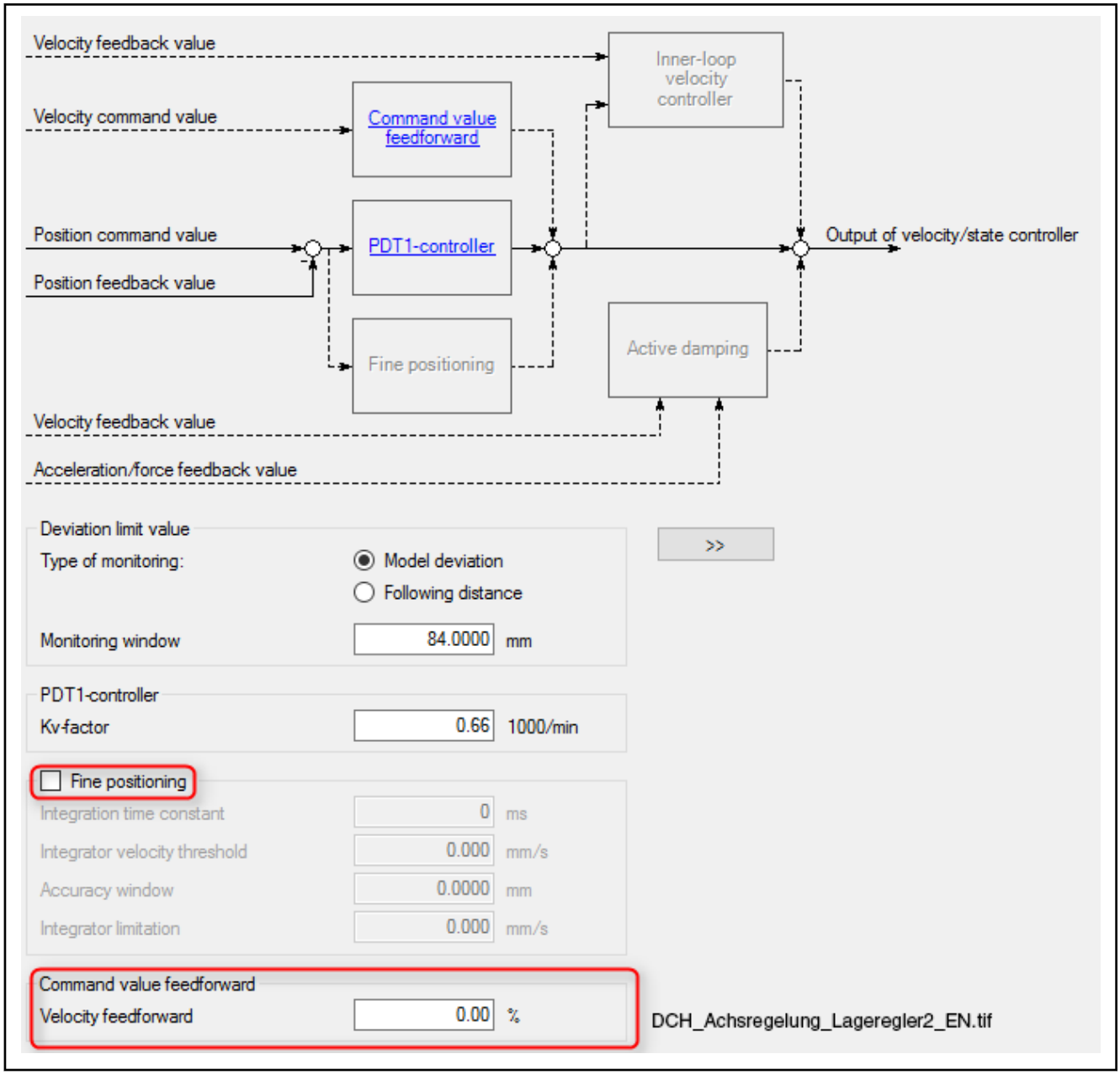


Fig. 11-34: Position controller dialog

The positioning block mode now can be activated via the easy startup mode. Here, switching between two positions is required. Start with a small Kv factor (e.g. 0.5) or enter the value suggested during initial parameterization.

After every change of the Kv factor, oscilloscope recording has to be started. Slowly increase the Kv factor until oscillation can be observed in the record. The optimum Kv factor is at 70 % of the “critical” value. Then you can activate fine positioning in order to optimize it. As starting value for the integration time, 500 ms may be assumed.

11.3 Commissioning a pump control

11.3.1 Initial parameterization of a pump control

Introduction

Before the pump controller can be operated, the Wizard for initial parameterizing has to be executed. The Wizard is started in the following dialog:

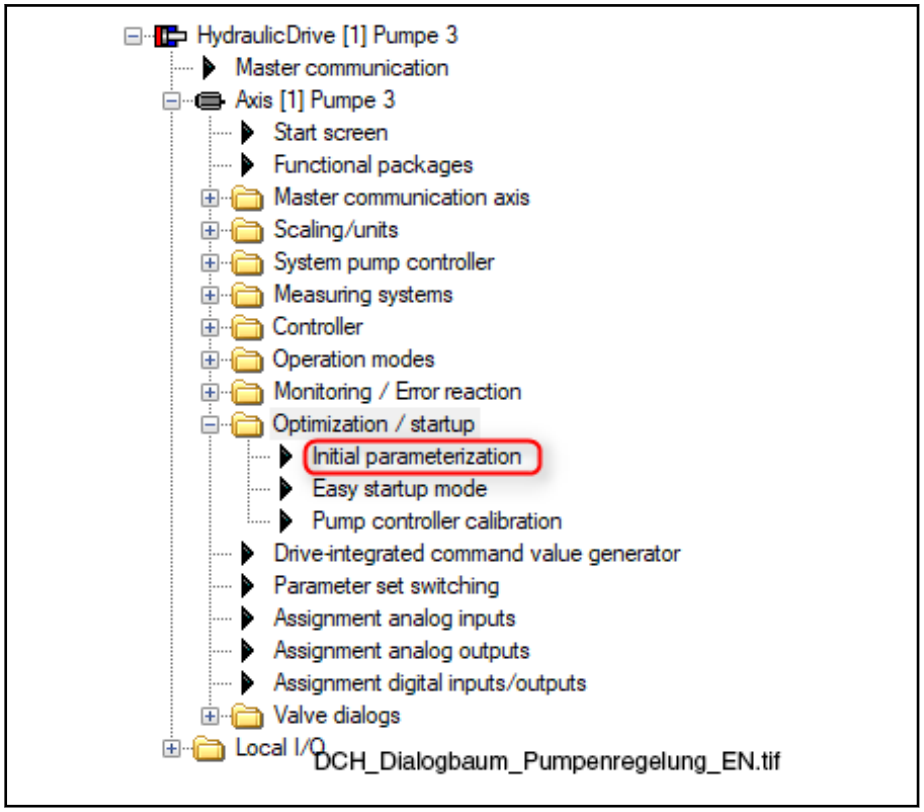


Fig. 11-35: Dialog tree in IndraWorks Ds

Not every dialog window of the Wizard for initial parameterization is explained in detail in the following. At the bottom of the initial parameterization windows notes on the current menu item are provided.

By clicking the info button  you will get information about possible parameter settings.

The warning triangle  indicates that input is required in the Wizard.

In the Wizard for initial parameterization only the most common applications are dealt with exemplarily. If additional setting options are necessary for operating the pump controller, the standard dialog can be opened in the relevant dialog via the link “Show standard dialog“ (at the bottom left). Here you can now enter additional setting options. To return to the Wizard, click the 

button.

Depending on the scope of functions of the pump controller (e.g. variable-speed operation), the Wizard shows additional windows or setting options. The screenshots in this chapter show the dialogs for a pump controller without additional functions. Further information, e.g. about variable-speed operation and additional selection options in the Wizard can be found in the supplementary information "Rexroth HydraulicDrive, HDx-20 pump control, 30237-Z".

Loading basic parameters

Here, the basic parameters have to be loaded first. If a part of it was already parameterized, it can be excluded from being cleared or this step can be skipped.

Basic configuration

Click “Next” to get to the next dialog window. Here you can set the required basic configuration for the pump controller. In the case of systems with pilot valve the corresponding configuration is entered in the factory when the complete system is being manufactured, and this factory configuration may be adjusted in the present dialog, if necessary. For electronics for control cabinet mounting or individual valves, e.g. as spare parts, the values have to be adapted here.

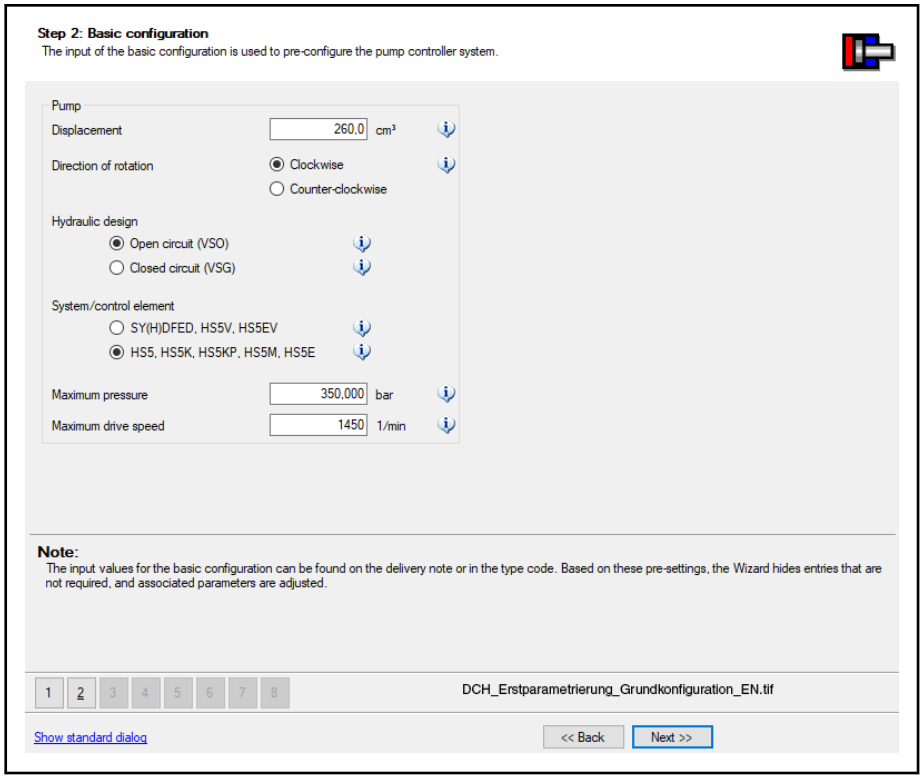


Fig. 11-36: Initial parameterization, basic configuration

Operation mode/function

In the next dialog you have to select the operation mode and the functions of the pump controller such as leakage compensation and torque limitation.

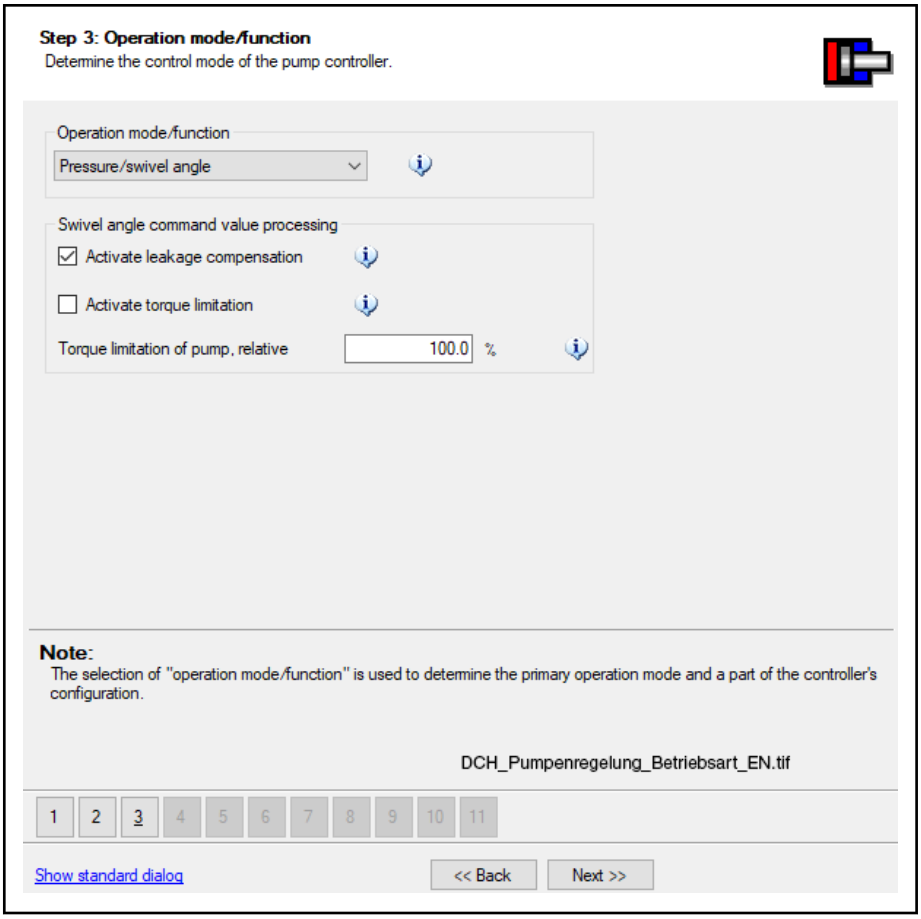


Fig. 11-37: Operation mode/function

For calculating the torque limit, the following calculation rule can be used:

$$P-0-2952=\frac{\text{admissible_torque_motor}}{\text{maximum_torque_pump}}$$

Fig. 11-38: Setting of swivel angle command value processing

Example:

Loading of a 30 kW motor up to 80 % of the nominal torque with an SYDFED 71 cm^3.

$$P-0-2952=\frac{(0,8*191Nm)\div(1,59*V*\triangle p)}{100*\eta_{mh}}=\frac{153Nm}{395Nm}=38,7\%$$

Fig. 11-39: Setting of swivel angle command value processing

η_{mh} hydraulic mechanical efficiency (0.9)

Δp nominal pump pressure (315 bar - fixed value)

V size 71 (71 cm^3)

Torque limitation can be activated by means of bit 1 of the pump controller control word.

Scaling/units

At this point the unit can be selected. You can select either “metric” or “imperial”.

Controller configuration

The behavior of the pump controller is largely influenced by the structure and the oil volume in the hydraulic system. In this respect, this dialog provides suggested values for configuring the controller. These suggested values can be adopted as active control parameters by clicking the button “Set”.

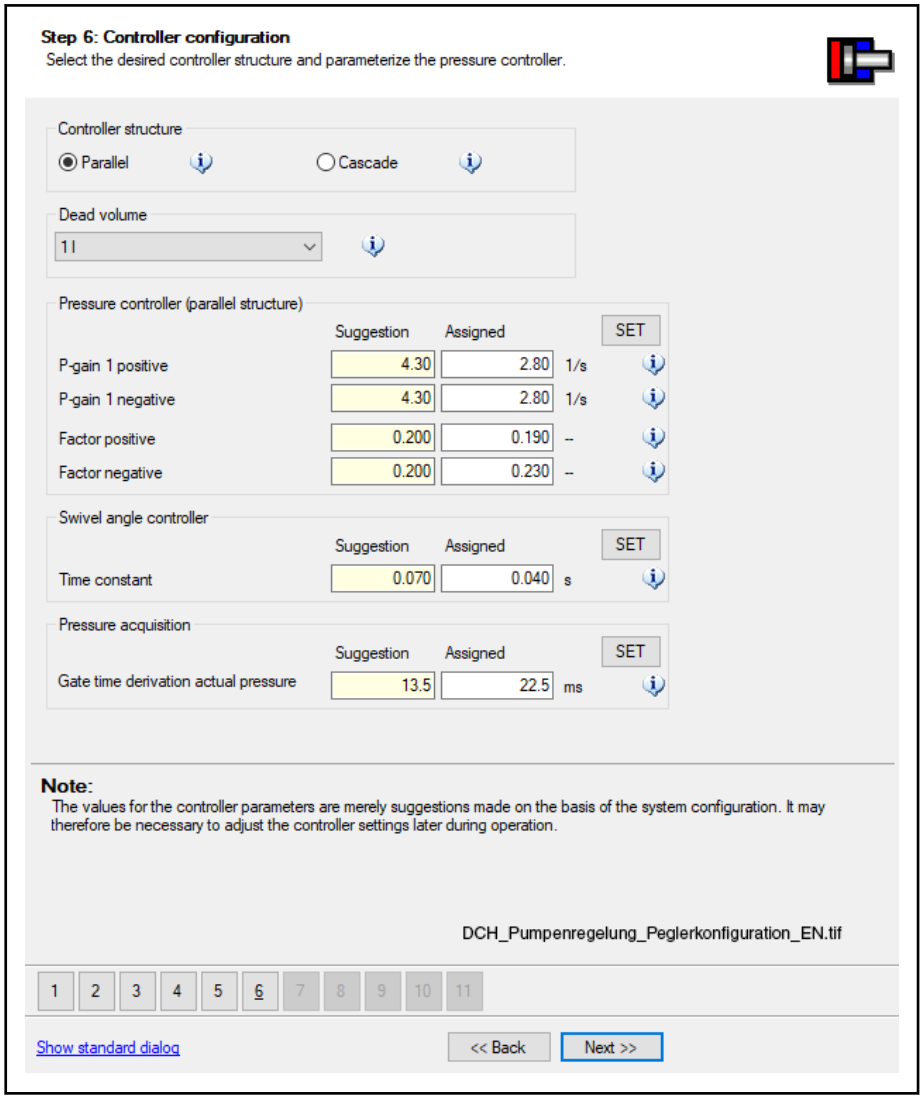


Fig. 11-40: Controller configuration

Master communication/command value provision

In the dialogs for master communication you can select the bus type. Additionally, you can specify in this dialog, which input values (command values, enable, etc.) are to be written via the bus system as well as via analog and digital inputs. When the configuration is completed, values are suggested for the cyclic data of the bus system and the digital and analog inputs are configured accordingly.

11.3.2 Easy startup mode

For setting up the pump controller the easy startup mode may be used. With the easy startup mode you can temporarily set the enable and provide command values from IndraWorks. This allows various working points to be approached and functioning of the pump controller to be tested.

Test of pump actuating system - direct valve control

With some pump systems like the HS5 control with HPC and external pilot oil supply the function of the actuating system is usually tested at the beginning of commissioning while the drive motor is at rest. For this, the operation mode “direct valve control” can be selected in the easy startup mode and a valve command value be provided. The pump will then swivel to the minimum or maximum limit stop depending on the valve command value:

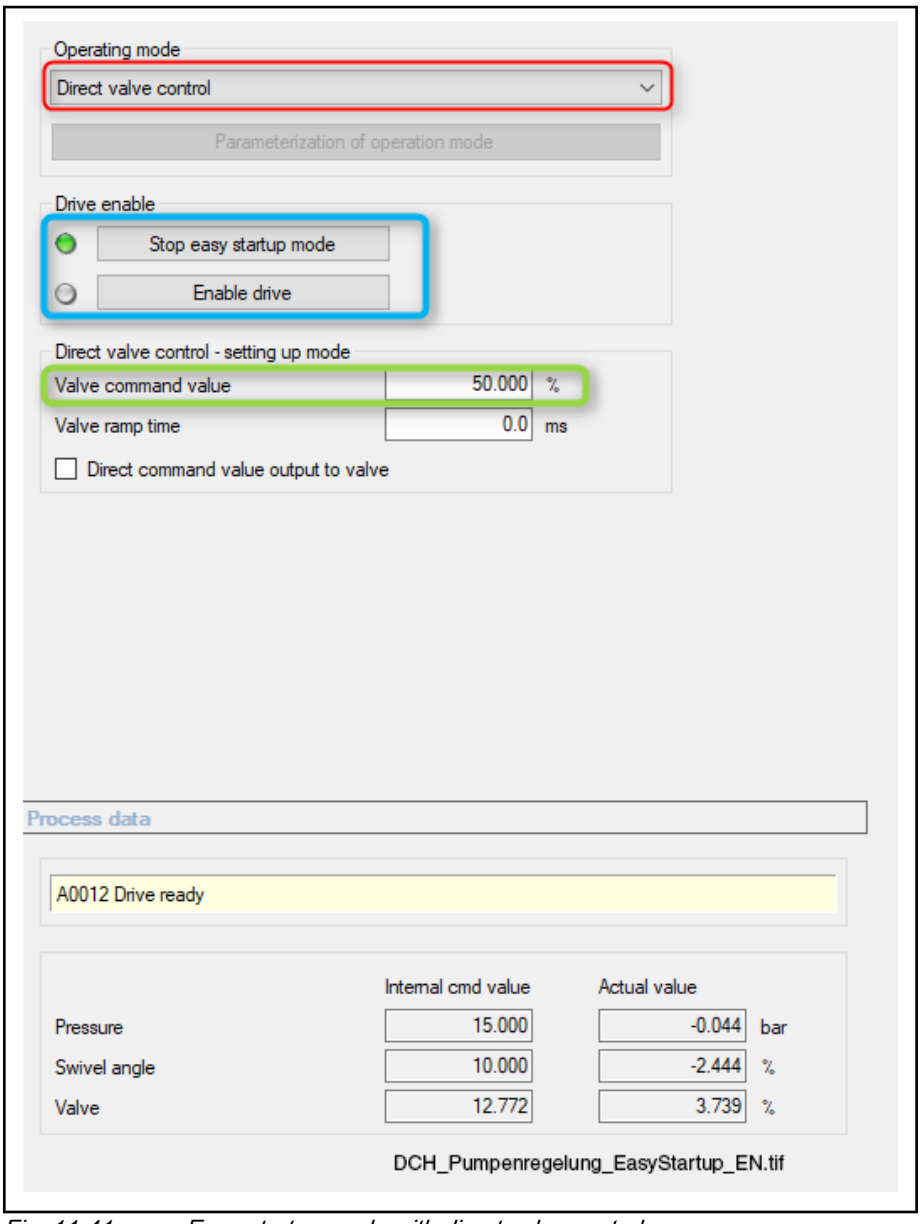


Fig. 11-41: Easy startup mode with direct valve control

As operation mode, select “Direct valve control", see red rectangle. As valve command value, a value of 50 % is to be assumed, see green rectangle. Before the values are transmitted to the drive, any errors have to be cleared by means of the button.

To send the values to the drive, easy startup mode has to be activated first. Before activating the enable, wait a moment until "A0012, Drive ready" appears under the process data. Following enabling, the button “Drive OFF” appears. It provides an emergency stop function. When it is actuated, the

enable is withdrawn and the original command value from the status "A0012, Drive ready" is active again.

Changes of the command and the actual value of the valve and the resulting movements of the swivel angle command value can be traced in the process data section.

Test of pump control - direct valve control

To test functioning of the pump controller while the drive motor is rotating, use the operation mode “pressure/swivel angle control” in the easy startup mode.

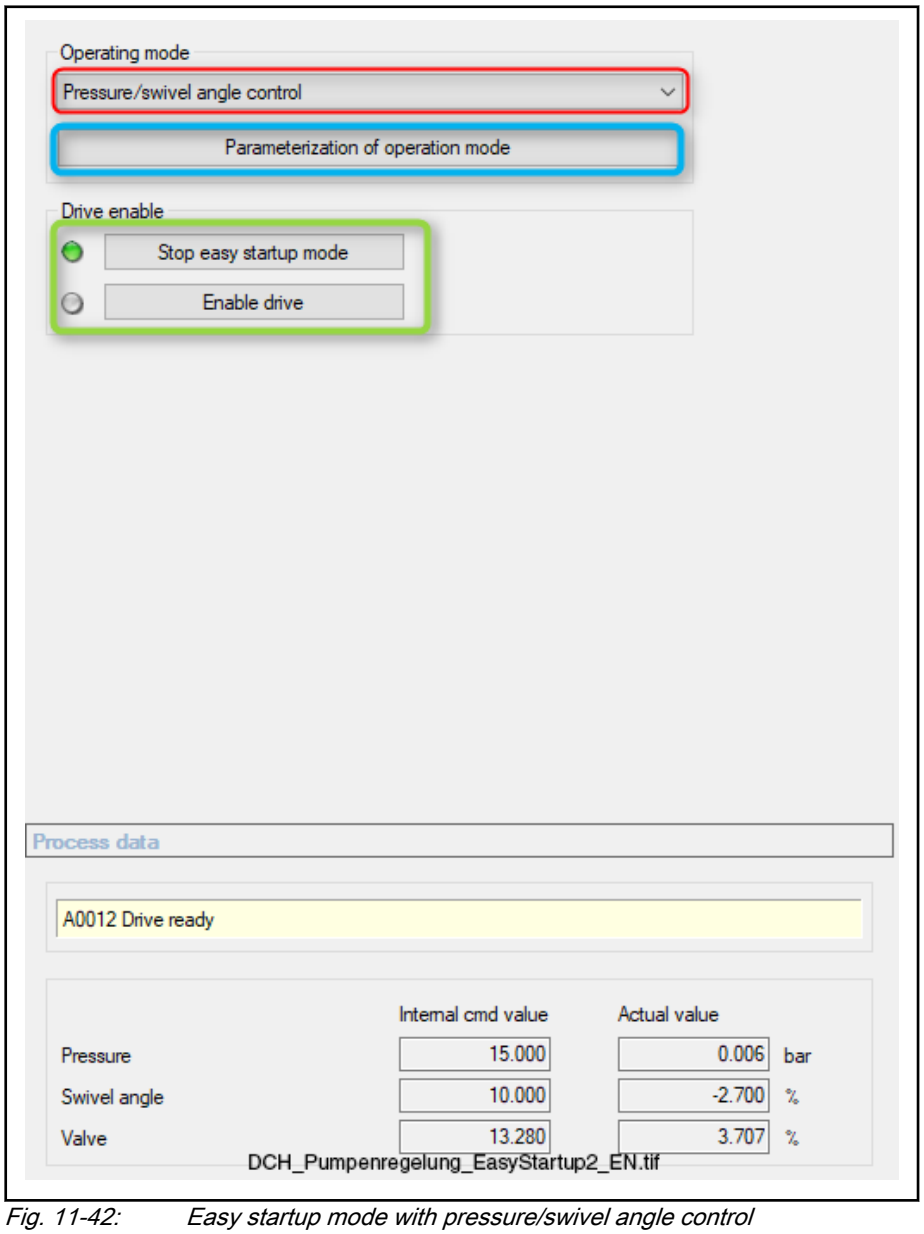


Fig. 11-42: Easy startup mode with pressure/swivel angle control

As operation mode, select “Pressure/swivel angle control” (red marking). The command values for pressure and swivel angle control are entered in a second dialog, which is called via the button “Parameterization of operation mode” (blue rectangle). In this new dialog you can now set the pressure command value and the swivel angle command value. To return to the easy startup mode click the Back button in the icon bar.

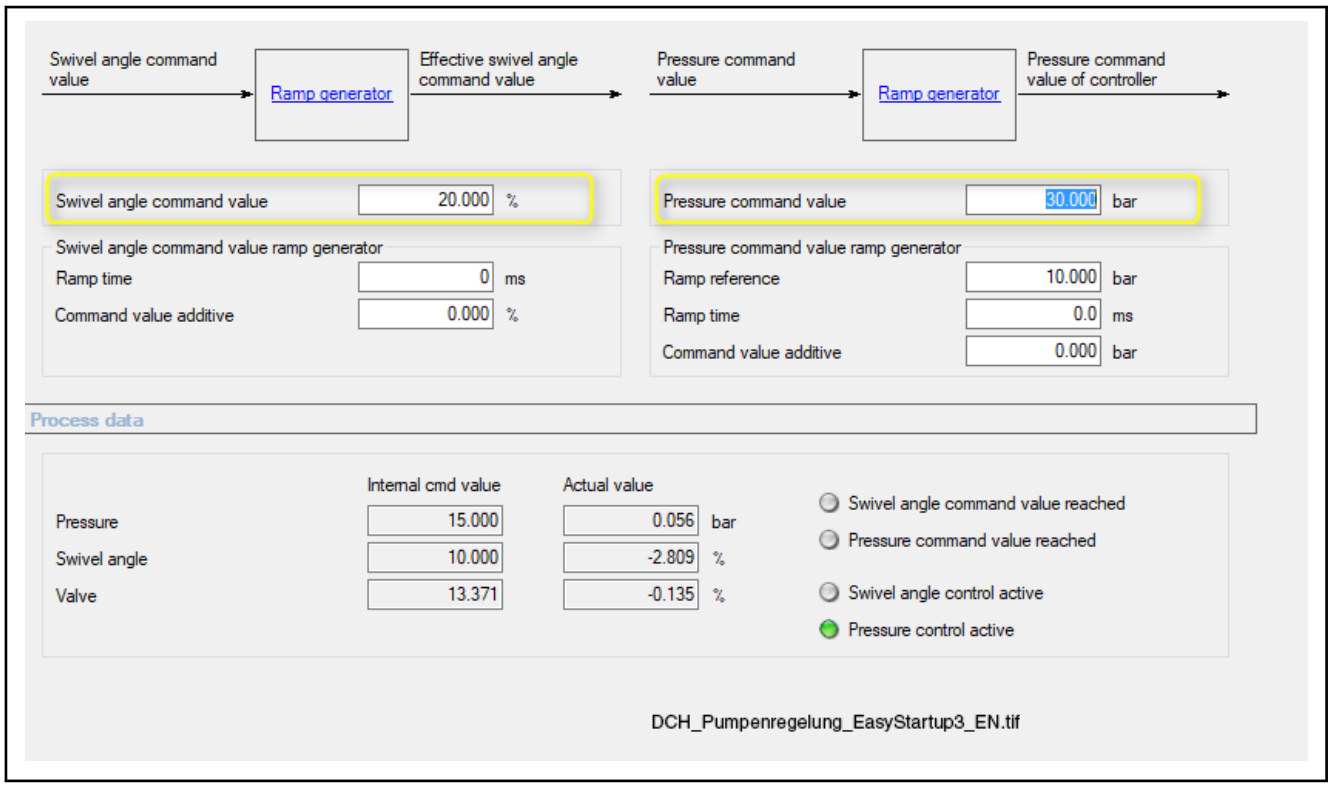


Fig. 11-43: Test of pump control - direct valve control

Before the values are transmitted to the drive, any errors present have to be cleared by means of the button. To be able to send the values to the drive, easy startup mode has to be activated first (green rectangle). Before activating the enable, wait a moment until "A0012, Drive ready" appears under the process data. Following enabling, the button “Drive OFF” appears, which has an emergency stop function. When it is actuated, the enable is withdrawn and the original command values or the state from status “A0012 Drive ready” is active again.

Changes in pressure and swivel angle can be observed in the process data.

11.3.3 Calibration of pump control

Various calibration functions are provided for the pump control. These calibration functions improve the accuracy of the pump control and compensate for drift effects that may be present and may result from wear over the service life. For this reason the calibration functions should be executed at the end of commissioning.

If the calibrations functions are not executed at the end of commissioning, the system is nevertheless ready for operation, but with reduced accuracy. The operating principle and calling of the calibration function is explained in more detail in chapter 5.8 "Calibration functions of pump" on page 281.

12 Service and Support

Contact for repairs

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Internet:	http://www.boschrexroth.com/service

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Phone:	**+49 9352 18 1132**
E-mail:	support.nc-system@boschrexroth.de

Helpful Information

For quick and efficient help please have the following information ready:

- Detailed description of the fault and the circumstances
- Information on the nameplate of the affected products, especially type codes and serial numbers
- Your contact data (phone, fax number and e-mail address)

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RE 30338-FK/02.2020

DOK-HYDRV*-HD*-20VRS**-AP07-DE-P