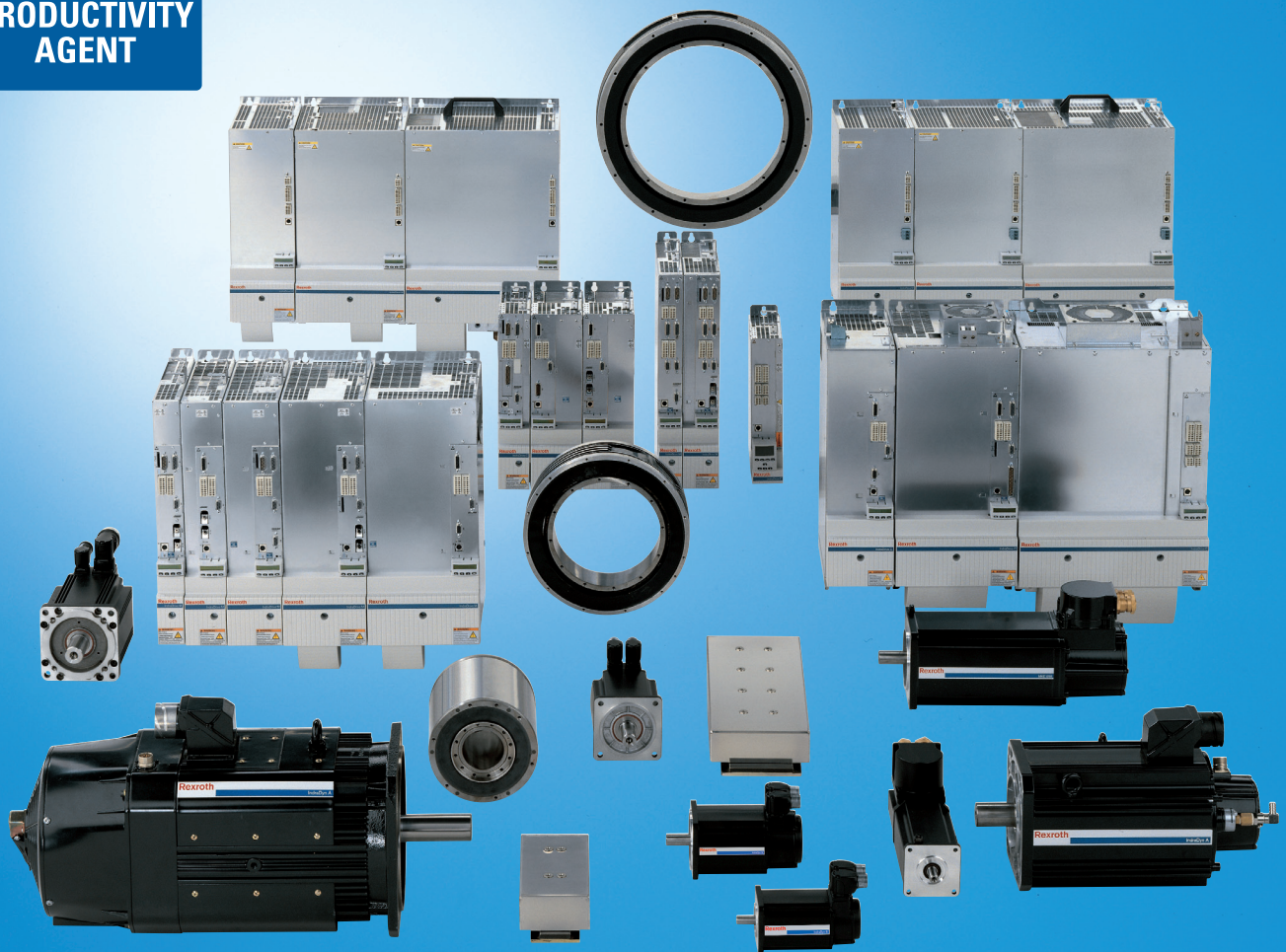


# Rexroth IndraDrive Productivity Agent Technology Functions

**R911323947**  
Edition 02

Application Manual

**PRODUCTIVITY  
AGENT**



| <b>Title</b>                                                         | Rexroth IndraDrive<br>Productivity Agent<br>Technology Functions                                                                                                                                                                                                                                  |                                                                                        |  |         |              |       |                                                                      |                          |                                                                                        |
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| <b>Type of Documentation</b>                                         | Application Manual                                                                                                                                                                                                                                                                                |                                                                                        |  |         |              |       |                                                                      |                          |                                                                                        |
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| <b>Purpose of Documentation</b>                                      | This documentation describes technology functions for drive controllers of the "Rexroth IndraDrive" product range. The extended technology functions are made available on the basis of the integrated PLC.                                                                                       |                                                                                        |  |         |              |       |                                                                      |                          |                                                                                        |
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# Table of Contents

|                                                                                                 | Page      |
|-------------------------------------------------------------------------------------------------|-----------|
| <b>1 About This Documentation.....</b>                                                          | <b>9</b>  |
| <b>2 Product Presentation "Productivity Agent".....</b>                                         | <b>11</b> |
| 2.1 Introduction.....                                                                           | 11        |
| 2.2 Main Features.....                                                                          | 11        |
| 2.3 Notes on Application and Use.....                                                           | 11        |
| 2.4 Required Components.....                                                                    | 12        |
| 2.5 Basic Knowledge / Fundamentals.....                                                         | 14        |
| 2.5.1 Explanation of Terms and Definitions.....                                                 | 14        |
| 2.5.2 Classification of the Extended Diagnostic Functions.....                                  | 15        |
| Introduction.....                                                                               | 15        |
| Diagnostic Function .....                                                                       | 15        |
| Diagnostic Range.....                                                                           | 16        |
| Diagnostic Method.....                                                                          | 16        |
| 2.6 Implementing the Function in the Drive.....                                                 | 17        |
| 2.6.1 Providing the Technology Functions .....                                                  | 17        |
| 2.6.2 Integration in the Diagnostic System.....                                                 | 17        |
| 2.6.3 Parameterization and Operation.....                                                       | 17        |
| 2.7 Type Codes and Overview of Functions.....                                                   | 18        |
| <b>3 Safety Instructions for Electric Drives and Controls.....</b>                              | <b>21</b> |
| 3.1 Definitions of Terms.....                                                                   | 21        |
| 3.2 General Information.....                                                                    | 22        |
| 3.2.1 Using the Safety Instructions and Passing Them on to Others.....                          | 22        |
| 3.2.2 Requirements for Safe Use.....                                                            | 22        |
| 3.2.3 Hazards by Improper Use.....                                                              | 23        |
| 3.3 Instructions with Regard to Specific Dangers.....                                           | 24        |
| 3.3.1 Protection Against Contact With Electrical Parts and Housings.....                        | 24        |
| 3.3.2 Protective Extra-Low Voltage as Protection Against Electric Shock .....                   | 25        |
| 3.3.3 Protection Against Dangerous Movements.....                                               | 26        |
| 3.3.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting..... | 27        |
| 3.3.5 Protection Against Contact With Hot Parts.....                                            | 28        |
| 3.3.6 Protection During Handling and Mounting.....                                              | 28        |
| 3.3.7 Battery Safety.....                                                                       | 28        |
| 3.3.8 Protection Against Pressurized Systems.....                                               | 29        |
| 3.4 Explanation of Signal Words and the Safety Alert Symbol.....                                | 29        |
| <b>4 Important Directions for Use .....</b>                                                     | <b>31</b> |
| 4.1 Appropriate Use .....                                                                       | 31        |
| 4.1.1 Introduction.....                                                                         | 31        |
| 4.1.2 Areas of Use and Application.....                                                         | 31        |
| 4.2 Inappropriate Use.....                                                                      | 32        |

## Table of Contents

|          | Page                                                                                             |
|----------|--------------------------------------------------------------------------------------------------|
| <b>5</b> | <b>Enabling Functional Packages..... 33</b>                                                      |
| <b>6</b> | <b>How to Load Technology Functions to the Drive..... 35</b>                                     |
| <b>7</b> | <b>Mechanical Analysis (FWS_MLDPAx_SAM_02Vxx_D0_MP0x)..... 37</b>                                |
| 7.1      | Brief Description..... 37                                                                        |
| 7.2      | Functional Description..... 39                                                                   |
| 7.3      | Notes on Commissioning and Operation..... 41                                                     |
| 7.3.1    | General Information on Commissioning..... 41                                                     |
| 7.3.2    | Configuration and Operation via Parameters..... 43                                               |
| 7.3.3    | Configuration and Operation by Means of IndraWorks..... 48                                       |
| 7.4      | Diagnostic and Status Messages..... 52                                                           |
| 7.5      | Description of the Parameters of the Mechanical Analysis (FWS_MLDPAx_SAM_02Vxx_D0_MP0x).... 54   |
| 7.5.1    | P-0-1370, PA: Configuration..... 54                                                              |
| 7.5.2    | P-0-1371, PA: Measuring progress..... 55                                                         |
| 7.5.3    | P-0-1372, PA: Allowed backlash/stiffness deviation..... 55                                       |
| 7.5.4    | P-0-1373, PA: Characteristic value deviation of backlash/stiffness..... 56                       |
| 7.5.5    | P-0-1374, PA: Backlash/stiffness sensitivity..... 56                                             |
| 7.5.6    | P-0-1375, PA: Allowed friction deviation..... 56                                                 |
| 7.5.7    | P-0-1376, PA: Characteristic value deviation of friction..... 57                                 |
| 7.5.8    | P-0-1377, PA: Friction sensitivity..... 57                                                       |
| 7.5.9    | P-0-1378, PA: Measuring range - lower limit..... 57                                              |
| 7.5.10   | P-0-1379, PA: Measuring range - upper limit..... 58                                              |
| 7.5.11   | P-0-1380, PA: Test profile - max. velocity..... 58                                               |
| 7.5.12   | P-0-1381, PA: Test profile - max. acceleration..... 59                                           |
| 7.5.13   | P-0-1382, PA: Test profile - velocity factor..... 59                                             |
| 7.5.14   | P-0-1383, PA: Test profile - acceleration factor..... 59                                         |
| 7.5.15   | P-0-1384, PA: Operating hours - reference measurement..... 60                                    |
| 7.5.16   | P-0-1385, PA: Operating hours - test measurement..... 60                                         |
| 7.5.17   | P-0-1387, PA: Status text..... 60                                                                |
| 7.5.18   | P-0-1389, PA: Reference data..... 60                                                             |
| 7.5.19   | P-0-1390, PA: Control word..... 63                                                               |
| 7.5.20   | P-0-1410, PA: Status word..... 63                                                                |
| <b>8</b> | <b>Frequency Response Measurement and Analysis<br/>(FWS_MLDPBP_FAGxxx_02Vxx_D0_MP0x)..... 67</b> |
| 8.1      | Brief Description..... 67                                                                        |
| 8.2      | Functional Description..... 71                                                                   |
| 8.3      | Notes on Commissioning and Operation..... 74                                                     |
| 8.3.1    | General Information..... 74                                                                      |
| 8.3.2    | Configuration and Operation via Parameters..... 76                                               |
| 8.3.3    | Configuration and Operation by Means of IndraWorks..... 81                                       |
| 8.4      | Diagnostic and Status Messages..... 88                                                           |

## Table of Contents

|                                                                                                                                | Page       |
|--------------------------------------------------------------------------------------------------------------------------------|------------|
| 8.5 Description of the Parameters of the Frequency Response Measurement and Analysis<br>(FWS_MLDPBP_FAGxxx_02Vxx_D0_MP0x)..... | 89         |
| 8.5.1 P-0-1155, Command value generator, amplitude .....                                                                       | 89         |
| 8.5.2 P-0-1316, PA: 1st characteristic amplitude - reference measurement.....                                                  | 89         |
| 8.5.3 P-0-1317, PA: 2nd characteristic amplitude - reference measurement.....                                                  | 89         |
| 8.5.4 P-0-1318, PA: 3rd characteristic amplitude - reference measurement.....                                                  | 89         |
| 8.5.5 P-0-1319, PA: 4th characteristic amplitude - reference measurement.....                                                  | 90         |
| 8.5.6 P-0-1320, PA: 1st characteristic amplitude - last measurement.....                                                       | 90         |
| 8.5.7 P-0-1321, PA: 2nd characteristic amplitude - last measurement.....                                                       | 90         |
| 8.5.8 P-0-1322, PA: 3rd characteristic amplitude - last measurement.....                                                       | 90         |
| 8.5.9 P-0-1323, PA: 4th characteristic amplitude - last measurement.....                                                       | 90         |
| 8.5.10 P-0-1368, PA: Characteristic value list of last measurement.....                                                        | 90         |
| 8.5.11 P-0-1370, PA: Configuration.....                                                                                        | 92         |
| 8.5.12 P-0-1371, PA: Tolerance band - error threshold factor.....                                                              | 93         |
| 8.5.13 P-0-1372, PA: Bandwidth - reference measurement .....                                                                   | 94         |
| 8.5.14 P-0-1373, PA: 1st characteristic frequency/amplitude - reference measurement.....                                       | 94         |
| 8.5.15 P-0-1374, PA: 2nd characteristic frequency/amplitude - reference measurement.....                                       | 94         |
| 8.5.16 P-0-1375, PA: 3rd characteristic frequency/amplitude - reference measurement.....                                       | 94         |
| 8.5.17 P-0-1376, PA: 4th characteristic frequency/amplitude - reference measurement.....                                       | 94         |
| 8.5.18 P-0-1377, PA: Bandwidth - last measurement.....                                                                         | 94         |
| 8.5.19 P-0-1378, PA: 1st characteristic frequency/amplitude - test measurement.....                                            | 95         |
| 8.5.20 P-0-1379, PA: 2nd characteristic frequency/amplitude - test measurement.....                                            | 95         |
| 8.5.21 P-0-1380, PA: 3rd characteristic frequency/amplitude - test measurement.....                                            | 95         |
| 8.5.22 P-0-1381, PA: 4th characteristic frequency/amplitude - test measurement.....                                            | 95         |
| 8.5.23 P-0-1382, PA: Tolerance band - amplitude values.....                                                                    | 95         |
| 8.5.24 P-0-1383, PA: Tolerance band - characteristic frequencies .....                                                         | 95         |
| 8.5.25 P-0-1384, PA: Operating hours - reference measurement.....                                                              | 96         |
| 8.5.26 P-0-1385, PA: Operating hours - test measurement.....                                                                   | 96         |
| 8.5.27 P-0-1387, PA: Status text.....                                                                                          | 96         |
| 8.5.28 P-0-1389, PA: Reference data.....                                                                                       | 97         |
| 8.5.29 P-0-1390, PA: Control word.....                                                                                         | 99         |
| 8.5.30 P-0-1410, PA: Status word.....                                                                                          | 99         |
| 8.5.31 P-0-1412, PA: Error/warning status.....                                                                                 | 101        |
| 8.5.32 P-0-1413, PA: Amplitude command value ideal - integral.....                                                             | 102        |
| 8.5.33 P-0-1414, PA: Amplitude command value ideal - decimal places.....                                                       | 102        |
| <b>9 Envelope Curve Monitoring (FWS_MLDPAx_SCH_02Vxx_D0_MP0x) .....</b>                                                        | <b>103</b> |
| 9.1 Brief Description.....                                                                                                     | 103        |
| 9.2 Functional Description.....                                                                                                | 105        |
| 9.3 Notes on Commissioning and Operation.....                                                                                  | 108        |
| 9.3.1 General Information on Commissioning.....                                                                                | 108        |
| 9.3.2 Configuration and Operation via Parameters.....                                                                          | 109        |
| 9.3.3 Configuration and Operation by Means of IndraWorks.....                                                                  | 116        |
| 9.4 Diagnostic and Status Messages.....                                                                                        | 122        |
| 9.5 Description of the Parameters of the Envelope Curve Monitoring<br>(FWS_MLDPBP_SCHxxx_02Vxx_D0_MP0x).....                   | 123        |

## Table of Contents

|                                                                                                    | Page       |
|----------------------------------------------------------------------------------------------------|------------|
| 9.5.1 P-0-1368, PA: Measuring curves.....                                                          | 123        |
| 9.5.2 P-0-1370, PA: Configuration.....                                                             | 123        |
| 9.5.3 P-0-1371, PA: Factor tolerance band 2, signal 1.....                                         | 124        |
| 9.5.4 P-0-1372, PA: Absolute tolerance positive.....                                               | 124        |
| 9.5.5 P-0-1373, PA: Absolute tolerance negative.....                                               | 125        |
| 9.5.6 P-0-1374, PA: Sensitivity.....                                                               | 125        |
| 9.5.7 P-0-1375, PA: Relative tolerance positive.....                                               | 125        |
| 9.5.8 P-0-1376, PA: Relative tolerance negative.....                                               | 126        |
| 9.5.9 P-0-1377, PA: Max. number of deviations - tolerance 1, signal 1.....                         | 126        |
| 9.5.10 P-0-1378, PA: Max. number of deviations - tolerance 2, signal 1.....                        | 126        |
| 9.5.11 P-0-1384, PA: Operating hours - reference measurement.....                                  | 127        |
| 9.5.12 P-0-1385, PA: Operating hours - test measurement.....                                       | 127        |
| 9.5.13 P-0-1387, PA: Status text.....                                                              | 127        |
| 9.5.14 P-0-1389, PA: Reference data.....                                                           | 128        |
| 9.5.15 P-0-1390, PA: Control word.....                                                             | 129        |
| 9.5.16 P-0-1410, PA: Status Word.....                                                              | 129        |
| <b>10 Collision Monitoring (FWS_MLDTFx_SCM_01Vxx_D0_MP07) .....</b>                                | <b>131</b> |
| 10.1 Brief Description.....                                                                        | 131        |
| 10.2 Functional Description.....                                                                   | 132        |
| 10.3 Notes on Commissioning and Operation.....                                                     | 133        |
| 10.3.1 General Information on Commissioning.....                                                   | 133        |
| 10.3.2 Configuration and Operation via Parameters.....                                             | 135        |
| 10.3.3 Configuration and Operation by Means of IndraWorks.....                                     | 140        |
| 10.4 Diagnostic and Status Messages.....                                                           | 141        |
| 10.5 Description of the Parameters of the Collision Monitoring (FWS_MLDTFx_SCM_01Vxx_D0_MP07)..... | 141        |
| 10.5.1 P-0-1311, Collision monitoring: Input list .....                                            | 141        |
| 10.5.2 P-0-1312, Collision monitoring: Collision recorder .....                                    | 142        |
| 10.5.3 P-0-1370, Collision monitoring: Config word .....                                           | 142        |
| 10.5.4 P-0-1375, Collision monitoring: Maximum value .....                                         | 143        |
| 10.5.5 P-0-1378, Collision monitoring: Collision counter .....                                     | 143        |
| 10.5.6 P-0-1387, Collision monitoring: Status text .....                                           | 144        |
| 10.5.7 P-0-1410, Collision monitoring: Function status word .....                                  | 144        |
| <b>11 Vibration Damping and Avoiding (FWS_MLDPAx_VDA_01Vxx_D0_MP0x).....</b>                       | <b>147</b> |
| 11.1 Brief Description.....                                                                        | 147        |
| 11.2 "Vibration Avoiding" (VA).....                                                                | 149        |
| 11.2.1 Functional Description.....                                                                 | 149        |
| 11.2.2 Notes on Commissioning and Operation.....                                                   | 151        |
| General Information.....                                                                           | 151        |
| Configuration and Operation of Vibration Avoiding by Means of IndraWorks.....                      | 151        |
| Configuration and Operation of Vibration Avoiding via Parameters.....                              | 154        |
| 11.3 "Vibration Damping" (VD).....                                                                 | 154        |
| 11.3.1 Functional Description .....                                                                | 154        |

## Table of Contents

|                                                                                                             | Page |
|-------------------------------------------------------------------------------------------------------------|------|
| 11.3.2 Notes on Commissioning and Operation.....                                                            | 157  |
| General Information.....                                                                                    | 157  |
| Configuration and Operation of Vibration Damping by Means of IndraWorks.....                                | 158  |
| Configuration and Operation of Vibration Damping via Parameters.....                                        | 169  |
| 11.4 Diagnostic and Status Messages.....                                                                    | 173  |
| 11.5 Description of the Parameters of Vibration Damping and Avoiding<br>(FWS_MLDPAx_VDA_01Vxx_D0_MP0x)..... | 174  |
| 11.5.1 P-0-1272, Adjusted feedback signal before the summation point.....                                   | 174  |
| 11.5.2 P-0-1273, Control difference after the summation point.....                                          | 174  |
| 11.5.3 P-0-1277, Control difference after high-pass and low-pass filtering.....                             | 174  |
| 11.5.4 P-0-1278, Controller output after limitation.....                                                    | 174  |
| 11.5.5 P-0-1279, Adjusted command signal before the summation point.....                                    | 175  |
| 11.5.6 P-0-1300, VA - NC position command value.....                                                        | 175  |
| 11.5.7 P-0-1301, VA - NC velocity command value.....                                                        | 175  |
| 11.5.8 P-0-1316, Sensor input, input filter time constant [ms].....                                         | 175  |
| 11.5.9 P-0-1317, Sensor input, analog input offset [V].....                                                 | 176  |
| 11.5.10 P-0-1318, Analog input, sensor dead zone (bipolar) [V].....                                         | 176  |
| 11.5.11 P-0-1319, Sensor sensitivity (incl. amplifier) [mV/g] or [mV/(rad/s <sup>2</sup> )].....            | 176  |
| 11.5.12 P-0-1320, Sensor distance to pivot [mm].....                                                        | 177  |
| 11.5.13 P-0-1321, Torque/force feedback value scaling factor [gm <sup>2</sup> ] or [kg].....                | 177  |
| 11.5.14 P-0-1324, VA - Position command value band-stop filter, center frequency [Hz].....                  | 178  |
| 11.5.15 P-0-1325, VA - Position command value band-stop filter, bandwidth [Hz].....                         | 178  |
| 11.5.16 P-0-1326, VA - Position command value anti-vibration, characteristic frequency [Hz].....            | 178  |
| 11.5.17 P-0-1327, VA - Position command value anti-vibration, damping degree [-].....                       | 179  |
| 11.5.18 P-0-1328, Error diagnosis Error ID.....                                                             | 179  |
| 11.5.19 P-0-1329, Error diagnosis ErrorId: Table.....                                                       | 179  |
| 11.5.20 P-0-1330, Error diagnosis ErrorId: Additional 1.....                                                | 180  |
| 11.5.21 P-0-1331, Error diagnosis ErrorId: Additional 2.....                                                | 180  |
| 11.5.22 P-0-1370, Config word.....                                                                          | 180  |
| 11.5.23 P-0-1371, VD - PI(D-T1) controller proportional gain.....                                           | 182  |
| 11.5.24 P-0-1372, VD - PI(D-T1) controller integral-action time [ms].....                                   | 182  |
| 11.5.25 P-0-1373, VD - PI(D-T1) controller derivative action time [ms].....                                 | 183  |
| 11.5.26 P-0-1374, VD - PI(D-T1) controller smoothing time constant, D-component [us].....                   | 183  |
| 11.5.27 P-0-1375, VD - PI(D-T1) controller limitation.....                                                  | 183  |
| 11.5.28 P-0-1376, VD - Control loop, high pass limit frequency [Hz].....                                    | 184  |
| 11.5.29 P-0-1377, VD - Control loop, low pass limit frequency [Hz].....                                     | 184  |
| 11.5.30 P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz].....                           | 184  |
| 11.5.31 P-0-1379, VD - Control loop, band-stop filter center frequency [Hz].....                            | 185  |
| 11.5.32 P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz].....                                   | 185  |
| 11.5.33 P-0-1381, Acceleration feedback value band-stop filter, center frequency [Hz].....                  | 185  |
| 11.5.34 P-0-1382, Acceleration feedback value band-stop filter, bandwidth [Hz].....                         | 186  |
| 11.5.35 P-0-1383, Acceleration command value delay [ms].....                                                | 186  |
| 11.5.36 P-0-1387, Error text display.....                                                                   | 186  |
| 11.5.37 P-0-1410, Status word.....                                                                          | 187  |

## Table of Contents

|                                                                                                                      | Page           |
|----------------------------------------------------------------------------------------------------------------------|----------------|
| <b>12 Analysis of Characteristic Curve S1 (FWS_MLDPAx_MCG_01V02_D0_MPxx).....</b>                                    | <b>189</b>     |
| 12.1 Brief Description.....                                                                                          | 189            |
| 12.2 Functional Description.....                                                                                     | 189            |
| 12.3 Notes on Commissioning and Operation.....                                                                       | 192            |
| 12.3.1 Configuration and Operation via Parameters.....                                                               | 192            |
| 12.3.2 Configuration and Operation by Means of IndraWorks.....                                                       | 193            |
| 12.4 Description of the Parameters of the Analysis of Characteristic Curve S1<br>(FWS_MLDPAx_MCG_01V02_D0_MPxx)..... | 193            |
| 12.4.1 P-0-1270, Status word.....                                                                                    | 193            |
| 12.4.2 P-0-1272, Absolute value of average speed.....                                                                | 193            |
| 12.4.3 P-0-1273, RMS value of motor current.....                                                                     | 194            |
| 12.4.4 P-0-1274, Characteristic curve S1 power dissipation.....                                                      | 194            |
| 12.4.5 P-0-1275, Working point power dissipation.....                                                                | 194            |
| 12.4.6 P-0-1370, Control word.....                                                                                   | 195            |
| 12.4.7 P-0-1371, Config word.....                                                                                    | 195            |
| 12.4.8 P-0-1372, Nominal speed.....                                                                                  | 196            |
| <br><b>13 Process Controller (FWS_MLDPCx_PRE_01Vxx_MPxx).....</b>                                                    | <br><b>197</b> |
| 13.1 Brief Description.....                                                                                          | 197            |
| 13.2 Functional Description.....                                                                                     | 199            |
| 13.3 Commissioning and Use.....                                                                                      | 205            |
| 13.3.1 General Information.....                                                                                      | 205            |
| 13.3.2 Operating the Process Controller by External Control Unit / Master Communication.....                         | 206            |
| 13.3.3 Operating and Setting the Process Controller by Dialogs in IndraWorks.....                                    | 209            |
| 13.4 Description of Diagnostic Messages.....                                                                         | 212            |
| 13.5 Description of the Parameters of the Process Controller (FWS_MLDPCx_PRE_01Vxx_MPxx).....                        | 212            |
| 13.5.1 P-0-1390, Control word.....                                                                                   | 212            |
| 13.5.2 P-0-1410, Status word.....                                                                                    | 213            |
| 13.5.3 P-0-1411, Switch cam status word.....                                                                         | 214            |
| 13.5.4 P-0-1270, Effective control difference.....                                                                   | 215            |
| 13.5.5 P-0-1271, Effective command value.....                                                                        | 215            |
| 13.5.6 P-0-1272, Torque feedforward, feedforward value.....                                                          | 216            |
| 13.5.7 P-0-1273, Effective process feedback value.....                                                               | 216            |
| 13.5.8 P-0-1274, Controller output.....                                                                              | 216            |
| 13.5.9 P-0-1275, Controller output, limited.....                                                                     | 217            |
| 13.5.10 P-0-1276, Controller cycle time.....                                                                         | 217            |
| 13.5.11 P-0-1316, Band-stop filter, center frequency.....                                                            | 217            |
| 13.5.12 P-0-1317, Band-stop filter, bandwidth.....                                                                   | 218            |
| 13.5.13 P-0-1318, Switch cam, switch-on threshold .....                                                              | 218            |
| 13.5.14 P-0-1319, Switch cam, switch-off threshold .....                                                             | 218            |
| 13.5.15 P-0-1320, P-gain 2 of controller.....                                                                        | 219            |
| 13.5.16 P-0-1321, I-component 2 of controller.....                                                                   | 219            |
| 13.5.17 P-0-1322, Switch point of controller setting 2.....                                                          | 220            |
| 13.5.18 P-0-1323, Switch point of controller setting 1.....                                                          | 220            |
| 13.5.19 P-0-1325, Torque feedforward factor.....                                                                     | 220            |
| 13.5.20 P-0-1326, PT1 command value filter, filter time constant [ms].....                                           | 221            |

## Table of Contents

|                                                                       | Page           |
|-----------------------------------------------------------------------|----------------|
| 13.5.21 P-0-1327, Maximum command value increase.....                 | 221            |
| 13.5.22 P-0-1328, Maximum command value decrease.....                 | 221            |
| 13.5.23 P-0-1329, Maximum controller output increase.....             | 222            |
| 13.5.24 P-0-1330, Maximum controller output decrease.....             | 222            |
| 13.5.25 P-0-1370, Configuration.....                                  | 223            |
| 13.5.26 P-0-1371, Process command value.....                          | 224            |
| 13.5.27 P-0-1372, Process feedback value, analog.....                 | 224            |
| 13.5.28 P-0-1373, P-gain of controller.....                           | 224            |
| 13.5.29 P-0-1374, I-component of controller.....                      | 224            |
| 13.5.30 P-0-1375, D-component of controller.....                      | 225            |
| 13.5.31 P-0-1377, Controller output limitation, upper.....            | 225            |
| 13.5.32 P-0-1378, Controller output limitation, lower.....            | 225            |
| 13.5.33 P-0-1380, Tolerance window.....                               | 226            |
| 13.5.34 P-0-1381, Position limitation, upper.....                     | 226            |
| 13.5.35 P-0-1382, Position limitation, lower.....                     | 227            |
| 13.5.36 P-0-1384, Command value feedforward factor.....               | 227            |
| 13.5.37 P-0-1385, Command value feedforward filter time constant..... | 227            |
| <br><b>14 Service and Support.....</b>                                | <br><b>229</b> |
| <br><b>Index.....</b>                                                 | <br><b>231</b> |



# 1 About This Documentation

## Editions of This Documentation

| Edition                          | Release date | Notes                                                                                                                                                                                                                                            |
|----------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOK-INDRV*-MLD-PAGENT*-AW01-EN-P | 2008-07-18   | First edition for general sales                                                                                                                                                                                                                  |
| DOK-INDRV*-MLD-PAGENT*-AW02-EN-P | 2012-07-18   | Complemented by the descriptions of the functions <ul style="list-style-type: none"> <li>"Vibration Damping and Avoiding"</li> <li>"Collision Detection"</li> <li>"Analysis of Characteristic Curve S1"</li> <li>"Process Controller"</li> </ul> |

Fig. 1-1: Record of Revisions

## Means of Representation in This Documentation

To make the reading of this documentation easier for you, 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        | With the safety function "safety related parking axis" the following monitoring functions are <b>deactivated</b> : ...                              |
| Parameter names, diagnostic message names, function designations | Quotation marks | The missing speed information can be replaced via the control bit "defined safety with parked axis" in "P-0-3210, Safety technology configuration". |

Fig. 1-2: Conventions of Notation

Notes and tips are highlighted. A symbol tells you whether a note or a tip is used in the text:



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



This symbol highlights useful tips and tricks.

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").

## Your Feedback

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

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

[brcedy1-dokusupport-drives@boschrexroth.de](mailto:brcedy1-dokusupport-drives@boschrexroth.de)

We need the following information to handle your feedback:

- The number indicated under "Internal File Reference".
- The page number.



## 2 Product Presentation "Productivity Agent"

### 2.1 Introduction

This documentation describes the "Productivity Agent". The "Productivity Agent" makes available technology functions for drive controllers of the "Rexroth IndraDrive" product range.

The technology functions must be adjusted (configured/parameterized) to the installation in which they are to be used.

### 2.2 Main Features

The "Productivity Agent" has the following features:

- Error detection in closed control loop in dynamic operation ("online method")
- Diagnostic ability of drive extended to entire axis (incl. mechanical system) for the following error situations:
  - Change in stiffness
  - Change in backlash
  - Change in friction
- Extended diagnosis of errors regarding type, cause, location, ...
- Increase in the machine's productivity and increase in product quality
- Longer life cycles of machines and their mechanical systems by reducing mechanical stress
- No additional sensors as drive is used as an "intelligent sensor". (If required, additional sensors can be included in the technology function.)
- Simple operation and practice-oriented error diagnosis

### 2.3 Notes on Application and Use

The "Productivity Agent" can be used in the following fields:

- Monitoring
- Optimization
- Analysis

Thereby, the "Productivity Agent" provides the following options:

- **Preventive maintenance**  
"Small" errors are detected early on in their initial stages [mechanical machine state (friction, backlash and stiffness)] to avoid malfunction resulting from these errors (preventive diagnosis). Necessary maintenance activities thus can be planned and carried out in due time.
- **Process monitoring and optimization**  
Measurements are executed in operation to detect process errors in due time and ensure product quality. In addition to the extended diagnostic function, automatic process optimization might take place to compensate errors to a certain extent and gain time for a maintenance action without diminishing the product quality ("operation under emergency conditions").
- **Simple and quick error analysis**

## Product Presentation "Productivity Agent"

When an error has occurred and it is important to identify the cause of the error, the location and the required remedy as quickly as possible, the "Productivity Agent" provides comprehensive analysis functions which are easy to use.

The installation can be monitored on 4 levels:

- ① **Drive:** Monitoring by the drive; additionally possible in the control unit
- ② **Mechanical axis system:** Monitoring by the drive; also possible in the control unit with specific mechanical systems
- ③ **Operating process:** Monitoring by the drive with axis-related processes, otherwise in the control unit (drive as an intelligent sensor)
- ④ **Installation:** Monitoring by the control unit (drive as an intelligent sensor)

The figure below shows the monitoring levels in an installation:

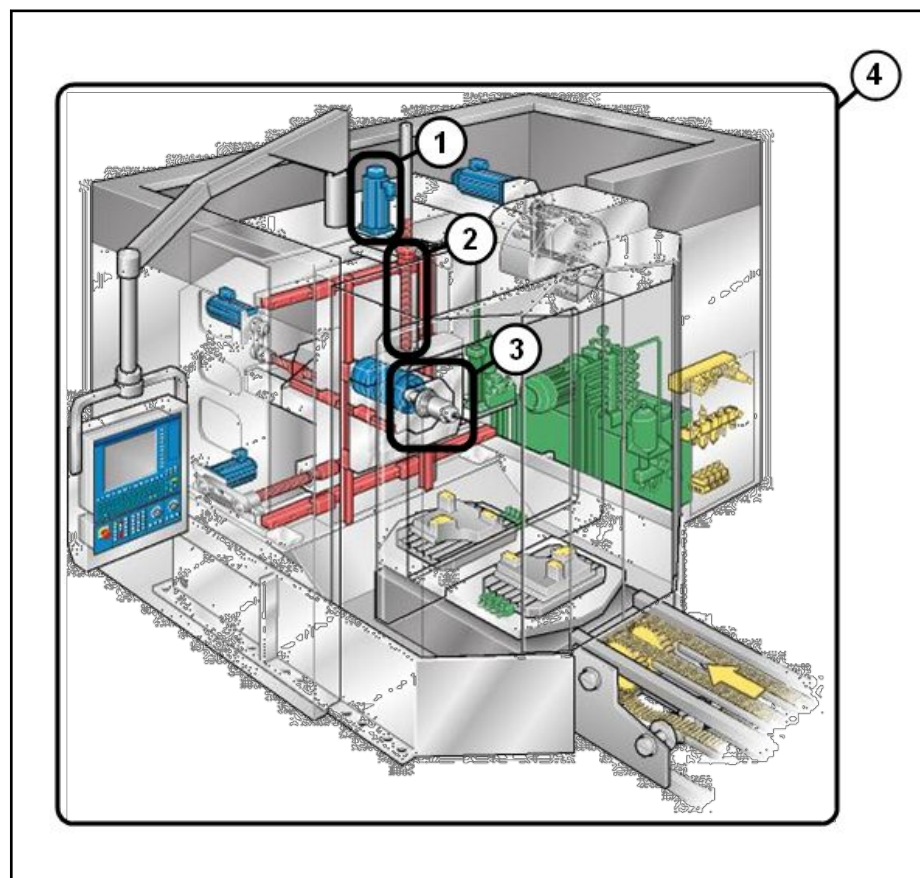


Fig.2-1: Monitoring Levels in an Installation

## 2.4 Required Components

Using the technology functions made available by the "Productivity Agent" requires the following components:

- **Drive controller**

Each power section of the "Rexroth IndraDrive" product range is suited to use the "Productivity Agent" (inverters: HMS01.1N-Wxxx, HMS02.1N-Wxxx; converters: HCS01.1E-Wxxxx, HCS02.1N-Wxxx, HCS03.1N-Wxxx).

## Product Presentation "Productivity Agent"

For control sections, there is the following restriction: The "Productivity Agent" currently can only be used with single-axis control sections [BASIC (CSB01.1) or ADVANCED (CSH01.xC)].

The distributed servo drive **KSM** and the distributed drive controller **KMS** are also suitable for using the "Productivity Agent".



For BASIC double-axis control sections, the "Productivity Agent" is not available, as the required integrated PLC (optional firmware expansion package "TF") is not available for these devices.



Due to their complexity and extent, the functions provided within the scope of PLC projects are only available for ADVANCED control sections (see "Type Codes and Overview of Functions").

- Drive firmware**

As the functions of the "Productivity Agent" have been realized on the basis of the integrated PLC (IndraMotion MLD), the optional functional package "ML" or "TF" (depending on the drive firmware) is required in addition to the drive firmware:

| Firmware version                                               | Characteristic | MLD-S |    | MLD-M |    |
|----------------------------------------------------------------|----------------|-------|----|-------|----|
|                                                                | Option         | TF    | ML | TF    | ML |
| FWA-INDRV-MP*02VRS                                             | MPB            | -     | -  | -     | -  |
|                                                                | MPH            | -     | X  | -     | -  |
|                                                                | MPD            | -     | -  | -     | -  |
| FWA-INDRV-MP*03VRS                                             | MPB            | X     | -  | -     | -  |
|                                                                | MPH            | -     | X  | -     | -  |
|                                                                | MPD            | -     | -  | -     | -  |
| FWA-INDRV-MP*04VRS                                             | MPB            | X     | -  | -     | -  |
|                                                                | MPH            | -     | X  | -     | X  |
|                                                                | MPD            | -     | -  | -     | -  |
| FWA-INDRV-MP*05VRS                                             | MPB            | X     | -  | -     | -  |
|                                                                | MPH            | -     | X  | -     | X  |
|                                                                | MPD            | -     | -  | -     | -  |
| FWA-INDRV-MP*06VRS<br>FWA-INDRV-MP*07VRS<br>FWA-INDRV-MP*08VRS | MPB            | X     | -  | -     | -  |
|                                                                | MPC            | X     | X  | X     | X  |
|                                                                | MPH            | X     | X  | -     | -  |
|                                                                | MPD            | -     | -  | -     | -  |

## Product Presentation "Productivity Agent"

|                    |     |   |   |   |   |
|--------------------|-----|---|---|---|---|
| FWA-INDRV-MP*17VRS | MPB | X | X | - | - |
|                    | MPC | X | X | X | X |
|                    | MPE | - | - | - | - |
|                    | MPM | - | - | - | - |

Option: "TF" Use of self-contained PLC programs (technology functions) of Bosch Rexroth or free programming possible with restrictions

Option: "ML" Freely programmable PLC

X Option possible for this firmware

*Fig.2-2: Firmware Requirements for IndraMotion MLD*

See also "Enabling Functional Packages"

- **Commissioning software**

All extended diagnostic functions can be configured and operated via parameters; you can therefore use the same software which you use for commissioning the drive controller: IndraWorks MLD 05V04. With this software version and higher versions, the functions are supported by individual operation and commissioning dialogs in IndraWorks. In older versions, there aren't any dialogs available; with these versions operation can only take place via the parameter editor or the predefined parameter group.

## 2.5 Basic Knowledge / Fundamentals

### 2.5.1 Explanation of Terms and Definitions

**Analysis** The term "analysis" describes a diagnosis which takes place "in offline form", i.e. not during operation but within the scope of a defined test run. The analysis allows determining the cause of error and, where possible, the error location. Measured data are interpreted and used for further processing.

**Monitoring** The term "monitoring" describes a diagnosis which takes place during operation (in online form) and can always be active in the background. The online diagnosis normally does not provide any information on the cause of error and the error location. It is only a comparison of measured values which takes place.

**Preventive Maintenance** "Preventive maintenance" diagnoses errors at an early stage which allows carrying out maintenance work before malfunction and therefore machine and installation downtimes occur.

**Process Control** The "process controller" function allows controlling an external variable, in addition to the operation modes and control types / loops already available in the drive. Thus, the drive can be used for direct, rapid process control.

**Vibration Damping and Avoiding** When vibrations are damped or even avoided, an intervention in the production process takes place to increase the productivity of a machine and the product quality. Likewise, a longer life cycle of the machine and of its mechanical system is achieved by reducing mechanical stress.

**Malfunction** "Malfunction" is a condition causing installation downtimes or failures and therefore production downtimes.

**Errors** "Errors" are characterized by malfunction of the axis that possibly influences the result of production, but does not yet cause machine downtimes or failures.

**Mechanical Drive System** The "mechanical drive system" is a mechanical connection of different mechanical transfer elements (gear, belt, toothed rack, ...). The mechanical drive system converts the mechanical energy of the motor (rotating shaft with torque) into a torque-speed range appropriate for the operating process.

**Operating Process** The process of the energy consumer absorbing the torque supplied by the mechanical drive system in order to machine (form, drill, mill, ...) or move different materials is called "operating process".

## 2.5.2 Classification of the Extended Diagnostic Functions

### Introduction

The extended diagnostic functions for drive controllers of the "Rexroth IndraDrive" product range are classified with regard to the following aspects:

- Diagnostic function (monitoring or analysis)
- Diagnostic range (frequency range, time range or model calculation)
- Diagnostic method (trend, envelope curve or limit value)

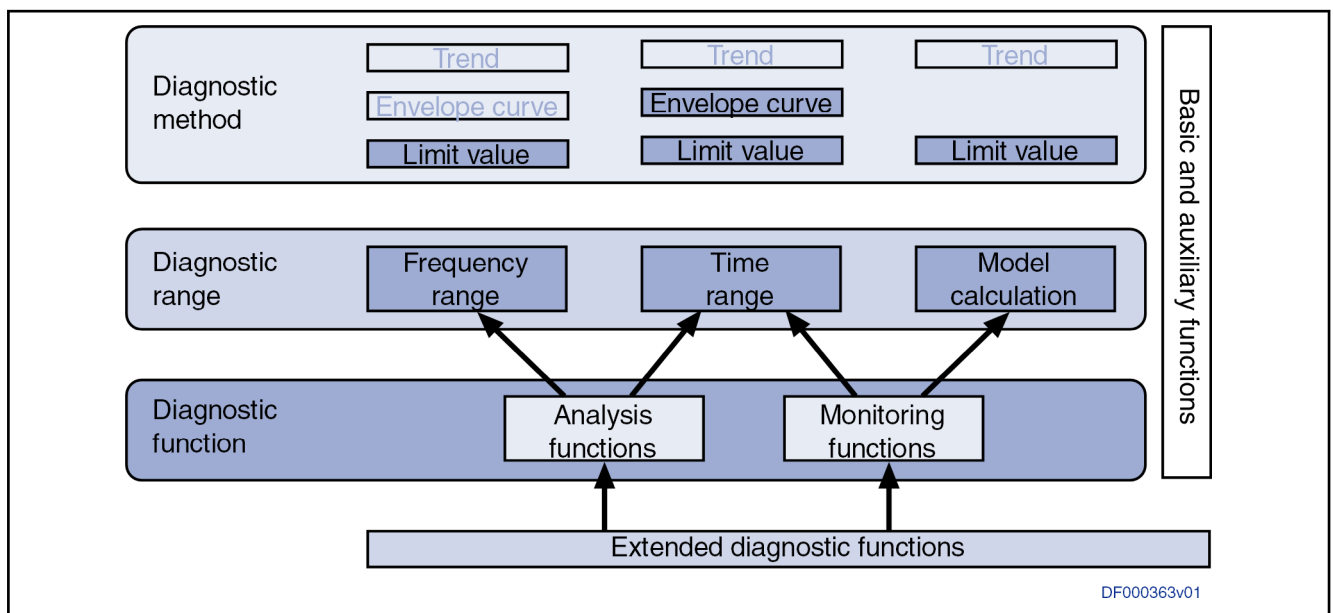


Fig.2-3: Overview – Extended Diagnostic Functions

### Diagnostic Function

We distinguish the following classes of functions:

- **Monitoring functions**

Extended diagnostic functions which run in the background during operation (in online form) and thereby allow permanent monitoring of the entire axis status (including the connected mechanical system). They might possibly suggest an extended system analysis which is to be carried out subsequently. For monitoring functions, the system makes available the required sensors. The sensor data are collected and adjusted (mathematical preprocessing, for example by means of filters). Monitoring functions normally only provide "good/bad information", but no information on the cause.

– There are different monitoring levels:

- Prewarning (E20xx), i.e. the drive continues running, but a warning is generated and signals that the drive will be shut-down with an error if operation continues.
- Error (F20xx), i.e. the drive is shutdown (cf. Functional Description of firmware "Best Possible Deceleration").

- **Maintenance schedule ("classic time-dependent maintenance")**

## Product Presentation "Productivity Agent"

Depending on the operating hours, different time intervals can be defined at which the drive generates a warning and thereby reminds you of due maintenance activities or the execution of an analysis.

- **Analysis**

The analysis functions include processes and methods which allow a more detailed diagnosis of the axis status. For the analysis, it is necessary to interrupt operation to start a separate test run in the offline method. Using extended analysis methods (e.g. frequency response measurement) it is possible to recognize more details regarding the system properties; in this way you can often even relate the error location to the cause of the error. To use an analysis function, all sensor data have to be collected. The correct interpretation of the data requires the installation operating company's general store of experience and exact knowledge of the installation (model calculation).

- **Prediction**

Prediction is a diagnostic function which allows forecasting errors. The prediction is based on exact system knowledge and empirical values available in the form of statistics or model calculations. By means of prediction, malfunction can be safely avoided.



Prediction is hard to realize in practical application and requires the machine operator's/machine manufacturer's cooperation, as empirical values are decisive for successful prediction.

---

## Diagnostic Range

The drive signals which are mostly available in the time range are internally adjusted so that there are the following possibilities for the actual interpretation:

- Time range
- Frequency range
- Model calculation



There are different aspects for each diagnostic range so that you have to consider carefully which diagnostic range is best suited for the corresponding diagnostic task.

---

## Diagnostic Method

We distinguish the following diagnostic methods:

- **Limit value** method

The measured values and characteristic values determined in the diagnostic range are checked as to whether they exceed several thresholds.

- **Envelope curve / tolerance band** method

A check is run as to whether the measured values and characteristic values determined in the corresponding diagnostic range leave a tolerance band related to a reference curve.

- **Trend** method

The measured values and characteristic values determined in the diagnostic range are checked with regard to their development during the time.

## 2.6 Implementing the Function in the Drive

### 2.6.1 Providing the Technology Functions

The technology functions are implemented in the drive by means of the drive-integrated PLC (IndraMotion MLD); collection and adjustment of the measured data take place in the drive.

Technology functions are made available as a compiled PLC project (\*.par files) which provides the technology functions like firmware functions. Using the technology functions made available as a compiled PLC project does not require any programming knowledge.



We are **planning** to make technology functions available as **individual technology function blocks**. The technology function blocks will be released in the form of a technology library and it will be possible to integrate them in existing customer projects. This requires programming knowledge, as the functions will be used on the function block level.

### 2.6.2 Integration in the Diagnostic System

The extended diagnoses of the technology functions are automatically integrated in the standard diagnostic system of the drive. They can be used in a way identical to the standard diagnoses:

- Access via the master communication interface and the serial interface.
- The diagnostic message appears on the control panel display at the drive.
- The existing mechanisms, such as operating hours counter and error memory of the drive, are used.



Additional information is output via individual status words of the corresponding technology function of the "Productivity Agent".

### 2.6.3 Parameterization and Operation

The function is parameterized and operated preferably via commissioning dialogs so that you do not need any programming knowledge or additional software to use the functions.

It is also possible to operate the entire function directly via the individual standard parameters (PLC registers). There are the following options to do this:

- With the IndraWorks commissioning software
- With a separate diagnosis PC via the serial interface or Ethernet (as of MP\*05VRS and CSH1.2)
- Via the higher-level control unit



The higher-level control unit can at any time take over control and, if required, start or terminate the extended analysis and monitoring functions in the drive. According to the type of function, command values are generated automatically via the integrated PLC function or by means of command value input by the external control unit (depending on the function of the "Productivity Agent" used).

## Product Presentation "Productivity Agent"

**Notes on How to Handle the Parameters of the Productivity Agent**

- The parameters, i.e. PLC registers, are partly used in a different way in the different technology functions.
- The function/significance of a PLC register depends on the technology function used.



All parameters/PLC registers allow data exchange of a higher-level control unit with the drive.

## 2.7 Type Codes and Overview of Functions

All existing technology functions in the form of PLC projects and PLC function blocks are only made available on the "Productivity Agent" CD; they cannot be ordered separately, but also have a type code for identification.

| Technology function                                      | Product | MPx03 |     | MPx04 |     | MPx05 |     | MPx07, MPx08 |     |     | MPx17 |     |
|----------------------------------------------------------|---------|-------|-----|-------|-----|-------|-----|--------------|-----|-----|-------|-----|
|                                                          |         | MPH   | MPB | MPH   | MPB | MPH   | MPB | MPH          | MPB | MPC | MPB   | MPC |
| <b>Mechanical Analysis</b><br>(Offline Analysis)         | Project | x     | x   | x     | x   | x     | x   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | -     | -   |
| <b>Envelope Curve Monitoring</b><br>(Online Monitoring)  | Project | x     | x   | x     | x   | x     | x   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | -     | -   |
| <b>Frequency Response Analysis</b><br>(Offline Analysis) | Project | -     | -   | x     | x   | x     | x   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | -     | -   |
| <b>Vibration Damping and Avoiding</b>                    | Project | -     | -   | -     | -   | x     | x   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | -     | -   |
| <b>Collision Monitoring</b><br>(Online Monitoring)       | Project | -     | -   | -     | -   | -     | -   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | -     | -   |
| <b>Analysis of Characteristic Curve S1</b>               | Project | -     | -   | -     | -   | x     | x   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | -            | -   | -   | x     | x   |
| <b>Process Controller</b>                                | Project | -     | -   | -     | -   | -     | -   | x            | x   | x   | x     | x   |
|                                                          | Library | -     | -   | -     | -   | -     | -   | x            | x   | x   | x     | x   |

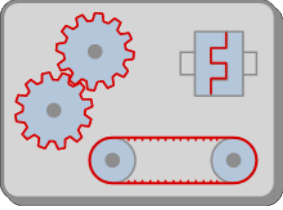
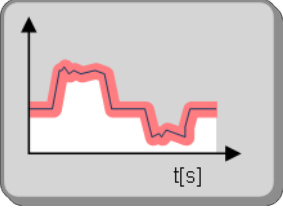
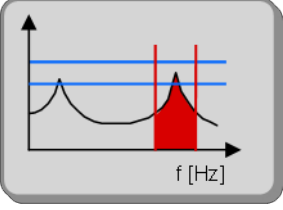
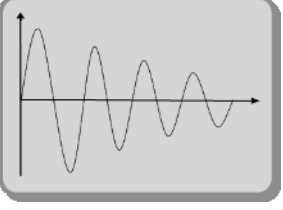
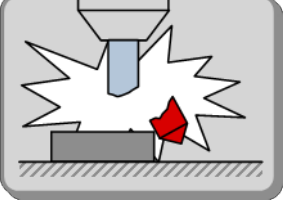
Fig. 2-4: Overview of Availability – Technology Functions

### Scope of Functions of "Productivity Agent" CD



The "Productivity Agent" CD contains the following functions:

Product Presentation "Productivity Agent"

|                                                                                     |                                                                                  | Version 1 of<br>"Productivity Agent" CD | Version 2 of<br>"Productivity Agent" CD |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
|    | Mechanical Analysis (offline analysis)<br>(FWS_MLDPAx_SAM_02Vxx_D0_MP0x)         | X                                       | X                                       |
|    | Envelope Curve Monitoring (online monitoring)<br>(FWS_MLDPAx_SCH_02Vxx_D0_MP0x)  | X                                       | X                                       |
|   | Frequency Response Analysis (offline analysis)<br>(FWS_MLDPAx_FAG_02Vxx_D0_MP0x) | X                                       | X                                       |
|  | Vibration Damping and Avoiding<br>(FWS_MLDPAx_VDA_01Vxx_D0_MP0x)                 | -                                       | X                                       |
|  | Collision Monitoring<br>(FWS_MLDTFx_SCM_01Vxx_D0_MP07)                           | -                                       | X                                       |

Product Presentation "Productivity Agent"

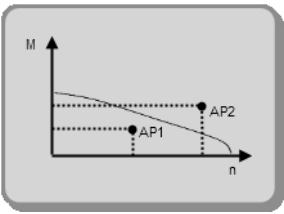
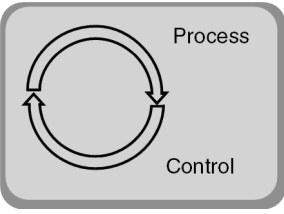
|                                                                                  |                                                                      | Version 1 of<br>"Productivity Agent" CD | Version 2 of<br>"Productivity Agent" CD |
|----------------------------------------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
|  | Analysis of Characteristic Curve S1<br>(FWS_MLDPAx_MCG_01V02_D0_MPx) | -                                       | X                                       |
|  | Process Controller<br>(FWS_MLDPCx_PRE_01Vxx_MPxx)                    | -                                       | X                                       |

Fig.2-5:      Scope of Functions of "Productivity Agent" CD (Type Code: SWA-IM\*MLD-LDI-01VRS-D0-CD650-COPY)

## 3 Safety Instructions for Electric Drives and Controls

### 3.1 Definitions of Terms

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Application Documentation</b> | 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.                                  |
| <b>Component</b>                 | 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 drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.                                                                                                                                                                                                                              |
| <b>Control System</b>            | A control system comprises several interconnected control components placed on the market as a single functional unit.                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Device</b>                    | A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Electrical Equipment</b>      | 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.                                                                                                                                                                                                                        |
| <b>Electric Drive System</b>     | 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 corresponding lines and cables.                                                                                                                                                                                                |
| <b>Installation</b>              | 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.                                                                                                                                                                                                                                                                                                        |
| <b>Machine</b>                   | 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, 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. |
| <b>Manufacturer</b>              | The manufacturer is an individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's 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.                                                     |
| <b>Product</b>                   | Examples of a product: Device, component, part, system, software, firmware, among other things.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Project Planning Manual</b>   | A project planning manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Qualified Persons</b>         | In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the hazards this implies, and who possess the qualifications their work                                                                                                                                                                                                 |

## Safety Instructions for Electric Drives and Controls

requires. To comply with these qualifications, it is necessary, among other things,

- 1) to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them
- 2) to be trained or instructed to maintain and use adequate safety equipment
- 3) to attend a course of instruction in first aid

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

## 3.2 General Information

### 3.2.1 Using the Safety Instructions and Passing Them on to Others

Do not attempt to install and operate the components of the electric drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible 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 follow 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.**

### 3.2.2 Requirements for Safe Use

Read the following instructions before initial commissioning of the components of the electric drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language 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 persons may work with components of the electric drive and control system or within its proximity.
- Only use accessories and spare parts approved by Rexroth.
- Follow the safety regulations and requirements of the country in which the components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technolo-

## Safety Instructions for Electric Drives and Controls

gy". If this is not the case, they are excluded. Functional safety is a 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 examples of applications 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 their 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 are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.

- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

*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 working 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 property damage by unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!

## Safety Instructions for Electric Drives and Controls

- 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!

### 3.3 Instructions with Regard to Specific Dangers

#### 3.3.1 Protection Against Contact With Electrical Parts and Housings



This section concerns components of the electric drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and 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 persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching 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 from reconnection.
- With electric components, observe the following aspects:  
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 the 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 has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).

## Safety Instructions for Electric Drives and Controls

- Secure built-in devices from penetrating foreign objects and water, as well as from 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 at all times. 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<sup>2</sup> (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

| Cross section outer conductor | Minimum cross section equipment grounding conductor |                                  |
|-------------------------------|-----------------------------------------------------|----------------------------------|
|                               | Leakage current $\geq 3.5$ mA                       |                                  |
|                               | 1 equipment grounding conductor                     | 2 equipment grounding conductors |
| 1,5 mm <sup>2</sup> (AWG 16)  | 10 mm <sup>2</sup> (AWG 8)                          | 2 × 1,5 mm <sup>2</sup> (AWG 16) |
| 2,5 mm <sup>2</sup> (AWG 14)  |                                                     | 2 × 2,5 mm <sup>2</sup> (AWG 14) |
| 4 mm <sup>2</sup> (AWG 12)    |                                                     | 2 × 4 mm <sup>2</sup> (AWG 12)   |
| 6 mm <sup>2</sup> (AWG 10)    |                                                     | 2 × 6 mm <sup>2</sup> (AWG 10)   |
| 10 mm <sup>2</sup> (AWG 8)    |                                                     | -                                |
| 16 mm <sup>2</sup> (AWG 6)    | 16 mm <sup>2</sup> (AWG 6)                          | -                                |
| 25 mm <sup>2</sup> (AWG 4)    |                                                     | -                                |
| 35 mm <sup>2</sup> (AWG 2)    |                                                     | -                                |
| 50 mm <sup>2</sup> (AWG 1/0)  | 25 mm <sup>2</sup> (AWG 4)                          | -                                |
| 70 mm <sup>2</sup> (AWG 2/0)  | 35 mm <sup>2</sup> (AWG 2)                          | -                                |
| ...                           | ...                                                 | ...                              |

Fig.3-1: Minimum Cross Section of the Equipment Grounding 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.

On components of an electric drive and control system provided by Rexroth, all connections and terminals with voltages between 5 and 50 volts 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.

## Safety Instructions for Electric Drives and Controls

**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 volts (e.g., the mains connection) are connected to Rexroth products, 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 faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after 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. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

**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 installed.

As a result of 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.

**To avoid accidents, injury and/or property damage:**

- Keep free and clear of 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 coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equip-

## Safety Instructions for Electric Drives and Controls

ment works. Do not operate the machine if the emergency stopping switch is not working.

- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterbalancing of the vertical axes.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety!**
- Disconnect electrical power to the components of the electric drive and control system using the master switch and secure them from reconnection ("lock out") for:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near 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. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

### 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 represent a serious danger to persons with heart pacemakers, metal implants and hearing aids.

**Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric components!**

- Persons with heart 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 heart pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of implanted heart pacemakers differs so greatly that no general rules can be given.
- Those with metal implants or metal pieces, as well as with hearing aids, must consult a doctor before they enter the areas described above.

## Safety Instructions for Electric Drives and Controls

### 3.3.5 Protection Against Contact With Hot Parts

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

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to 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 for a sufficient period of time. Cooling down can require **up to 140 minutes!** The time required for cooling down is approximately five times the thermal time constant specified in the technical data.
- After switching chokes, supply units and drive controllers off, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, and in accordance with the respective safety regulations, the manufacturer of the machine or installation must take measures to avoid injuries caused by burns in the final application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings 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 appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

### 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.

## Safety Instructions for Electric Drives and Controls

- 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 dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

### 3.3.8 Protection Against Pressurized Systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics 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 explosion).
- Observe the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to the risk of falling!



Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment 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.



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

## Safety Instructions for Electric Drives and Controls

** 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 Important Directions for Use

### 4.1 Appropriate Use

#### 4.1.1 Introduction

Rexroth products represent state-of-the-art developments and manufacturing. 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 the industrial environment 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 damages 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 carries all responsibility of the risks.

Before using Rexroth products, make sure that all the pre-requisites for an appropriate use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with 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.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

#### 4.1.2 Areas of Use and Application

Drive controllers made by Rexroth are designed to control electrical motors and monitor their operation.

Control and monitoring of the Drive controllers may require 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 Descriptions.

Drive controllers have to be programmed before commissioning, making it possible for the motor to execute the specific functions of an application.

Drive controllers of the IndraDrive series have been developed for use in single- and multi-axis drive and control tasks.

## Important Directions for Use

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

Typical applications include, for example:

- Handling and mounting systems,
- Packaging and food machines,
- 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 as described (temperature, degree of protection, humidity, EMC, etc.).

## 4.2 Inappropriate Use

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

Drive controllers must not be used, if ...

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

### DANGER

The functions of the "Productivity Agent" help the user with machine diagnosis. Faulty diagnoses can result from incorrect commissioning (faulty configuration of a function of the "Productivity Agent"), utilization, further processing of the data, critical machine properties and failures.

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

Safety-relevant functions/elements mustn't be exclusively diagnosed with the Productivity Agent; this means that when using functions of the "Productivity Agent" for safety-relevant functions/elements, you must take additional measures for personal protection.

Bosch Rexroth excludes liability for failures resulting from the use of the functions of the "Productivity Agent".

## 5 Enabling Functional Packages

As the functions of the "Productivity Agent" have been realized on the basis of the integrated PLC (IndraMotion MLD), the optional functional package "ML" or "TF" (depending on the drive firmware) is required in addition to the drive firmware:



In IndraWorks, functional packages can be conveniently enabled via the submenu "Enabling of Functional Packages"; the submenu "Enabling of Functional Packages" is contained in the menu bearing the device name (example in figure below). Basically, functional packages can also be enabled by writing the parameter "P-0-2003, Selection of functional packages".

**Please observe that functional packages can only be enabled, when they have been licensed (see also Functional Description of firmware "Enabling of Functional Packages")! If you use a non-licensed function, any guarantee on the part of Bosch Rexroth will expire!**

## Enabling Functional Packages

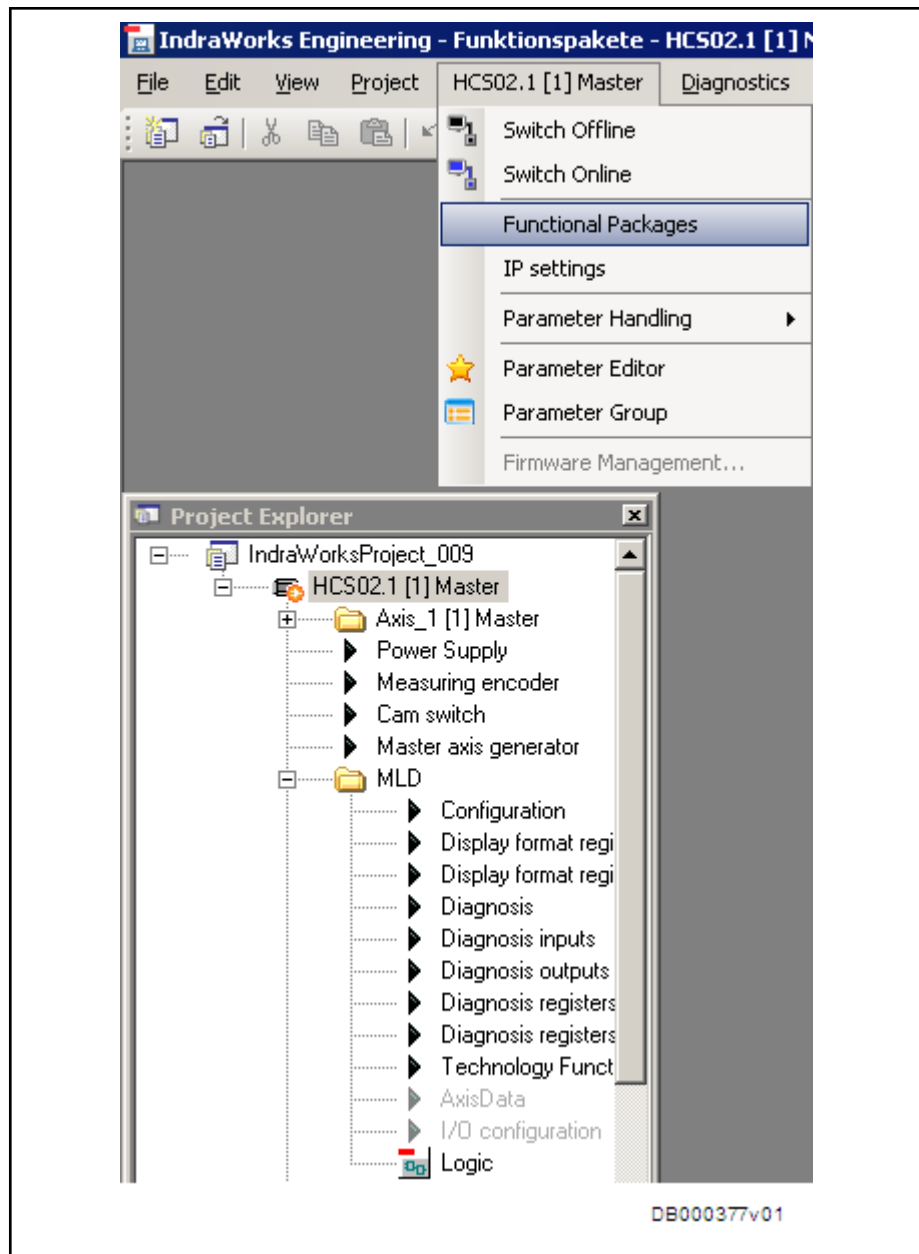


Fig.5-1: Enabling of Functional Packages

## 6 How to Load Technology Functions to the Drive

Carry out the following steps once and one after the other to transmit the desired technology function of the "Productivity Agent" to the drive (in the form of a parameter file):

1. Switch drive to parameter mode (start command C0400).
2. Open "Technology Functions" dialog.

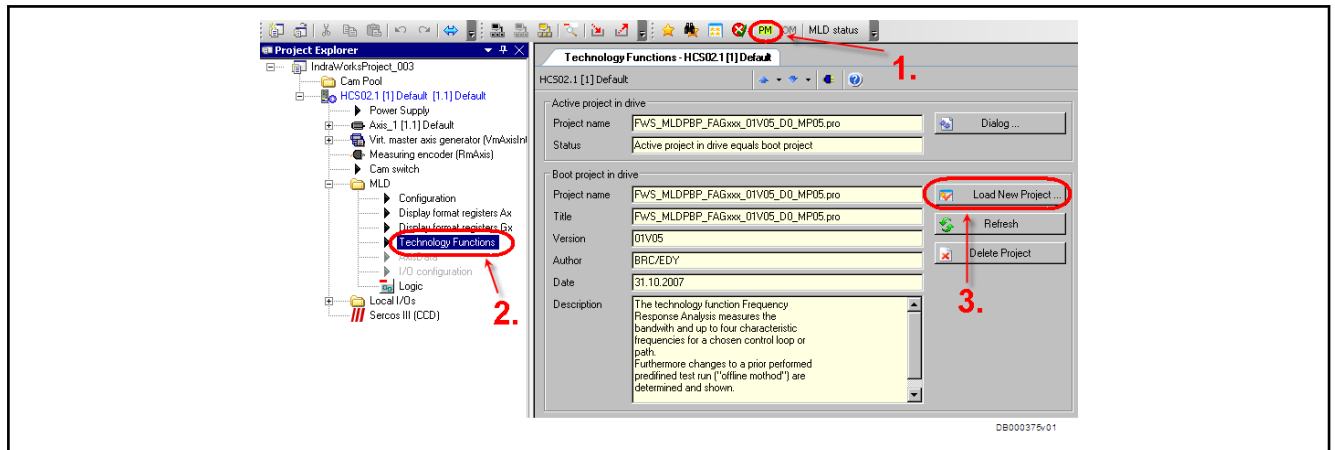


Fig. 6-1: Transmitting a Technology Function of the "Productivity Agent" to the Drive

3. Via "Load New Project ..." button, select desired technology function of "Productivity Agent" (parameter file from hard disk/CD to be loaded) and transmit it to drive.

Parameter values are transmitted to drive.

4. Switch drive off and on again.

Transmitted technology function is running and available as from now (even if drive is switched off again).

5. Via "Dialog ..." button, a function-specific user interface can be opened according to technology function which was loaded.

## How to Load Technology Functions to the Drive

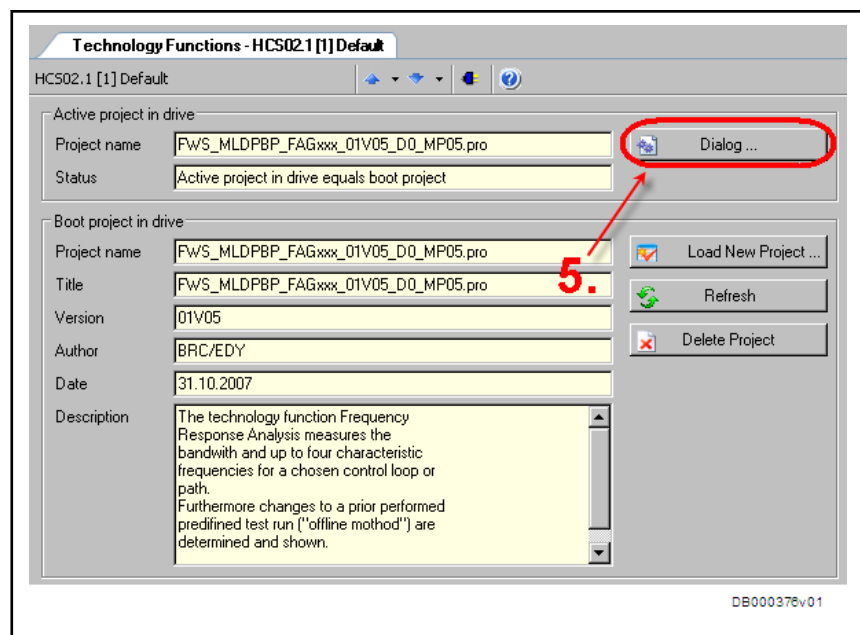


Fig.6-2: Opening Function-Specific User Interface



The extended technology functions are made available on the so-called "Diagnosis CD". For information on availability and pricing, contact our sales representative.

## 7 Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

### 7.1 Brief Description

**Fields of Application** The mechanical analysis can be used to check the mechanical drive system for mechanical changes. For this purpose, a predefined test run is executed in which the following properties are analyzed:

- Friction conditions of the entire axis
- Total backlash in the mechanical system
- Total stiffness of the axis

The figure below illustrates the functional principle of the mechanical analysis:

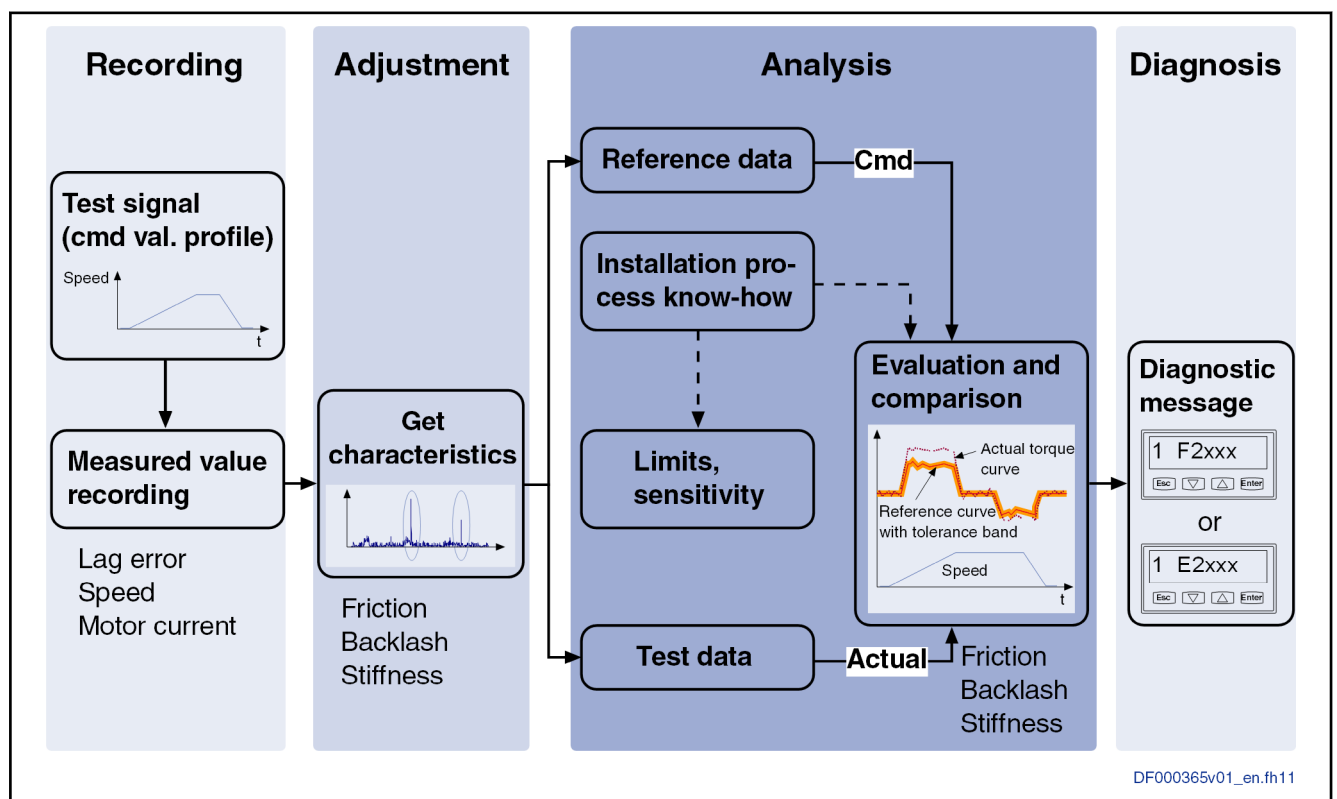


Fig.7-1: Functional Principle of the Mechanical Analysis

#### Functional Features

The function has the following features:

- No additional sensors are required (available drive sensors are used).
- The function allows checking the following mechanical properties:
  - Friction conditions
  - Backlash of mechanical system
  - Stiffness of axis
- Parameterization and operation of the function take place via an IndraWorks dialog or by means of individual parameters (optionally via a PDA [Personal Digital Assistant]), HMI, etc.
- Freely parameterizable travel range, velocity and acceleration to allow adjustment to the mechanical requirements.

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

- The function is divided into 2 steps:
  - Step 1: Execution of a reference measurement in running operation during which the "actual" or "good" state of the mechanical drive system is determined.
  - Step 2: Execution of a test measurement later on in operation in order to compare, at any time, the state of the mechanical drive system to the state at the time of reference measurement.
- Freely definable thresholds and sensitivity for monitoring.
- Reloading/change of reference data for tool change, for example.
- Parameterizable reaction (error, warning) when a difference between reference and test states is detected.

**Requirements of Use**

To use the extended diagnostic functions, the software, firmware and hardware requirements must have been fulfilled (see "Required Components").

To use the signal-based mechanical analysis, the PLC project "FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x" must in addition have been loaded and activated in the drive (see "How to Load Technology Functions to the Drive").

**Limitations of the Function**

The analysis function is subject to the following limitations:

- The function is limited to the monitoring of a mechanical drive system when there is no machining process taking place; process diagnosis is therefore impossible.
- Between reference and test measurement, parameters influencing the control behavior or scaling of the drive mustn't be changed, because otherwise there will be faulty diagnoses.
- During the reference and test measurements, the ambient conditions (e.g. temperature) should possibly be the same to obtain the best possible diagnosis result.
- The mechanical analysis is a so-called "offline method"; i.e. it cannot run in the background in running operation. It is necessary to start a test run during which you mustn't use any other drive function.
- It is impossible to diagnose decrease in friction and backlash/stiffness in comparison to the reference data.
- The mechanical analysis is not suited to diagnose vertical axes.
- During the reference and test motions, the axis must be able to move both in positive and in negative direction.
- S-0-0092 mustn't have been cyclically configured (MDT or analog input).

**Pertinent Parameters**

The following parameters are used in conjunction with the extended diagnostic function "mechanical analysis". (The parameter names correspond to the respective significances for the diagnostic functions and not to the actual parameter names which are displayed, for example, in IndraWorks.)

- P-0-1370, PA: Configuration
- P-0-1371, PA: Measuring progress
- P-0-1372, PA: Allowed backlash/stiffness deviation
- P-0-1373, PA: Characteristic value deviation of backlash/stiffness
- P-0-1374, PA: Backlash/stiffness sensitivity
- P-0-1375, PA: Allowed friction deviation
- P-0-1376, PA: Characteristic value deviation of friction
- P-0-1377, PA: Friction sensitivity

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

- P-0-1378, PA: Measuring range - lower limit
- P-0-1379, PA: Measuring range - upper limit
- P-0-1380, PA: Test profile - max. velocity
- P-0-1381, PA: Test profile - max. acceleration
- P-0-1382, PA: Test profile - velocity factor
- P-0-1383, PA: Test profile - acceleration factor
- P-0-1384, PA: Operating hours - reference measurement
- P-0-1385, PA: Operating hours - test measurement
- P-0-1387, PA: Status text
- P-0-1389, PA: Reference data
- P-0-1390, PA: Control word
- P-0-1410, PA: Status word

### Pertinent Diagnostic Messages

In the case of error, the drive generates, amongst others, the warning (E2011) or the error (F2011) (see also "Diagnostic and Status Messages").

## 7.2 Functional Description

The mechanical analysis allows detecting changes in the mechanical properties backlash, friction and stiffness by means of the system behavior.

In the first step, the "actual" or "good" state of the mechanical drive system is recorded and stored; this ideally takes place after successful commissioning, optimization and when the mechanical drive system has run in/warmed up.



The operating company of the machine or the machine manufacturer has to assess the mechanical drive system as "good", this assessment is not a functionality of the "Productivity Agent".

In the second step, the test measurement is executed later on, if required, in order to compare, at any time, the state of the mechanical drive system to the state at the time of reference measurement.



For the reference and test measurements, command values for acceleration and velocity stored internally in the drive are used. The parameterizable travel range defines the range of the mechanical system that is checked.

Depending on freely definable thresholds and sensitivity (evaluation criteria) for friction and backlash/stiffness monitoring, a diagnostic warning or error message is output when the threshold is exceeded.



The thresholds are given in percent related to the measured values when executing the reference measurement.

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

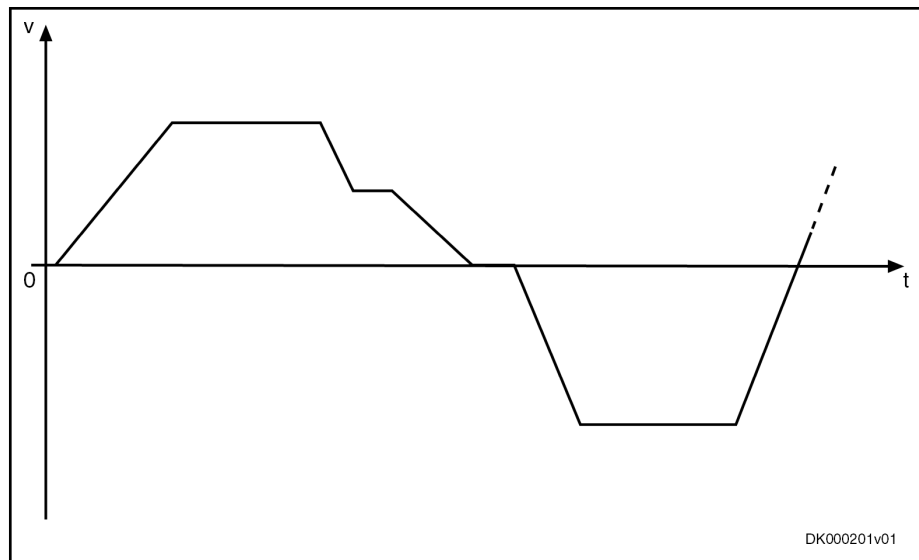


Fig. 7-2: Travel Profile of the Mechanical Analysis

The sequence of motion of a reference or test measurement is according to the following scheme:

1. At the start of the measurement (reference or test measurement), the drive moves from its actual position (initial position) to the measuring range, i.e. to the upper limit of the measuring range (P-0-1379).
2. The drive moves six times between the upper and the lower measuring range limit (travel range) and carries out its measuring motion.
3. After the measurement has been completed, the drive moves back to its initial position.



The initial position can be outside of the measuring range.

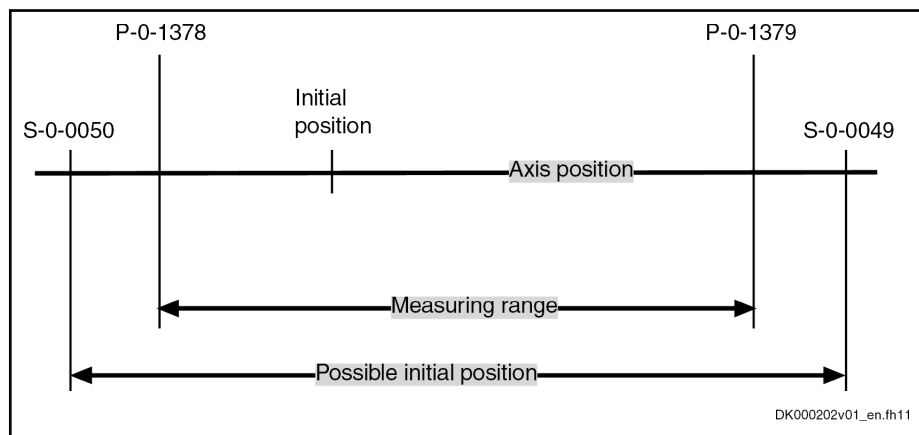


Fig. 7-3: Travel Range (Measuring Range)

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

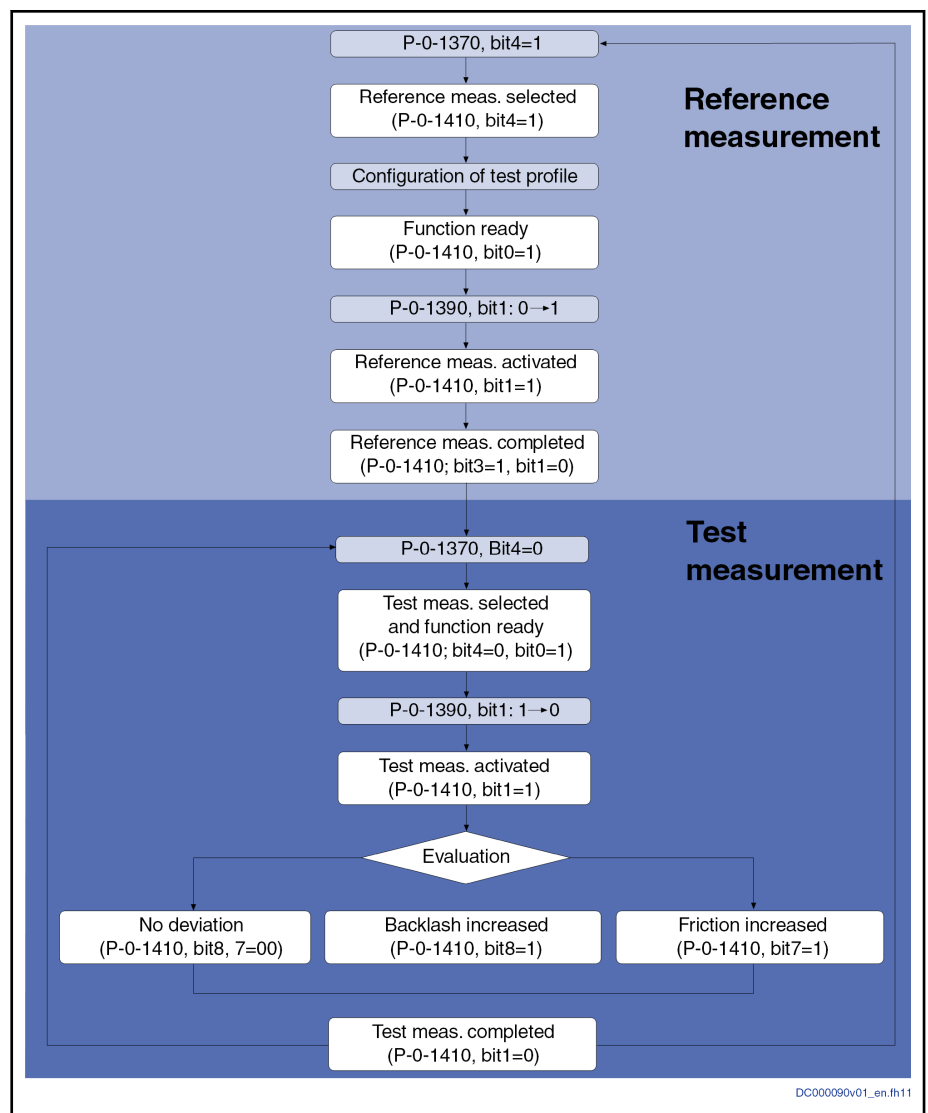


Fig. 7-4: States and Transitions for the Mechanical Analysis

## 7.3 Notes on Commissioning and Operation

### 7.3.1 General Information on Commissioning

- Initial Situation** The successful commissioning of the extended diagnostic function "mechanical analysis" requires the following initial situation:
- The drive has been commissioned, i.e. it is operable.
  - The communication between control unit and drive exists.
  - The installation has run in and all operation parameters have reached their stationary state.
  - The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
  - The PLC project "FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x" has been loaded and activated (see "How to Load Technology Functions to the Drive").

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

- During the reference and test measurements, the ambient conditions (e.g. temperature) should possibly be the same to obtain the best possible diagnostic result.

**Functional Steps** The actual operation of the function can be divided into the following steps:

- **Initialization (configuration) of the function**

Define tolerance window for characteristic values (friction, stiffness and backlash) and sensitivity, set travel range. Store reference data, if available.

- **Running operation (control) of the function**

Start or abort a reference or test measurement and evaluate analysis results or states.

Load reference data, if available.

**Parameter Interface to Configure and Operate the Function**

Apart from a cyclically configurable control and status word, there are other parameters available to configure and operate the function; these parameters can be accessed via the acyclic channel.

The following paragraphs explain the significance and function of the parameters and PLC registers used for configuration and operation.



All parameters and PLC registers allow data exchange of a higher-level control unit with the drive.

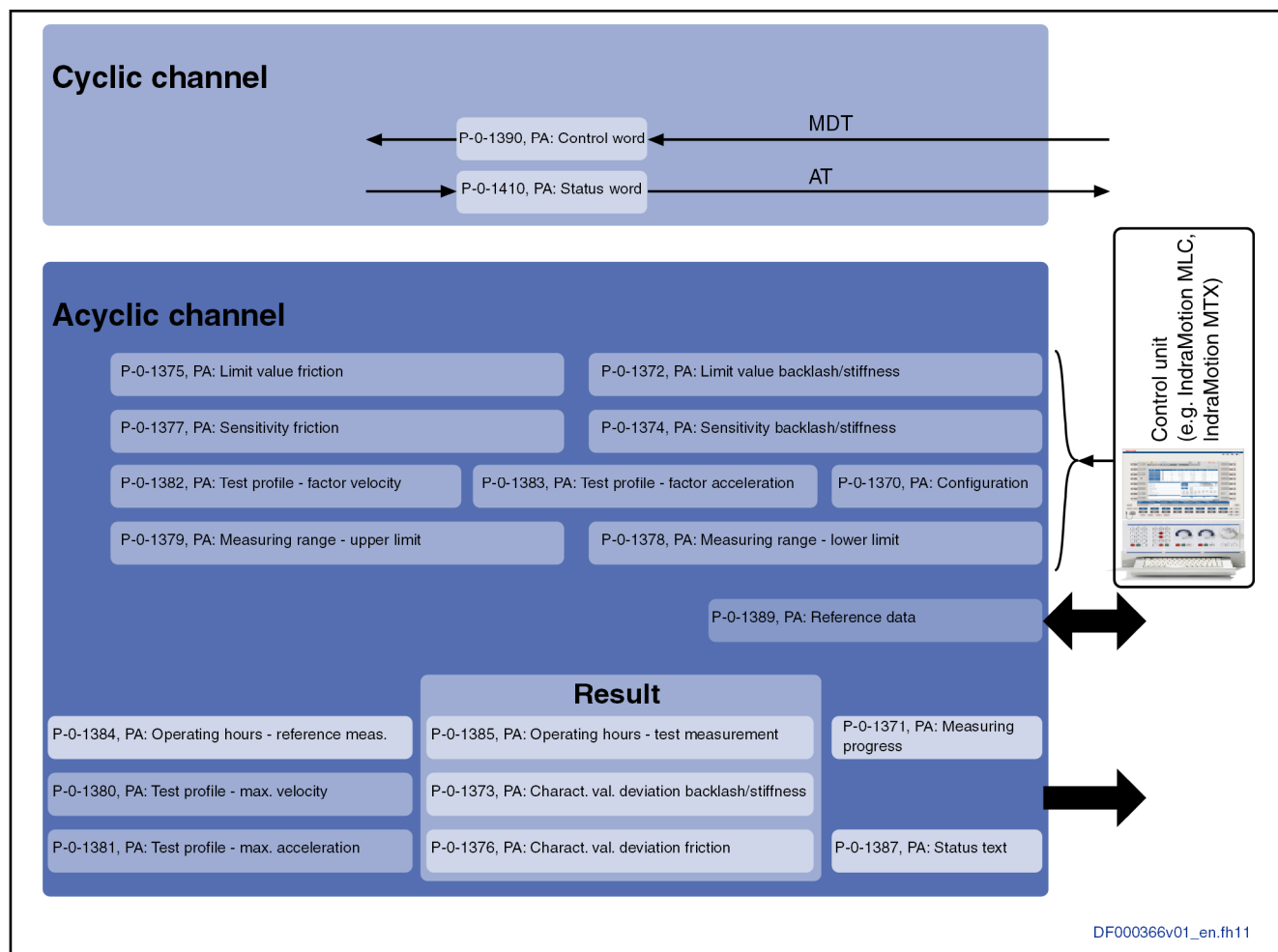


Fig. 7-5: Overview of Parameters for the Mechanical Analysis

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

### Status Display and Operation of the Function

The following information is available on the current state of the axis and the analysis function:

- Status information over the entire drive system (e.g. S-0-0390)
- Counts of operating hours counters (P-0-0191, P-0-1384, P-0-1385)
- Characteristic value deviation of test measurement from reference measurement (cf. P-0-1373, P-0-1376)
- Display of the name of the technology function (cf. P-0-1361)
- Status of the mechanical analysis in P-0-1410
- Display of the measuring progress in P-0-1371
- Display of the status text and diagnostic message text (cf. P-0-1387)

### Required Individual Steps

The commissioning of the extended diagnostic function "mechanical analysis" consists of the following steps:

1. Set the allowed travel range and travel profile.
2. Start the reference curve recording or load already recorded and previously stored reference data.
3. Set the thresholds for friction, stiffness and backlash.
4. Set the sensitivity.
5. Select the type of diagnosis.
6. Start or activate the cyclic test measurement.
7. Display and evaluate the results.



After successful reference curve recording, it is only necessary to make test measurements and evaluate the results (→ steps 6 and 7).

## 7.3.2 Configuration and Operation via Parameters

### Commissioning Step 1: Setting the Allowed Travel Range and Travel Profile

The positioning data used for the measurements (P-0-1380, and P-0-1381) are defined internally depending on the mechanical axis system and the scaling which was set. Via the acceleration and velocity factors (P-0-1382, P-0-1383), the motion profile can be adjusted to the requirements.

The travel range (measuring range) can be freely parameterized by the user:

- P-0-1378
- P-0-1379

The measuring motion set for reference measurement is valid for the following test measurements, too. When the positioning data are changed, this automatically requires carrying out a reference measurement again or loading the corresponding reference data.

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)



When the measuring range limits are determined, the position limit values (S-0-0049, S-0-0050) and the maximum travel range (S-0-0278) must be taken into account with position limit value monitoring (S-0-0055) activated. The standstill window (S-0-0124) and the position window (S-0-0057) are used for the measuring motion. According to the setting, the measuring range limits which have been set might thereby not be reached (in the case of high values in S-0-0124, S-0-0057).

For the diagnosis (also friction), only a certain part of the measuring motion is taken into account so that it is not advantageous to select an unnecessarily big measuring range. More data are not used for diagnosis. The measuring motion thus does not take more than approx. 2 s or 180°/20mm (with velocity and acceleration factor = 1).

A minimum travel range depending on the scaling has to be complied with:

- Linear scaling: (P-0-1379 minus P-0-1378) > 0.5 inch or 10 mm
- Rotary scaling: (P-0-1379 minus P-0-1378) > 10 degrees

### Commissioning Step 2: Starting, Saving and Loading the Reference Curve Recording

The reference measurement is executed in the following steps:

1. Set the bit4 in P-0-1370.



The drive is ready for measurement, when this is signaled in P-0-1410 (bit0="1"). If bit0="0", the drive is not ready. The reason of it is given in P-0-1410 with the bits 12 to 15 and the status text (P-0-1387) or via the standard diagnostic message (S-0-0390) of the drive.

In addition, the following setting must apply in P-0-0115: bit15="1" and bit14="1". The measuring system must have been homed (S-0-0403, bit0="1").

- 2.

#### **WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the reference measurement with a positive edge of bit1 in P-0-1390. While the measurement is running, bit0 is "0" and bit1 is "1" in

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

P-0-1410 (not ready to start a measurement, a measurement is running just now).

The progress of the reference measurement is displayed in P-0-1371.



A running measurement can be aborted.

The running measurement is aborted by a positive edge of bit2 in P-0-1390. Afterwards, the bits 1,0 in P-0-1410 go from "10" to "00".

Via bit8 in P-0-1370 you can select whether a return motion is to be carried out when the measurement is aborted or whether the drive is to stop immediately. Return motion means that the drive moves back to its initial position.

After a test or reference measurement has been aborted, the mechanical analysis has the same state (operating hours counter, status register) as before the start of the corresponding measurement.

**If several reference data are to be used** (e.g. for work with different tools), the following elements from P-0-1389 must be saved/exported directly after the corresponding reference measurement:

- Element0, "Operating hours reference" so that later on the time (operating hours) corresponding to the reference is displayed in P-0-1384.
- Element1, "Reference value backlash/stiffness"
- Element2, "Reference value friction"
- Element3, "Lower measuring range limit"
- Element4, "Upper measuring range limit"
- Element5, "Velocity factor"
- Element6, "Acceleration factor"
- Element7, "Checksum"

For any later test measurement, the checksum ensures that the current settings of the test measurement (measuring range, measuring velocity, ...) comply with the settings of the corresponding reference measurement.

- Element8, "Control loop setting"
- Element9, "Evaluation limit"



- You absolutely have to make sure for the test measurement that the settings of measuring motion, filter and control loop comply with the ones of the corresponding reference measurement. Otherwise, faulty diagnoses can occur due to different settings.
- If the sensitivities and thresholds change with the reference values, these variables should also be exported and saved together with the reference data.

**If the reference data are to be loaded** without executing a new reference measurement (e.g., in the case of product change), the elements0 to 9 in P-0-1389 must be written accordingly before the next test measurement is started. The entered values are directly applied to the corre-

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

sponding individual parameters (P-0-1378, P-0-1379, P-0-1382, P-0-1383, P-0-1384). The lower and upper measuring range limits (P-0-1378, P-0-1379), as well as the velocity and acceleration factors (P-0-1382, P-0-1383) are automatically taken from P-0-1389.



A reference import can also take place during a test measurement which has already been started (and is running).

If, apart from the actual reference data from P-0-1389, other drive parameters have been modified (control loop settings, limitations, thresholds, etc.), they have to be adjusted, too.

By means of the checksum in P-0-1389, element7, a check is run as to whether the reference settings (cf. values in P-0-1389) comply with the current parameter setting. This avoids faulty diagnoses due to unsuitable settings/reference data. If the checksum is not to be verified, enter "1" in P-0-1389, element7.

Upon successful reference measurement ...

- ... the bit3 in P-0-1410 is set ("Reference available") and
- ... the bits0 and 1 in P-0-1410 go from "01" to "10".
- ... the operating hours count of the last reference measurement is displayed in P-0-1384.
- ...the reference data are saved and output in P-0-1389: Characteristic reference values, operating hours count (cf. P-0-1384), variables of the motion profile (cf. P-0-1378, P-0-1379, P-0-1382, P-0-1383), as well as the checksum and several data regarding the generation of the characteristic values.

### Commissioning Step 3: Setting the Thresholds for Friction, Stiffness and Backlash

With the thresholds for backlash/stiffness (P-0-1372) and friction (P-0-1375), you have to set as of which deviation from the corresponding reference value (P-0-1389) a mechanical change is detected after the successful test measurement.



Independent of the parameterized thresholds, the deviations from the reference measurements for backlash/stiffness (P-0-1373) and friction (P-0-1376) diagnosed at the last test measurement are indicated (averaged over the 6 measuring motions).

To set useful thresholds, several test measurements should be executed upon successful reference measurement. The thresholds should have maximum values so that faulty mechanical systems are not detected at first. By means of the detected deviations of the test measurements from the reference measurement displayed for backlash/stiffness (P-0-1373) and friction (P-0-1376), you can estimate how high the normal deviation is in the so-called "good" state and how the thresholds can be set.

### Commissioning Step 4: Setting the Sensitivity

Within one test measurement, the profile defined by the travel range which has been set is traveled six times in succession. The sensitivity for backlash/stiffness (P-0-1374) and the sensitivity for friction (P-0-1377) indicate at how many of the six test motions the thresholds set for backlash/stiffness (P-0-1372) and friction (P-0-1375) must be exceeded so that an error / a warning is output.

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

Commissioning Step 5: Selecting  
the Type of DiagnosisCommissioning Step 6: Test  
Measurement

If you want very small changes in the mechanical system to be diagnosed, it is recommended that you set the sensitivity to a very low value so that there won't be any faulty diagnosis prematurely generated due to measurement variations. If you want only big changes in the mechanical system to be detected, you can set the sensitivity value accordingly high in order to get the diagnostic message quickly when the change occurs.

When the sensitivity has been set to a high value, this means that it is sufficient, for example, if the corresponding threshold has already been exceeded during one of the six test motions, in order to output the corresponding change in the mechanical system in the status.

Via bit7 in P-0-1370, you can select whether a warning (E2011) or an error (F2011) is to be output at the drive, when an error in the mechanical system is detected during the test measurement. Independent thereof, the diagnostic message is always output in P-0-1370, bit7 (friction) and bit8 (backlash).

The test measurement is carried out in the following steps:



The test measurement is only possible, if a valid reference measurement has already been executed before or a reference measurement has been loaded to P-0-1389 (P-0-1410, bit3="1").

1. Select the "test measurement" in P-0-1370: Bit4 in P-0-1370 must be cleared.



The drive is ready for measurement, when this is signaled in P-0-1410 (bit1,0="01"). If both bits are "0", the drive is not ready for measurement. The reason of it is given in P-0-1410 with the bits 12 to 15, or via the status text (P-0-1387) and S-0-0390 (standard diagnostic message of the drive).

Other requirements so that the drive is ready for measurement:

- In P-0-0115, the bits15 and 14 must be "1".
- The measuring system must have been homed (S-0-0403, bit0="1").

2.

**⚠ WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

Start the test measurement with a positive edge of bit1 in P-0-1390.

While the measurement is running, bit0 is "0" and bit1 is "1" in P-0-1410 (not ready to start a measurement, a measurement is running just now). The progress of the test measurement is displayed in P-0-1371.



A running measurement can be aborted.

The running measurement is aborted by a positive edge of bit2 in P-0-1390. Afterwards, the bits 1,0 in P-0-1410 go from "10" to "00". After a test or reference measurement has been aborted, the mechanical analysis has the same state (operating hours counter, status register) as before the start of the corresponding measurement.

Via bit8 in P-0-1370 you can select whether a return motion is to be carried out when the measurement is aborted or whether the drive is to stop immediately. "Return motion" means that the drive moves back to its initial position.

After the test measurement has been completed, bit1 goes to "0" and bit0 goes to "1" in P-0-1410 (measurement not active, ready for new measurement).

#### Commissioning Step 7: Displaying and Evaluating the Results

Upon successful test measurement ...

- ... the bit6 in P-0-1410 ist set (test measurement available).
- ... the deviation in percent from the backlash or the stiffness of the reference state is displayed in P-0-1373.
- ... the deviation in percent from the friction reference state is displayed in P-0-1376.
- ... the operating hours count of the last test measurement is displayed in P-0-1385.
- ... the determined state of the mechanical drive system is displayed in the bits7 and 8 of P-0-1410.



The diagnostic status message depends on the parameterized evaluation criteria (thresholds: P-0-1372, P-0-1374; sensitivities: P-0-1375, P-0-1377).

### 7.3.3 Configuration and Operation by Means of IndraWorks

When the extended diagnostic function "mechanical analysis" has been loaded to the axis by means of IndraWorks (see "How to Load Technology Functions to the Drive"), the user interface can be opened in the technology functions window via the "Dialog ..." button.

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

Fig. 7-6: IndraWorks Dialog to Operate the Mechanical Analysis

### Commissioning Step 1: Setting the Allowed Travel Range and Travel Profile

1. On the user interface, activate the "Configuration" button.  
The IndraWorks dialog for configuring the mechanical analysis opens.

Fig. 7-7: IndraWorks Dialog to Configure the Mechanical Analysis

2. In the "Configuration of Mechanical Analysis" dialog, select "Reference measurement" in the "Measurement" section to get write access to the text fields of the "Measuring range" and "Test profile" sections.
3. In the text fields of the mentioned sections, enter values to define the allowed travel range and the travel profile.

### Commissioning Step 2: Starting, Saving and Loading the Reference Curve Recording

#### Requirements for starting the reference measurement:

1. In the "status of mechanical analysis", the drive must signal that is is ready to start a measurement: "measurement ready".

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

2. By ticking the check box "Position data reference exists", the correct status of the reference encoder for the measurement is acknowledged.
3. By ticking the check box "Drive with torque (AF)", the drive acknowledges the ready-for-operation state of the drive.
1. Close the configuration dialog.
- 2.

**⚠ WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the reference curve recording by activating the "Start Reference Measurement" button on the user interface.

The measuring progress is displayed in a separate dialog.

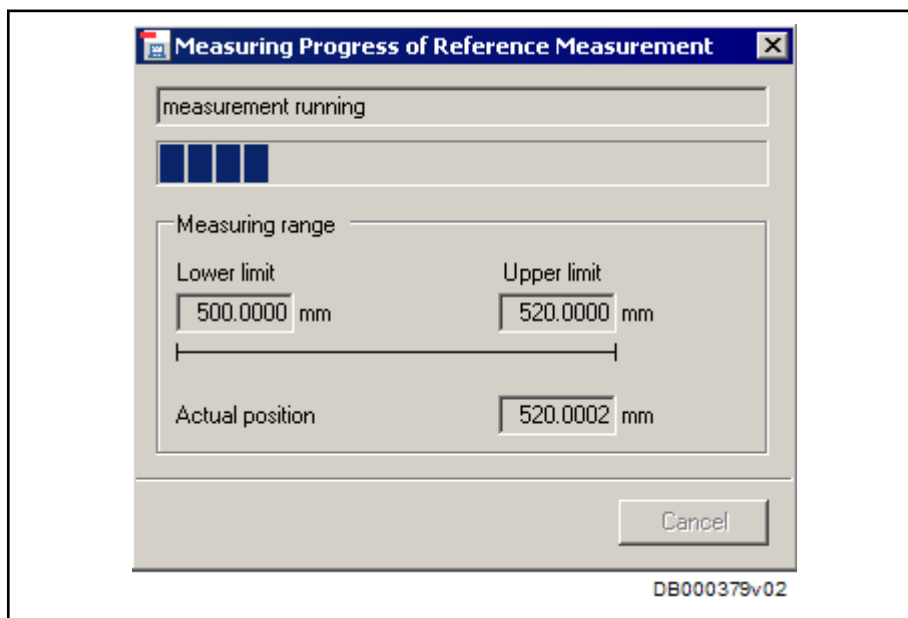


Fig. 7-8: IndraWorks Dialog to Operate the Mechanical Analysis; Measuring Progress of Reference Measurement

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)



**If several reference data are to be used** (e.g., for work with different tools), save the reference data after the corresponding reference measurement ["Configuration of Mechanical Analysis" dialog, "Save Reference Data" button (see 7-7)].

**If the reference data are to be loaded** without executing a new reference measurement (e.g. in the case of product change), activate the "Load Reference Data" button in the "Configuration of Mechanical Analysis" dialog (see 7-7).

### Commissioning Step 3: Setting the Thresholds for Friction, Stiffness and Backlash

In the "Configuration of Mechanical Analysis" dialog, "Allowed deviation" section, set the diagnosis thresholds for backlash/stiffness and friction, independently of each other. The values entered here define as of which determined deviation from the corresponding reference value a mechanical change is output after successful test measurement. The percentage value to be entered refers to the determined characteristic reference values.



Independent of the parameterized thresholds, the deviations from the reference measurements for backlash/stiffness and friction diagnosed at the last test measurement are indicated (averaged over the 6 measuring motions) in the operation dialog ("Characteristic value deviation" section).

To set useful thresholds, several test measurements should be executed upon successful reference measurement. The thresholds should have maximum values so that faulty mechanical systems are not detected at first. By means of the detected deviations of the test measurements from the reference measurement for backlash/stiffness displayed in the "Characteristic value deviation" section, you can estimate how high the normal deviation is in the so-called "good" state and how the thresholds can be set.

### Commissioning Step 4: Setting the Sensitivity

Within one test measurement, the profile defined by the travel range which has been set is traveled six times in succession.

Set the sensitivities for backlash/stiffness and friction by means of the sliders in the "Sensitivity" section. You thereby define at how many of the six test motions the thresholds for backlash/stiffness and friction which have been set must be exceeded so that an error / a warning is output.



If you want very small changes in the mechanical system to be diagnosed, it is recommended that you set the sensitivity to a very low value so that there won't be any faulty diagnosis prematurely generated due to measurement variations. If you want only big changes in the mechanical system to be detected, you can set the sensitivity value accordingly high in order to get the diagnostic message quickly when the change occurs.

When the sensitivity has been set to a high value, this means that it is sufficient, for example, if the corresponding threshold has already been exceeded during one of the six test motions, in order to output the corresponding change in the mechanical system in the status.

### Commissioning Step 5: Selecting the Type of Diagnosis

In the "Configuration of Mechanical Analysis" dialog, "Drive reaction" section, you can select whether a warning (E2011) or an error (F2011) is to be output at the drive, when an error in the mechanical system is detected during the test measurement. (Whether an error in the mechanical system is detected or not depends on the limits and sensitivities which have been set.)

## Mechanical Analysis (FWS\_MLDPaX\_SAM\_02Vxx\_D0\_MP0x)

If the drive is to immediately move to its initial position after the measurement was aborted, select "Return motion after abortion".

The mechanical diagnosis is output on the user interface, "Analysis result" section.

**Commissioning Step 6: Test Measurement**

*Requirements for starting the test measurement:*

- *In the "status of mechanical analysis", the drive must signal that it is ready to start a measurement: "measurement ready".*
- *By ticking the check box "Position data reference exists", the correct status of the reference encoder for the measurement is acknowledged.*
- *By ticking the check box "Drive with torque (AF)", the drive acknowledges the ready-for-operation state of the drive.*
- *A reference measurement must exist.*
- *In the "Configuration of Mechanical Analysis" dialog, "Measurement" section, select "Test measurement".*

1.

**⚠ WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the test measurement by activating the "Start Test Measurement" button on the user interface.

The measuring progress is displayed in a separate dialog.

**Commissioning Step 7: Displaying and Evaluating the Results**

Upon successful test measurement, the user interface ...

- ... in the "Characteristic value deviation" section displays the deviation in percent of the backlash or the stiffness related to the reference state and
- the deviation in percent from the friction reference state is displayed.
- ... in the "Operating hrs power section" section, "Last test measurement" field, displays the operating hours count at the last test measurement.
- ... in the "Analysis result" section displays the determined state of the mechanical drive system by means of the stop light symbols.

## 7.4 Diagnostic and Status Messages

The standard diagnostic message of the drive is used; in the case of error, the drive generates the warning (E2011) or the error (F2011) (according to the configuration in P-0-1370, bit7).

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

### Status Messages of the Technology Function

The diagnostic and status messages are also available as binary information in P-0-1410 and are displayed as text strings in P-0-1387.

The tables below show the assignment of the status or diagnostic text (cf. P-0-1387) to the content of P-0-1410 depending on the selected type of measurement, priority from top to bottom. The status or diagnostic text shows the last status or the last diagnostic message determined by the technology function.

| P-0-1410            | P-0-1387                          |
|---------------------|-----------------------------------|
| xxxx_0011_xxxx_xx00 | P-0-1378 > P-0-1379               |
| xxxx_0100_xxxx_xx00 | Measuring range too small         |
| xxxx_0010_xxxx_xx00 | P-0-1379 > S-0-0049 <sup>1)</sup> |
| xxxx_0011_xxxx_xx00 | P-0-1378 < S-0-0050 <sup>1)</sup> |
| xxxx_0000_xxxx_xx01 | Measurement ready                 |

1) Only with activated position limit value monitoring (S-0-0055)  
Fig. 7-9: Assignment Status Word or Status/Diagnostic Text for a Reference Measurement

| P-0-1410            | P-0-1387                                              |
|---------------------|-------------------------------------------------------|
| xxxx_xxxx_xxxx_xx00 | No reference measurement available                    |
| xxxx_0101_xxxx_xx00 | P-0-1372 outside of valid numeric range (0...100)     |
| xxxx_0110_xxxx_xx00 | P-0-1374 outside of valid numeric range (0...100)     |
| xxxx_0111_xxxx_xx00 | P-0-1375 outside of valid numeric range (0...100)     |
| xxxx_1000_xxxx_xx00 | P-0-1377 outside of valid numeric range (0...100)     |
| xxxx_0010_xxxx_xx00 | P-0-1379 > S-0-0049 <sup>1)</sup> at ref. measurement |
| xxxx_0011_xxxx_xx00 | P-0-1378 < S-0-0050 <sup>1)</sup> at ref. measurement |
| xxxx_0000_xxxx_xx01 | Measurement ready                                     |

1) Only with activated position limit value monitoring (S-0-0055)  
Fig. 7-10: Assignment Status Word or Status/Diagnostic Text for a Test Measurement

### Diagnostic Messages of the Technology Function

The diagnostic status messages of the monitoring function on the one hand are available as binary information (bit 7-8) in P-0-1410 and on the other hand are displayed as text strings in P-0-1387.



The diagnostic status messages are only valid, when a test measurement is available (bit6 in P-0-1410 has been set)!

According to the error reaction which has been set (cf. P-0-1370, bit7), the warning E2011 or the error F2011 is generated when a mechanical change has been detected in the mechanical drive system (depending on thresholds and sensitivities which have been set).

Mechanical Analysis (FWS\_MLDPa<sub>x</sub>\_SAM\_02Vxx\_D0\_MP0x)

An error always causes an error reaction and has to be cleared again. In the case of a warning, the drive can still be normally operated and the warning will persist until a repeated test run, during which no error is detected, or a repeated reference measurement is carried out!

The table below illustrates the assignment of diagnostic message, status word and status/diagnostic text, depending on the detected changes in the mechanical drive system.

| P-0-1410            | P-0-1387            | Diagnostics         | Cause                                               |
|---------------------|---------------------|---------------------|-----------------------------------------------------|
| xxxx_xxx0_0xxx_xxxx | No mechanical error | None                | No threshold exceeded                               |
| xxxx_xxx0_1xxx_xxxx | Mechanical error    | X2011 <sup>1)</sup> | Friction threshold exceeded                         |
| xxxx_xxx1_0xxx_xxxx | Mechanical error    | X2011 <sup>1)</sup> | Backlash/stiffness threshold exceeded               |
| xxxx_xxx1_1xxx_xxxx | Mechanical error    | X2011 <sup>1)</sup> | Friction and backlash/stiffness thresholds exceeded |

1) "X"=E (warning) or "X"=F (error), depending on type of diagnosis (P-0-1370, bit7)

Fig. 7-11: Overview of Diagnostic Messages

### ⚠ CAUTION

**Danger of faulty diagnoses by changes made between reference and test measurement!**

⇒ The conditions must be the same when executing the reference and test measurements!

## 7.5 Description of the Parameters of the Mechanical Analysis (FWS\_MLDPa<sub>x</sub>\_SAM\_02Vxx\_D0\_MP0x)

### 7.5.1 P-0-1370, PA: Configuration

The parameter P-0-1370 is used to configure (control) the mechanical analysis.

| Bit | Designation/function                                           | Comment                                           |
|-----|----------------------------------------------------------------|---------------------------------------------------|
| 0-3 | No function                                                    |                                                   |
| 4   | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement |                                                   |
| 5-6 | Reserved                                                       |                                                   |
| 7   | <b>Error reaction</b><br>0: Warning<br>1: Error                | Only effective when test measurement was selected |

Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

| Bit  | Designation/function                                                          | Comment |
|------|-------------------------------------------------------------------------------|---------|
| 8    | <b>Abortion behavior</b><br>0: With return motion<br>1: Without return motion |         |
| 9-31 | No function                                                                   |         |

Fig. 7-12: Parameter Structure

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | -/-            |
| Format                              | BIN            |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 7-13: Parameter Attributes

## 7.5.2 P-0-1371, PA: Measuring progress

The parameter P-0-1371 displays the measuring progress when the test or reference measurement has been started. The count is incremented (from 0, then 20, 40, 60, 80 to 100) to show how many of the six measuring motions of a reference or test measurement have taken place.

|                                     |                                      |
|-------------------------------------|--------------------------------------|
| Min./max. value                     | 0/100                                |
| Format                              | DEC_OV                               |
| Unit                                | %                                    |
| Type                                | Display register (cannot be changed) |
| Decimal places                      | None                                 |
| Buffered when control voltage fails | Yes                                  |

Fig. 7-14: Parameter Attributes

## 7.5.3 P-0-1372, PA: Allowed backlash/stiffness deviation

With the parameter P-0-1372, set the deviation in percent from the reference state as limit value for backlash/stiffness detection.

Example:

Determined characteristic values: Reference state =10, test state =12 ⇒ deviation in percent =20%

If the deviation in percent determined for the backlash/stiffness during a test measurement exceeds this value, an error or a warning is output (depending on the sensitivity set in P-0-1374).

|                 |                |
|-----------------|----------------|
| Min./max. value | 0/-            |
| Format          | DEC_OV         |
| Unit            | %              |
| Type            | Input register |

Mechanical Analysis (FWS\_MLDPa<sub>x</sub>\_SAM\_02Vxx\_D0\_MP0x)

|                                     |      |
|-------------------------------------|------|
| Decimal places                      | None |
| Buffered when control voltage fails | Yes  |

Fig.7-15: Parameter Attributes

**7.5.4 P-0-1373, PA: Characteristic value deviation of backlash/stiffness**

The parameter P-0-1373 displays the deviation in percent of the test measurement from the reference state for backlash/stiffness detection. (This is the averaged value over the six measuring motions of a test measurement.)

Example: Determined characteristic values: Reference state =10, test state =12  $\Rightarrow$  deviation in percent =20%

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | %               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | Yes             |

Fig.7-16: Parameter Attributes

**7.5.5 P-0-1374, PA: Backlash/stiffness sensitivity**

Via the parameter P-0-1374, set the sensitivity for backlash/stiffness detection.

Input is only possible in steps (0, 20, 40, 60, 80, 100).

Together with the threshold (P-0-1372), the sensitivity is decisive for the output of error or warning. The sensitivity sets how many of the six measuring motions of a test measurement must exceed the threshold for backlash/stiffness detection so that an error / a warning is output. The value 100 (0) means that one (six) of six measuring motions must exceed the threshold for backlash/stiffness detection so that an error / a warning is output.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/100          |
| Format                              | DEC_OV         |
| Unit                                | %              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig.7-17: Parameter Attributes

**7.5.6 P-0-1375, PA: Allowed friction deviation**

With the parameter P-0-1375, set the deviation in percent from the reference state as limit value for friction detection.

Example: Determined characteristic values: Reference state =10, test state =12  $\Rightarrow$  deviation in percent =20%

If the deviation in percent determined for the friction during a test measurement exceeds this value, an error or a warning is output (depending on the sensitivity set in P-0-1377).

Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_OV         |
| Unit                                | %              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 7-18: Parameter Attributes

## 7.5.7 P-0-1376, PA: Characteristic value deviation of friction

The parameter P-0-1376 displays the deviation in percent of the test measurement from the reference state for friction detection. (This is the averaged value over the six measuring motions of a test measurement.)

Example: Determined characteristic values: Reference state =10, test state =12  $\Rightarrow$  deviation in percent =20%

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | %               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | Yes             |

Fig. 7-19: Parameter Attributes

## 7.5.8 P-0-1377, PA: Friction sensitivity

Via the parameter P-0-1377, set the sensitivity for friction detection.

Input is only possible in steps (0, 20, 40, 60, 80, 100).

Together with the limit value (P-0-1375), the sensitivity is decisive for the output of error or warning. The sensitivity sets how many of the six measuring motions of a test measurement must exceed the limit value for friction detection so that an error / a warning is output. The value 100 (0) means that one (six) of six measuring motions must exceed the limit value for friction detection so that an error / a warning is output.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/100          |
| Format                              | DEC_OV         |
| Unit                                | %              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 7-20: Parameter Attributes

## 7.5.9 P-0-1378, PA: Measuring range - lower limit

With the parameter P-0-1378, set the lower measuring range limit. Together with the value entered in P-0-1379, the lower measuring range limit defines the measuring range for the test and reference measurement.

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

P-0-1378 and the measuring range are checked for validity and the corresponding status is output (see P-0-1410).

The measuring range must be at least 10 degrees, 10 mm or 0.5 inch (according to the scaling).

|                                     |                           |
|-------------------------------------|---------------------------|
| Min./max. value                     | -/-                       |
| Format                              | DEC_MV                    |
| Unit                                | Cf. S-0-0079              |
| Type                                | Input register            |
| Decimal places                      | Cf. S-0-0077 and S-0-0078 |
| Buffered when control voltage fails | Yes                       |

Fig. 7-21: Parameter Attributes

### 7.5.10 P-0-1379, PA: Measuring range - upper limit

With the parameter P-0-1379, set the upper measuring range limit. Together with the value entered in P-0-1378, the upper measuring range limit defines the measuring range for the test and reference measurement.

P-0-1379 and the measuring range are checked for validity and the corresponding status is output (see P-0-1410).

The measuring range must be at least 10 degrees, 10 mm or 0.5 inch (according to the scaling).

|                                     |                           |
|-------------------------------------|---------------------------|
| Min./max. value                     | -/-                       |
| Format                              | DEC_MV                    |
| Unit                                | Cf. S-0-0079              |
| Type                                | Input register            |
| Decimal places                      | Cf. S-0-0077 and S-0-0078 |
| Buffered when control voltage fails | Yes                       |

Fig. 7-22: Parameter Attributes

### 7.5.11 P-0-1380, PA: Test profile - max. velocity

The parameter P-0-1380 displays the maximum velocity which is input during the measurements when traveling. This value can be adjusted via the velocity factor from P-0-1382. Depending on the scaling and P-0-1382, the velocity is:  $P-0-1382 \cdot 0.05$  rev/s, 3 rpm, 1000 mm/min, 40 inch/min, 15 mm/s or 0.7 inch/s.

|                                     |                           |
|-------------------------------------|---------------------------|
| Min./max. value                     | -/-                       |
| Format                              | DEC_OV                    |
| Unit                                | Cf. S-0-0044              |
| Type                                | Display register          |
| Decimal places                      | Cf. S-0-0045 and S-0-0046 |
| Buffered when control voltage fails | Yes                       |

Fig. 7-23: Parameter Attributes

## 7.5.12 P-0-1381, PA: Test profile - max. acceleration

The parameter P-0-1381 displays the maximum acceleration which is input during the measurements when traveling. This value can be adjusted via the acceleration factor from P-0-1383. Depending on the scaling and P-0-1383, the acceleration is: P-0-1383\*800 inch/s<sup>2</sup>, 20000 mm/s<sup>2</sup> or 5000 rad/s<sup>2</sup>.

|                                     |                                      |
|-------------------------------------|--------------------------------------|
| Min./max. value                     | -/-                                  |
| Format                              | DEC_OV                               |
| Unit                                | Cf. S-0-0160                         |
| Type                                | Display register (cannot be changed) |
| Decimal places                      | Cf. S-0-0161 and S-0-0162            |
| Buffered when control voltage fails | Yes                                  |

Fig. 7-24: Parameter Attributes

## 7.5.13 P-0-1382, PA: Test profile - velocity factor

In parameter P-0-1382, you can set the factor which influences the preset velocity of the measuring profile (depending on the scaling 0.05 rev/s, 3 rpm, 1000 mm/min, 40 inch/min, 15 mm/s or 0.7 inch/s). The resulting velocity is displayed in P-0-1380.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0,001/-        |
| Format                              | DEC_OV         |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | 3              |
| Buffered when control voltage fails | Yes            |

Fig. 7-25: Parameter Attributes



If the value "0" has been entered, this is considered as default configuration and interpreted as factor "1"!

## 7.5.14 P-0-1383, PA: Test profile - acceleration factor

In parameter P-0-1383, you can set the factor which influences the preset acceleration of the measuring profile (depending on the scaling 800 inch/s<sup>2</sup>, 20000 mm/s<sup>2</sup> or 5000 rad/s<sup>2</sup>). The resulting acceleration is displayed in P-0-1381.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0,001/-        |
| Format                              | DEC_OV         |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | 3              |
| Buffered when control voltage fails | Yes            |

Fig. 7-26: Parameter Attributes



If the value "0" has been entered, this is considered as default configuration and interpreted as factor "1"!

### 7.5.15 P-0-1384, PA: Operating hours - reference measurement

The parameter P-0-1384 displays the count of the operating hours counter in the power section (cf. P-0-0191) at the last valid **reference measurement**. In the case of a reference download via P-0-1389, the corresponding value from element 0 is entered.

|                                     |                                      |
|-------------------------------------|--------------------------------------|
| Min./max. value                     | -/-                                  |
| Format                              | DEC_OV                               |
| Unit                                | Seconds                              |
| Type                                | Display register (cannot be changed) |
| Decimal places                      | 1                                    |
| Buffered when control voltage fails | Yes                                  |

Fig. 7-27: Parameter Attributes

### 7.5.16 P-0-1385, PA: Operating hours - test measurement

The parameter P-0-1385 displays the count of the operating hours counter in the power section (cf. P-0-0191) at the last **test measurement** that was carried out.

|                                     |                                      |
|-------------------------------------|--------------------------------------|
| Min./max. value                     | -/-                                  |
| Format                              | DEC_OV                               |
| Unit                                | Seconds                              |
| Type                                | Display register (cannot be changed) |
| Decimal places                      | 1                                    |
| Buffered when control voltage fails | Yes                                  |

Fig. 7-28: Parameter Attributes

### 7.5.17 P-0-1387, PA: Status text

The parameter P-0-1387 is used to output the extended status text / diagnostic message text.

|                                     |                                     |
|-------------------------------------|-------------------------------------|
| Min./max. value                     | -/-                                 |
| Format                              | ASCII                               |
| Unit                                | -                                   |
| Type                                | Output register (cannot be changed) |
| Decimal places                      | None                                |
| Buffered when control voltage fails | Yes                                 |

Fig. 7-29: Parameter Attributes

### 7.5.18 P-0-1389, PA: Reference data

The list parameter P-0-1389 is used to exchange the reference data. Upon successful reference measurement, the corresponding reference data are entered and thus can be read via P-0-1389 and stored. If the reference data are

## Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

to be changed, the corresponding data have to be entered in P-0-1389 before the test measurement starts.

| List element number | Designation/function               | Comment                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0                   | Operating hours counter            | The operating hours count is not used for the checksum generation during the reference measurement. By means of this value, the operating hours count corresponding to the reference measurement can be displayed in P-0-1384 even after the reference import, when several reference measurements are used (e.g., due to product change). After a reference measurement, this list element contains the same values as P-0-1384. |
| 1                   | Reference value backlash/stiffness | Displays the value of the characteristic value "backlash/stiffness" determined with the reference measurement. When loading a reference measurement (e.g., after tool change), in this element enter the corresponding reference value for the next test measurement.                                                                                                                                                             |
| 2                   | Friction reference value           | Displays the value of the characteristic value "friction" determined with the reference measurement. When loading a reference measurement (e.g., after tool change), in this element enter the corresponding reference value for the next test measurement.                                                                                                                                                                       |
| 3                   | Lower measuring range limit        | When loading a reference measurement, in this element enter the lower measuring range limit corresponding to the characteristic reference value (cf. P-0-1378).                                                                                                                                                                                                                                                                   |
| 4                   | Upper measuring range limit        | When loading a reference measurement, in this element enter the upper measuring range limit corresponding to the reference measurement (cf. P-0-1378).                                                                                                                                                                                                                                                                            |
| 5                   | Velocity factor                    | For the reference import, in this element enter the velocity factor corresponding to the reference measurement (cf. P-0-1382).                                                                                                                                                                                                                                                                                                    |
| 6                   | Acceleration factor                | For the reference import, in this element enter the acceleration factor corresponding to the reference measurement (cf. P-0-1383).                                                                                                                                                                                                                                                                                                |

Mechanical Analysis (FWS\_MLDPa<sub>x</sub>\_SAM\_02Vxx\_D0\_MP0x)

| List element number | Designation/function | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7                   | Checksum             | <p>Displays the checksum regarding the settings for measuring motion after reference measurement. When loading the reference data before a test measurement (e.g., after tool change), enter the correct checksum.</p> <p><b>NOTES:</b> When the checksums do not match, it is impossible to execute the test measurement.</p> <p>With the value "1", the verification of the checksum can be deactivated before each test measurement.</p>                                    |
| 8                   | Control loop setting | <p>Displays the control loop setting regarding the settings for measuring motion after reference measurement. When loading the reference data before a test measurement (e.g., after tool change), enter the correct value. This is a calculated value which directly influences the determination of the characteristic value.</p> <p><b>NOTE:</b> Incorrect control loop setting can have a negative influence on the diagnostic quality.</p>                                |
| 9                   | Evaluation limit     | <p>After reference measurement, this element displays the evaluation limit for internal generation of diagnoses related to the measuring motion. When loading the reference data before a test measurement (e.g., after tool change), enter the correct value. This is a calculated value which directly influences the determination of the characteristic value.</p> <p><b>NOTE:</b> Incorrect evaluation limit can have a negative influence on the diagnostic quality.</p> |
| 10-1023             | Reserved             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

Fig. 7-30: Parameter Structure

|                        |                                                                                                                      |
|------------------------|----------------------------------------------------------------------------------------------------------------------|
| <b>Min./max. value</b> | <p>Element 0: 0/-</p> <p>Element 1 to 4: -/-</p> <p>Element 5 and 6: 0,001/-</p> <p>Element 7 to 9: -/-</p>          |
| <b>Format</b>          | <p>Element 0 to 4: DEC_MV</p> <p>Element 5 and 6: DEC_OV</p> <p>Element 7 and 8: DEC_MV</p> <p>Element 9: DEC_OV</p> |

Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

|                                            |                                                                                                                             |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| <b>Unit</b>                                | Element 0: Second<br>Element 1 and 2: -<br>Element 3 and 4: Cf. S-0-0079<br>Element 5 to 8: -<br>Element 9: -               |
| <b>Type</b>                                | Element 0 to 9: Output register/ input register (when loading a reference before test measurement)                          |
| <b>Decimal places</b>                      | Element 0: 1<br>Element 1 and 2: -<br>Element 3 and 4: Cf. S-0-0077 and S-0-0078<br>Element 5 and 6: 3<br>Element 7 to 9: - |
| <b>Buffered when control voltage fails</b> | Element 0 to 9: Yes                                                                                                         |

Fig.7-31: Parameter Attributes

## 7.5.19 P-0-1390, PA: Control word

The parameter P-0-1390 is used to control the mechanical analysis in operation.

| Bit  | Designation/function                             | Comment                                                                                                                                                                     |
|------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | No function                                      |                                                                                                                                                                             |
| 1    | Start measurement (reference/test)               | <ul style="list-style-type: none"> <li>Starts measuring motion and analysis at positive edge</li> <li>Reference or test measurement depends on bit 4 in P-0-1370</li> </ul> |
| 2    | Stop/abort measurement/analysis (reference/test) | Aborts measurement/analysis started at positive edge                                                                                                                        |
| 3-15 | Reserved                                         |                                                                                                                                                                             |

Fig.7-32: Parameter Structure

|                                            |                |
|--------------------------------------------|----------------|
| <b>Min./max. value</b>                     | -/-            |
| <b>Format</b>                              | BIN            |
| <b>Unit</b>                                | -              |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | None           |
| <b>Buffered when control voltage fails</b> | No             |

Fig.7-33: Parameter Attributes

## 7.5.20 P-0-1410, PA: Status word

The parameter P-0-1410 provides the status of the mechanical analysis and is used for communication with a higher-level control unit.

Mechanical Analysis (FWS\_MLDPa<sub>x</sub>\_SAM\_02Vxx\_D0\_MP0x)

| Bit  | Designation/function                                                                  | Comment                                                                   |
|------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 0    | <b>Ready</b>                                                                          | 0: Not ready to start a measurement<br>1: Ready to start a measurement    |
| 1    | <b>Active</b>                                                                         | 0: No measurement/evaluation started<br>1: Measurement/evaluation running |
| 2    | <b>Not used</b>                                                                       |                                                                           |
| 3    | <b>Reference measurement exists</b><br>0: No<br>1: Yes                                |                                                                           |
| 4    | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement                        |                                                                           |
| 5    | No function                                                                           |                                                                           |
| 6    | <b>Test measurement exists</b><br>0: No<br>1: Yes                                     |                                                                           |
| 8/7  | Diagnostic status message<br>00: No error<br>X1: Friction<br>1X: Backlash / stiffness | Analysis result                                                           |
| 9-11 | No function                                                                           |                                                                           |

Mechanical Analysis (FWS\_MLDPAx\_SAM\_02Vxx\_D0\_MP0x)

| Bit     | Designation/function                                                                                                  | Comment                                                                                                                                                  |
|---------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15...12 | <b>Operation/input status</b>                                                                                         |                                                                                                                                                          |
|         | 0000                                                                                                                  | Parameter setting ok                                                                                                                                     |
|         | 0001: P-0-1378 (lower measuring range limit) < S-0-0050 (negative position limit value)                               |                                                                                                                                                          |
|         | 0010: P-0-1379 (upper measuring range limit) > S-0-0049 (positive position limit value)                               |                                                                                                                                                          |
|         | 0011: P-0-1378 (lower measuring range limit) > P-0-1379 (upper measuring range limit)                                 |                                                                                                                                                          |
|         | 0100: Measuring range [P-0-1379 (upper measuring range limit) minus P-0-1378 (lower measuring range limit)] too small | Measuring range depends on scaling:<br><b>Linear:</b> (P-0-1379 minus P-0-1378) > 0.5 inch/10mm<br><b>Rotary:</b> (P-0-1379 minus P-0-1378) > 10 degrees |
|         | 0101: P-0-1372 invalid                                                                                                | Threshold for backlash outside of valid numeric range (0 .. 100)                                                                                         |
|         | 0110: P-0-1374 invalid                                                                                                | Sensitivity for backlash outside of valid numeric range (0 .. 100)                                                                                       |
|         | 0111: P-0-1375 invalid                                                                                                | Threshold for friction outside of valid numeric range (0 .. 100)                                                                                         |
|         | 1000: P-0-1377 invalid                                                                                                | Sensitivity for friction outside of valid numeric range (0 .. 100)                                                                                       |
|         | 1001: Checksum wrong                                                                                                  | Checksum transmitted in P-0-1389, element 7, does not comply with the transmitted settings                                                               |

Fig. 7-34: Parameter Structure

|                                            |                 |
|--------------------------------------------|-----------------|
| <b>Min./max. value</b>                     | -/-             |
| <b>Format</b>                              | BIN             |
| <b>Unit</b>                                | -               |
| <b>Type</b>                                | Output register |
| <b>Decimal places</b>                      | None            |
| <b>Buffered when control voltage fails</b> | No              |

Fig. 7-35: Parameter Attributes



## 8 Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

### 8.1 Brief Description

The extended diagnostic function "frequency response measurement and analysis" is a signal-based offline method. It can be used to analyze the mechanical drive system with regard to mechanical and electrical changes in the frequency range (frequency response).

Monitoring takes place with a freely definable frequency and amplitude threshold to find out whether the characteristic values are within the windows defined by the thresholds.

The extended diagnostic function can be started if required.

The frequency responses of the control loops and controlled systems to be selected and their characteristic values (bandwidth, resonance points, attenuation values) can be used both as means for initial commissioning and for detailed, regular analysis and diagnosis of the wear/state of the mechanical system.

The figure below illustrates the basic principle of the frequency response measurement and analysis:

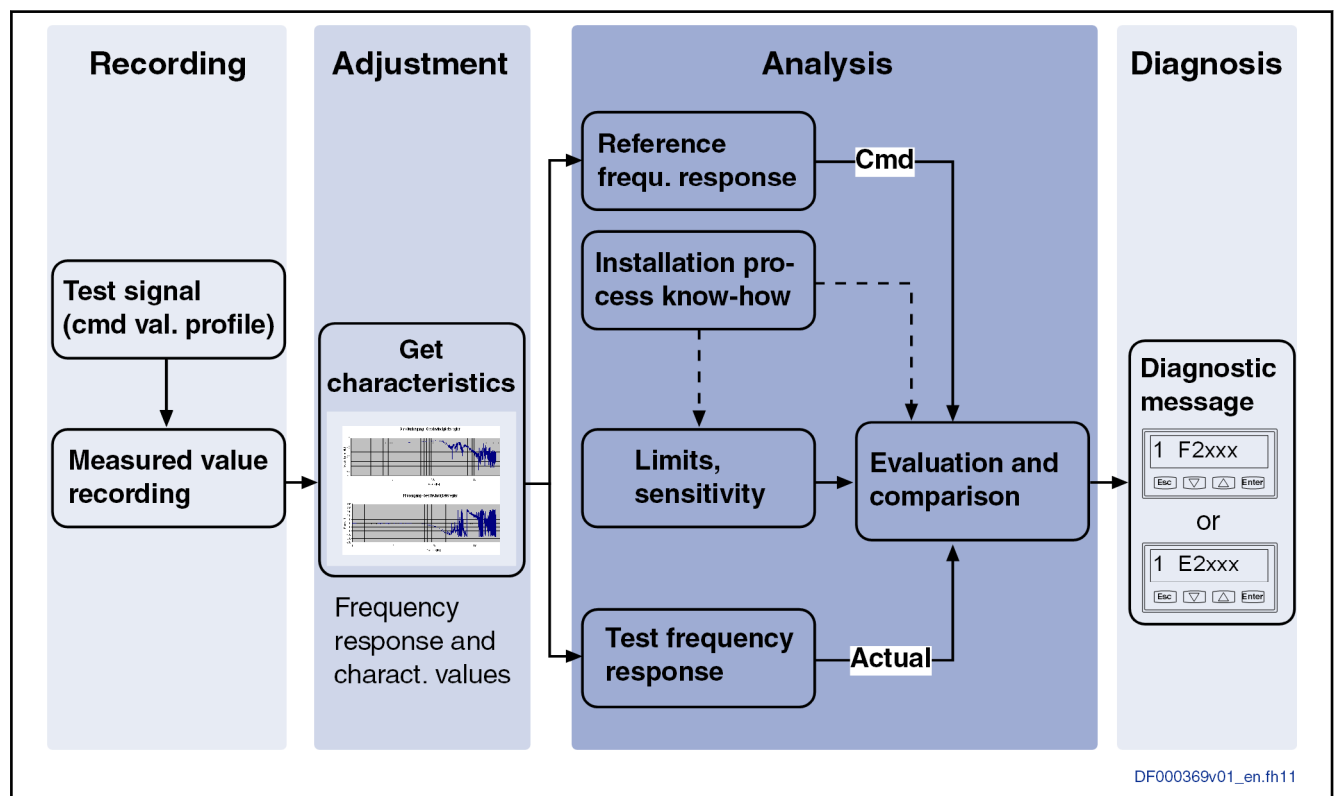


Fig. 8-1: Frequency Response Measurement and Analysis in Closed Control Loop

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

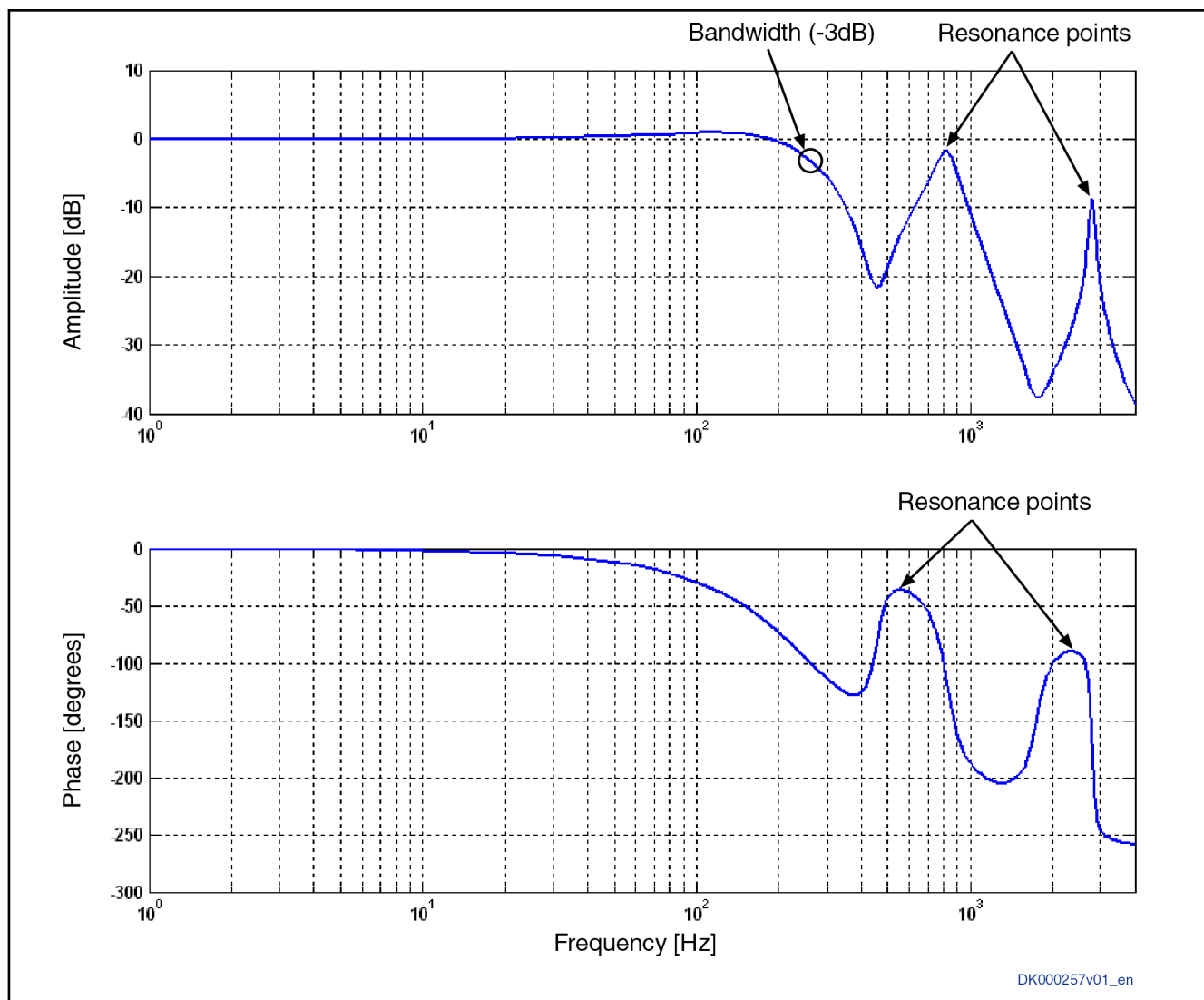


Fig.8-2: Theoretical Frequency Response of a Controlled 3-Mass Oscillator

#### Requirements of Use

To use the extended diagnostic functions, the software, firmware and hardware requirements must have been fulfilled (see "Required Components").

To use the extended diagnostic function "frequency response measurement and analysis", the PLC project "FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x" must in addition have been loaded and activated in the drive (see "How to Load Technology Functions to the Drive").

#### Fields of Application

The extended diagnostic function "frequency response measurement and analysis" can be used to analyze the mechanical drive system with regard to mechanical and electrical changes in the frequency range (frequency response). This allows realizing the following applications:

- **Frequency response measurement**
  - Frequency response measurement to determine bandwidth for current, speed and position control loops
  - Determination of frequency response of speed-controlled section
  - Determination of characteristic values (type, amplitude, attenuation, phase, coherence)
- **Analysis and extended axis diagnosis**

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

- Displacement of characteristic frequency values  $f_{res}$
- Change in corner frequency (bandwidth)
- Change in attenuation of a characteristic value



Using the function requires a wide-band excitation which is automatically generated by means of the drive-integrated noise generator (see also Functional Description of firmware "Command Value Generator").

**Functional Features**

The frequency response measurement and analysis has the following features:

- No additional sensors are required (available drive sensors are used).
- The function allows measuring and analyzing the closed control loop (speed, position, current), as well as the speed-controlled section and the frequency response of the mechanical system.
- Excitation by means of integrated noise generator ("white noise") in position loop or velocity loop clock ( $f_{max} = 4\text{kHz}$  for ADVANCED control sections).
- Recording in velocity loop clock by use of integrated oscilloscope function ( $f_{max} = 8\text{kHz}$  for ADVANCED control sections).
- User friendly parameterization and operation, as well as detailed visualization of the function by means of the "IndraWorks" commissioning software.
- Determination of measured bandwidth (-3dB limit) and up to 4 characteristic values and output in individual parameters (cf. P -0-1372 to P -0-1381). Detailed information on the characteristic values (type, phase, amplitude, frequency, coherence) contained in list registers P -0-1368 (test measurement) and P -0-1389 (reference measurement).
- The function is divided into 2 steps:
  - Step 1: Execution of the reference measurement during which the "actual" or "good" state in the form of a measured reference frequency response, or the individual characteristic values (characteristic frequency values and amplitude values, as well as corner frequency) are recorded.
  - Step 2: Execution of the test measurement later on in operation during which the frequency response or the individual characteristic values (characteristic frequency values and amplitude values, as well as corner frequency) are determined again and compared to the values of the reference measurement.
- Freely definable tolerance ranges for monitoring frequency and amplitude values of the individual characteristic values.

**Limitations of the Function**

The function has the following limitations:

- A test measurement complying with the reference measurement must be executed. The test measurement must be executed with the same signal amplitude for the noise signal.
- Between reference measurement and cyclic test measurements, data and parameters influencing the behavior of the drive mustn't be changed, because otherwise there will be faulty diagnoses.
- This is an offline method, i.e. it is necessary to interrupt normal operation to carry out the diagnosis (reference and test measurement).

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

- During the reference and test measurements, the ambient conditions (e.g. temperature) should possibly be the same to obtain the best possible diagnostic result.
- When using the firmware version MPx04 in conjunction with a field bus master communication and profile type setting "0xFF82" or "0xFF92" (parameter "P-0-4084, Field bus: Profile type"), the following analysis types **cannot** be carried out:
  - Frequency response of current control loop
  - Frequency response of speed-controlled section

**Pertinent Parameters**

The lists below contain the parameters used in conjunction with the extended diagnostic function "frequency response measurement and analysis". (The parameter names correspond to the respective significances for the diagnostic functions and not to the actual parameter names which are displayed, for example, in IndraWorks.)

**Acyclic channel:**

- P-0-1155, Command value generator, amplitude
- P-0-1316, PA: 1st characteristic amplitude - reference measurement
- P-0-1317, PA: 2nd characteristic amplitude - reference measurement
- P-0-1318, PA: 3rd characteristic amplitude - reference measurement
- P-0-1319, PA: 4th characteristic amplitude - reference measurement
- P-0-1320, PA: 1st characteristic amplitude - last measurement
- P-0-1321, PA: 2nd characteristic amplitude - last measurement
- P-0-1322, PA: 3rd characteristic amplitude - last measurement
- P-0-1323, PA: 4th characteristic amplitude - last measurement
- P-0-1368, PA: Characteristic value list of last measurement
- P-0-1370, PA: Configuration
- P-0-1371, PA: Tolerance band - error threshold factor
- P-0-1372, PA: Bandwidth - reference measurement
- P-0-1373, PA: 1st characteristic frequency/amplitude - reference measurement
- P-0-1374, PA: 2nd characteristic frequency/amplitude - reference measurement
- P-0-1375, PA: 3rd characteristic frequency/amplitude - reference measurement
- P-0-1376, PA: 4th characteristic frequency/amplitude - reference measurement
- P-0-1377, PA: Bandwidth - last measurement
- P-0-1378, PA: 1st characteristic frequency/amplitude - last measurement
- P-0-1379, PA: 2nd characteristic frequency/amplitude - last measurement
- P-0-1380, PA: 3rd characteristic frequency/amplitude - last measurement
- P-0-1381, PA: 4th characteristic frequency/amplitude - last measurement
- P-0-1382, PA: Tolerance band - amplitude values
- P-0-1383, PA: Tolerance band - characteristic frequencies

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

- P-0-1384, PA: Operating hours - reference measurement
- P-0-1385, PA: Operating hours - test measurement
- P-0-1387, PA: Status text
- P-0-1389, PA: Reference data

### Cyclic channel:

- P-0-1390, PA: Control word
- P-0-1410, PA: Status word
- P-0-1412, PA: Error/warning status
- P-0-1413, PA: Amplitude command value ideal - integral
- P-0-1414, PA: Amplitude command value ideal - decimal places

### Pertinent Diagnostic Messages

In conjunction with the extended diagnostic function "frequency response measurement and analysis", the following diagnoses are used and shown on the display of the drive and in "S -0-0390, Diagnostic message number".

- E2011 and E2012
- F2011 and F2012



The diagnoses are only output when the accordingly big amplitude or frequency deviation has occurred during a test measurement and the error reaction has been parameterized in P -0-1370 (bit7 has been set).



Via P -0-1371, you can set whether and when an error is output.

When values exceed the tolerance ranges, this is always displayed in P-0-1412 (in the bits for the corresponding characteristic values).

## 8.2 Functional Description

The figure below illustrates the functional principle of the extended diagnostic function "frequency response measurement and analysis". The reference frequency response (or its characteristic values) once recorded and stored is compared to the currently determined frequency response (test values). In the case of a deviation or displacement of characteristic frequency value or attenuation value with regard to a characteristic value, which is greater than a previously defined tolerance range (P -0-1382 and P -0-1383), a warning is generated (can be seen in P -0-1410 and output of E2011/E2012 in the case of parameterized drive diagnosis). If this deviation exceeds one of the error thresholds defined by P -0-1371 in conjunction with the preset tolerance windows, an error is output (can be seen in P -0-1410, bit6 and output of F2011/F2012 in the case of parameterized drive diagnosis).

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

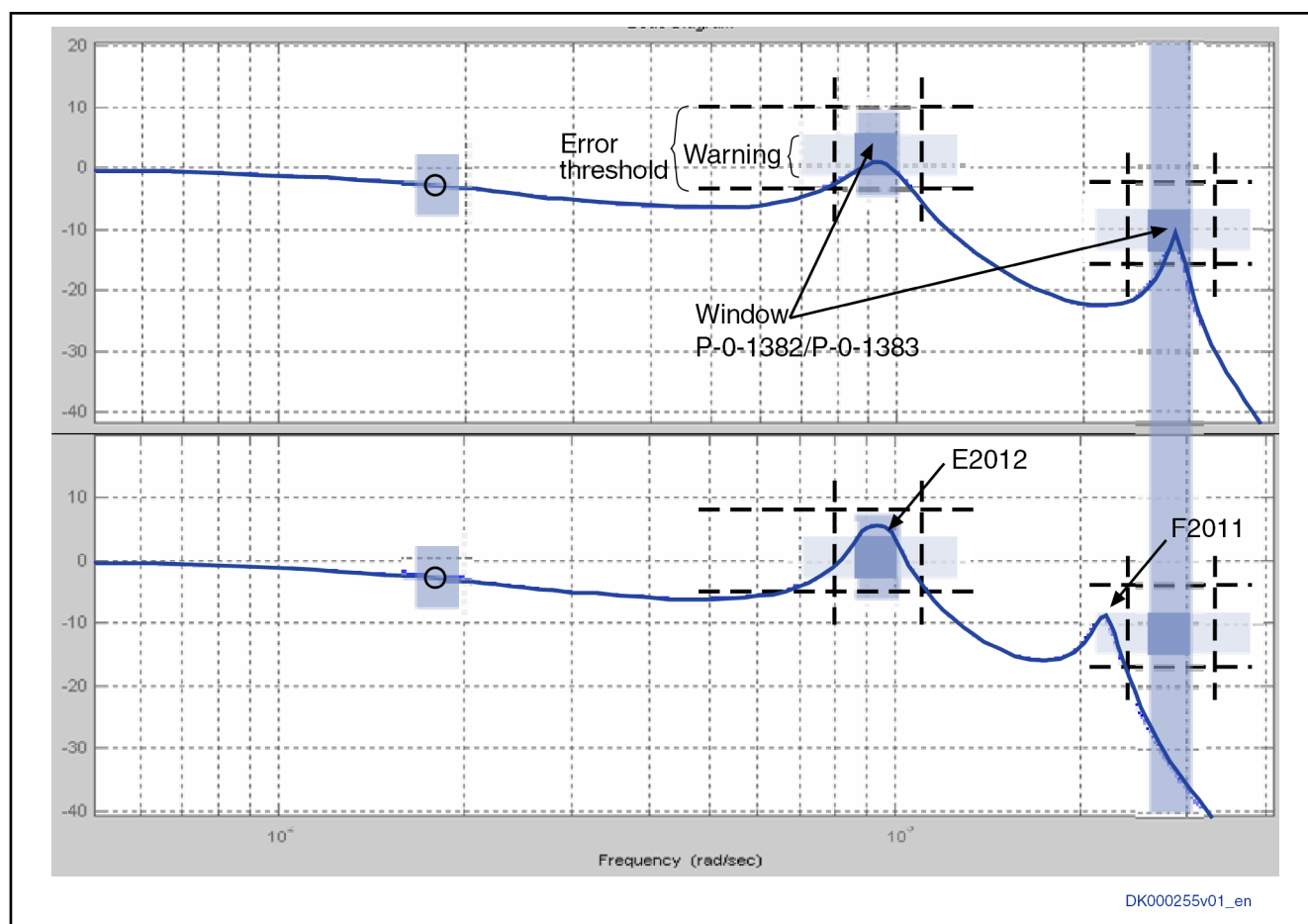


Fig.8-3: Amplitude Curves for Reference (Above) and Test Measurement (Below)

The extended diagnostic function "frequency response measurement and analysis" is divided into the following steps:

- In the first step, the reference measurement records the "actual" or "good" state of the mechanical drive system in the form of a frequency response (or its characteristic values); the state is ideally recorded after commissioning and optimization have taken place.



The operating company of the machine or the machine manufacturer has to assess the mechanical drive system as "good", this does not take place automatically!

- In the second step later on in operation, the current measured values/characteristic values are compared to the previously stored reference values. Depending on two freely definable tolerance ranges for frequency displacements and amplitude changes (evaluation criteria), a PLC warning or a PLC error is output when one of the two ranges is exceeded.



Upon successful reference measurement, the higher-level control unit, if required, can read out and archive the characteristic values of the frequency response stored in the drive, or can write characteristic values, which have been read out, to the drive at a later point of time.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

### Travel Range and Positioning Data

The travel range is not separately determined, because the drive during the measurement wants to follow changes in direction and the travel distance or angle around the initial position/starting point depends on the signal amplitude which has been set (cf. S -0-0049, S -0-0050).

The reference and test measurements are carried out according to the following scheme:

1. Start of measurement: Drive carries out movements with rapid changes in direction around its initial position. A drift movement can even occur during the measurement.



Which distance or angle is run during the measurement depends on the test signal amplitude, the type of analysis and the axis configuration. The strongest movements occur during measurements for the current control loop and the speed-controlled section, as an additive torque is added to the axis in these cases. For critical mechanical systems, it is therefore recommended that for the first measurements you reduce the test signal amplitude to 10% of the recommended value and increase it afterwards.

2. To minimize measuring errors due to stochastic disturbances, four measuring runs are carried out at each start of a test or reference measurement.
3. When the axis is in reference, the drive moves back to its initial position after the measurement has been completed; otherwise, the measurement causes an offset in position which persists after the four measuring runs.



During the different measurements for velocity, current and position loop, the preset maximum amplitude should not be exceeded. This prevents signal limitations from invalidating the result.

If the measurement is aborted due to a limitation invalidating the result, this is displayed in the status word and in the status text.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

## 8.3 Notes on Commissioning and Operation

### 8.3.1 General Information

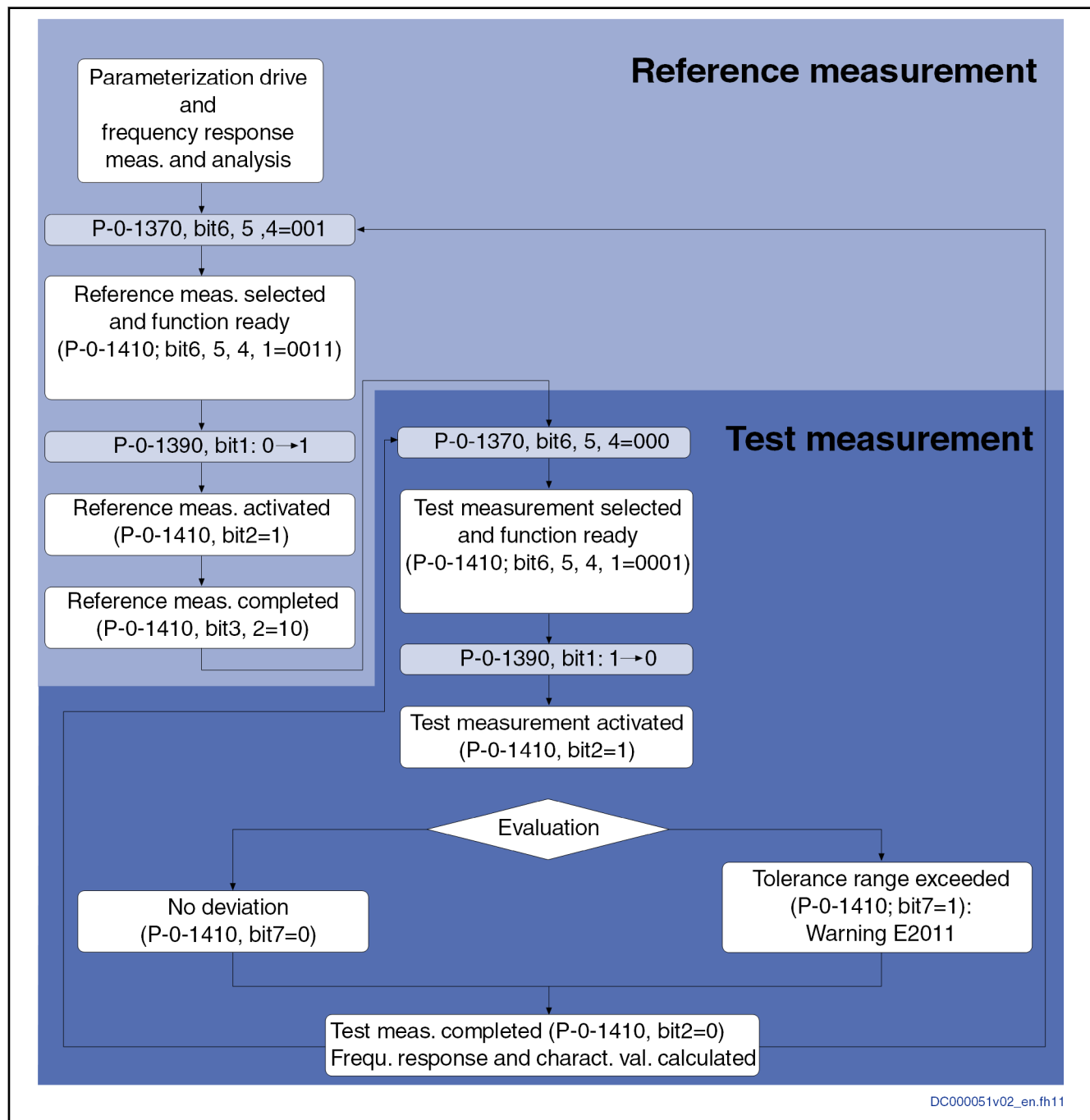


Fig.8-4: States and Transitions for Frequency Response Measurement and Analysis

**Initial Situation**

The successful commissioning of the extended diagnostic function "frequency response measurement and analysis" requires the following initial situation:

- The drive has been commissioned, i.e. it is operable.
- The communication between control unit and drive exists.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

**Overview of Required Individual Steps for Commissioning**

- All operation parameters have reached their stationary status.
- The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
- The PLC project "FWS\_MLDPBP\_SCHxxx\_02Vxx\_D0\_MP0x" has been loaded and activated for the firmware version at hand (see "How to Load Technology Functions to the Drive").
- During the reference and test measurements, the ambient conditions (e.g. temperature) should possibly be the same to obtain the best possible diagnostic result.

The commissioning of the extended diagnostic function "frequency response measurement and analysis" consists of the following steps:

**Configuring the function**

1. Select and configure the frequency response type to be monitored (e.g. speed loop, mechanical system frequency response etc.).
2. Start a reference curve recording (via P -0-1390) or, if available, load reference values already determined (via P -0-1389).

**Operating/using the function**

The function is used permanently, also later in operation and this implies triggering a test measurement or adjusting tolerance bands and the error threshold. The operation/use of the function is divided into the following steps which have to be repeated, if required:

1. Set the tolerance windows (P -0-1382 and P -0-1383) for allowed amplitude and frequency deviations and set the error threshold (P -0-1371).
2. Select the type of diagnosis.
3. Start (via P -0-1390) or activate (cyclically) a test measurement.
4. Display and evaluate the results by means of IndraWorks or the parameters P -0-1372 to P -0-1381, P -0-1410 and P -0-1412.



Below, the individual steps will be described in detail and another chapter will explain the Configuration and Operation by Means of IndraWorks.

**Parameter Interface to Configure and Operate the Function**

Apart from a cyclically configurable control and status word, there are other parameters available to configure and operate the function; these parameters can be accessed via the acyclic channel. The following interface parameters are supported:

- Status information on the entire drive system
- Counts of operating hours counters
- Display of the name of the technology function (cf. P-0-1361)
- Display of the status text and diagnostic message text (cf. P-0-1387)



All parameters and PLC registers allow data exchange of a higher-level PLC or control unit with the drive.

The PLC registers can be written in the following ways:

- Via the master communication (SERCOS, Profibus, ...)
- Via a digital input of the control section
- The comfort control panel (VCP01)
- The serial interface (e.g. IndraWorks)

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

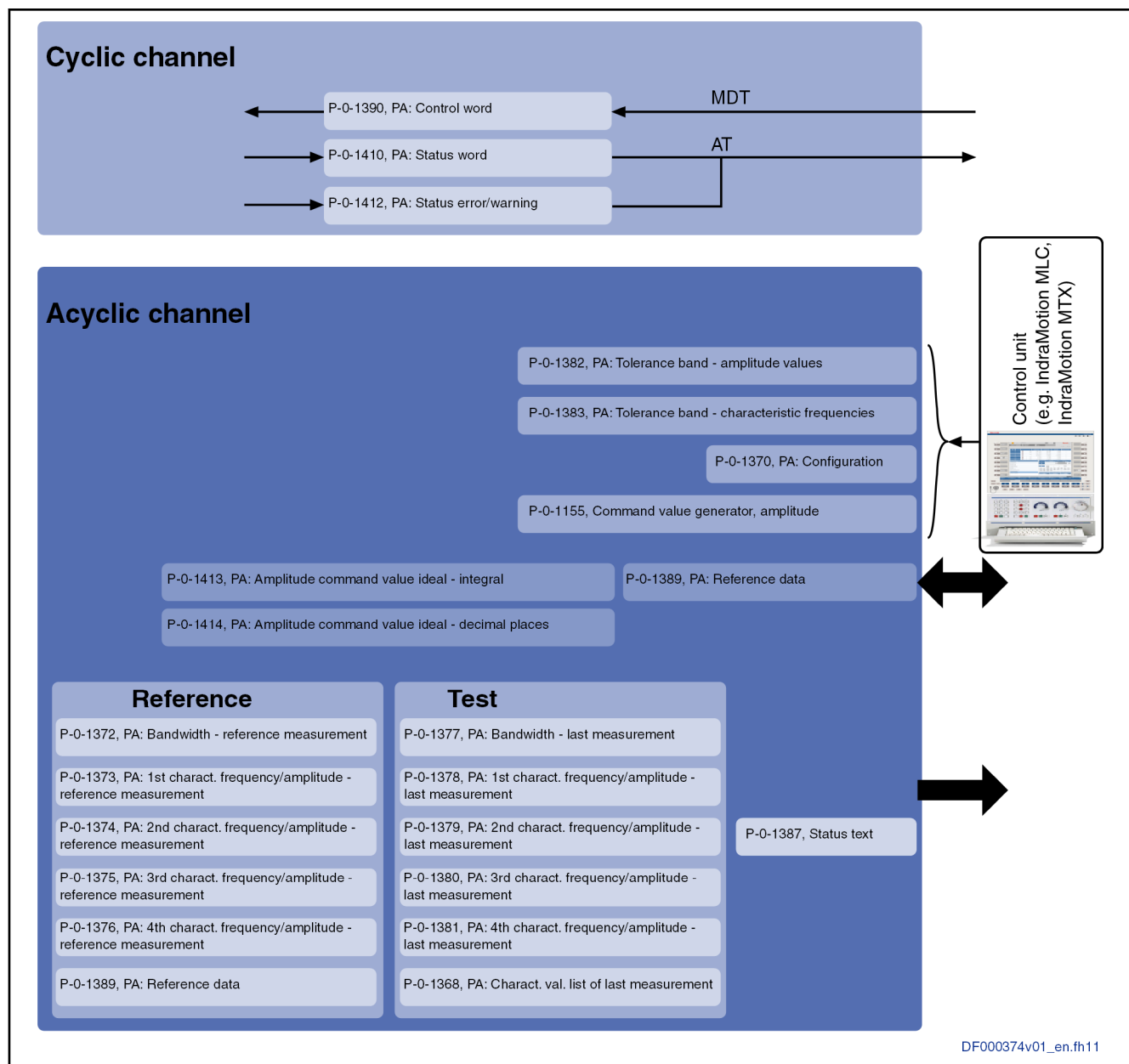


Fig. 8-5: Overview of Parameters for the Frequency Response Measurement and Analysis

### 8.3.2 Configuration and Operation via Parameters

#### Commissioning Step 1: Selecting and Configuring the Frequency Response Type

1. Select the excitation and recording possibilities.

# Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

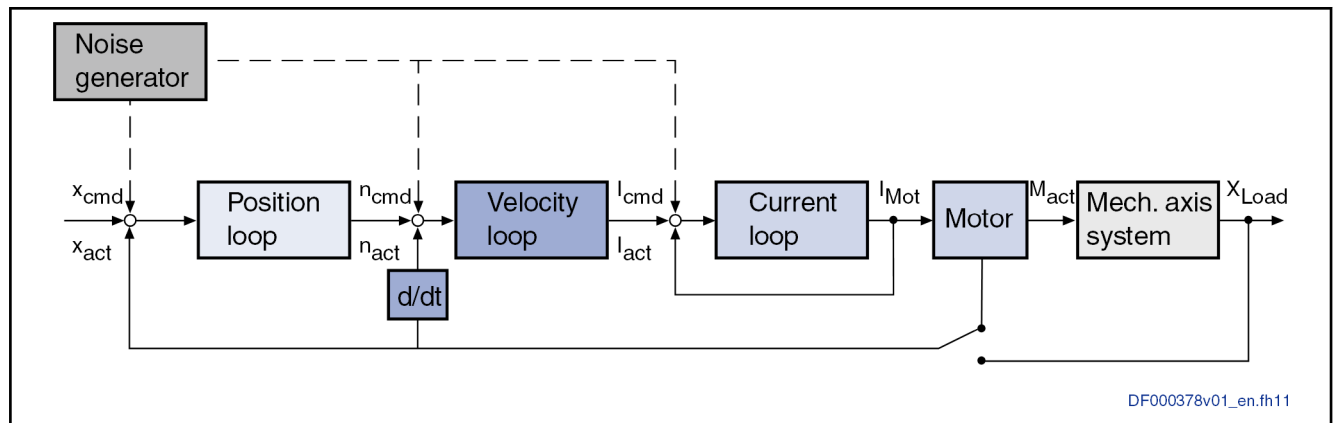


Fig.8-6: Overview of Possible Excitations and Recording Possibilities at the Mechanical Axis System

The following frequency responses are provided for selection via P-0-1370 (bit16-18 and bit11):

- **Speed-controlled section (motor and mechanical system)**
  - Input = motor current (P-0-0043)
  - Output = velocity feedback value (S-0-0040/S-0-0156)
- **Frequency response of mechanical system**
  - Input = velocity feedback value motor (S-0-0040)
  - Output = velocity feedback value load (S-0-0156)
- **Current control loop**
  - Input: Current command value (S-0-0081)
  - Output: Current feedback value (S-0-0084)
- **Speed control loop**
  - Input: Velocity command value (P-0-0048)
  - Output: Velocity feedback value (S-0-0040/S-0-0156)
- **Position control loop**
  - Input: Position command value of controller (P-0-0434)
  - Output: Position feedback value (S-0-0051 or S-0-0053)



When analyzing the position control loop, the velocity feedforward can be taken into account. Via P-0-0556, bit9, you can define the point at which the position command value addition takes effect (on this topic, see Parameter Description of drive firmware).



Via P-0-1370, bit10 and 9, it is possible to implement a compensation of the friction torque for the analysis of the speed control loop by adding a positive or negative offset motion. The offset motion is 55% of the preset test signal amplitude in the configured direction. If a test signal amplitude of 100 rpm is preset, for example, each of the 4 additions of the test signal is based on an offset velocity of 55 rpm. According to the controller settings, each signal addition takes between 1 and 2 seconds. This means that in the worst case, the axis moves for 4\*2 seconds at 55 rpm in one direction, additionally to the drift movements of the axis during noise addition.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

Commissioning Step 2: Starting,  
Saving and Loading the Reference  
Measurement

- Furthermore, a test signal amplitude must be preset to execute the reference measurement. In P -0-1155, you can enter the recommended amplitude value (P -0-1413 and P -0-1414) for the test signal.



For programming reasons, the recommended amplitude value has to be output in two parameters.

- In P -0-1370, bit4="1", configure the start of a reference measurement.

2.

**WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Setting P -0-1390, bit1 (positive edge), starts the reference measurement.



In P -0-1410, bit1 displays whether a measurement can be triggered.

Upon successful reference measurement:

- The operating hours count for the reference measurement is entered in P-0-1384.
- The determined characteristic values are stored in P-0-1372 to P-0-1377.
- The operating hours count of the reference measurement is displayed in the list element 200 of P-0-1389.
- The bit3 in P-0-1410 is set (reference available).
- The determined characteristic values and the requirements for the reference measurement are stored in the list elements 201-279 of P-0-1389.

**If several reference data are to be used** (e.g., for monitoring and analyzing different frequency responses), the following elements from P -0-1389 must be saved/exported directly after the corresponding reference measurement:

- Element200, "Operating hours counter control section"  
To establish a time reference, this element contains the point of time at which the corresponding measurement was recorded.
- Element201, "Type of analysis"
- Element202, "Analysis encoder"
- Element203, "Checksum"

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

For any later test measurement, the checksum ensures that the current settings of the test measurement (offset speed, signal amplitude, ...) comply with the settings of the corresponding reference measurement.

- Element204, "Preset noise signal amplitude"
- Elements210 to 279

**If the reference data are to be loaded** without executing a new reference measurement (e.g., in the case of product change), the elements200 to 279 in P-0-1389 must be written accordingly before the next test measurement is started. The entered values are directly applied to the corresponding individual parameters and the status display is adjusted (P-0-1372 to P-0-1376, P-0-1384 and P-0-1410).



You absolutely have to make sure for the test measurement executed later on that the settings of filter and control loop comply with the ones of the corresponding reference measurement. Otherwise, faulty diagnoses can occur due to different settings.

### Commissioning Step 3: Tolerance Windows and Error Threshold

In this step, you have to set tolerance windows for frequency displacements (P-0-1383) and attenuation amplitude changes (P-0-1382) for the analysis carried out later on. Via the list elements #301 to #361 of P-0-1389, these tolerance windows can be individually preset for each characteristic value.



These individual windows are only used for analysis, when the parameters P-0-1382 and P-0-1383 have been set to zero. If values are entered in these parameters, they are the basis of the analyses of all characteristic values.

P-0-1371 is used to preset a factor (>1) by which the windows are multiplied; in this way you get thresholds and a PLC error F201x is triggered when the thresholds are exceeded.



If there aren't any tolerance ranges preset for one or all characteristic values ("0"), a default threshold is automatically set.

Default frequency tolerance: 10Hz

Default amplitude tolerance: 5dB

Default error threshold: 2

### Commissioning Step 4: Selecting the Type of Diagnosis

Via bit7 in P-0-1370, you can select whether a warning (E2011/E2012) or an error (F2011/F2012) is to be output at the drive, when a change in the characteristic frequency or amplitude is detected during the test measurement. Independent thereof, the diagnostic message is always output in P-0-1410, bits 6,7 and 8.

### Commissioning Step 5: Starting the Test Measurement

If valid reference data are available (P -0-1410, bit1="1"), the test measurement can be started. A validity check comprises the checks of:

- Analysis type (speed loop, mechanical system frequency response, etc.)
  - Control encoder for the analysis
  - Checksum (is generated internally, depending on the analysis type)
1. To start a test measurement, set bit4="0" in P-0-1370.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

2.

 **WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the test measurement by a positive edge of bit1 in P-0-1390.

The signal amplitude on which the reference measurement was based, is automatically applied.

Upon successful test measurement:

- The bit2 in P-0-1410 is cleared.
- The operating hours count for the test measurement is entered in the parameter P-0-1385.
- The characteristic value evaluation of reference and current measurement is carried out and, if necessary, the corresponding warning or error is output.
- The determined characteristic values are stored in the parameters P-0-1378 to P-0-1381.
- The detailed data of the characteristic values and the support points of amplitude response and phase response are stored in the parameter P-0-1368.



If at least one of the characteristic values regarding amplitude or frequency is outside of the tolerance range, the bit7 or bit8 in P-0-1410 is set and the PLC reaction E2011/F2011 or E2012/F2012 is generated.

**Commissioning Step 6: Displaying the Results**

1. When the last triggered analysis has been completed, bit2 of P -0-1410 is cleared and the user can start a new measurement.
2. The diagnoses and results can be seen in P -0-1410:
  - The bits7 and 8 show whether there is a change in characteristic values outside of the tolerated windows.
  - Bit6 shows whether the error threshold has been exceeded, too.
3. As regards the evaluation and display of the results, it is additionally possible
  - to evaluate "S-0-0390, Diagnostic message number",
  - read the display of the drive and

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

- evaluate the class 1 diagnostics or class 2 diagnostics bit in the corresponding status word of the drive, or  
read the logbook entry of the drive.



To use these standard mechanisms of the drive, bit7 in P-0-1370 must have been set. When the bit has been set, the warning E2011 or E2012 is generated in the drive when the tolerance window for displacement of characteristic frequency values or amplitude change has been exceeded, and the error F2011 or F2012 is generated in the drive when the error thresholds have been exceeded. Otherwise, it is only the bits6 to 8 in P -0-1410 which are set according to the exceeded tolerance bands.

Characteristic values and measurement circumstances are entered in the corresponding single registers (P-0-1377 to P-0-1381) and the list register P-0-1368.



For display and graphic evaluation of the determined frequency response and the characteristic values, you can use the "IndraWorks" commissioning software (see "Configuration and Operation by Means of IndraWorks").

### 8.3.3 Configuration and Operation by Means of IndraWorks

When the extended diagnostic function "frequency response measurement and analysis" has been loaded to the axis by means of IndraWorks (see "How to Load Technology Functions to the Drive"), the user interface can be opened in the technology functions window via the "Dialog ..." button.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

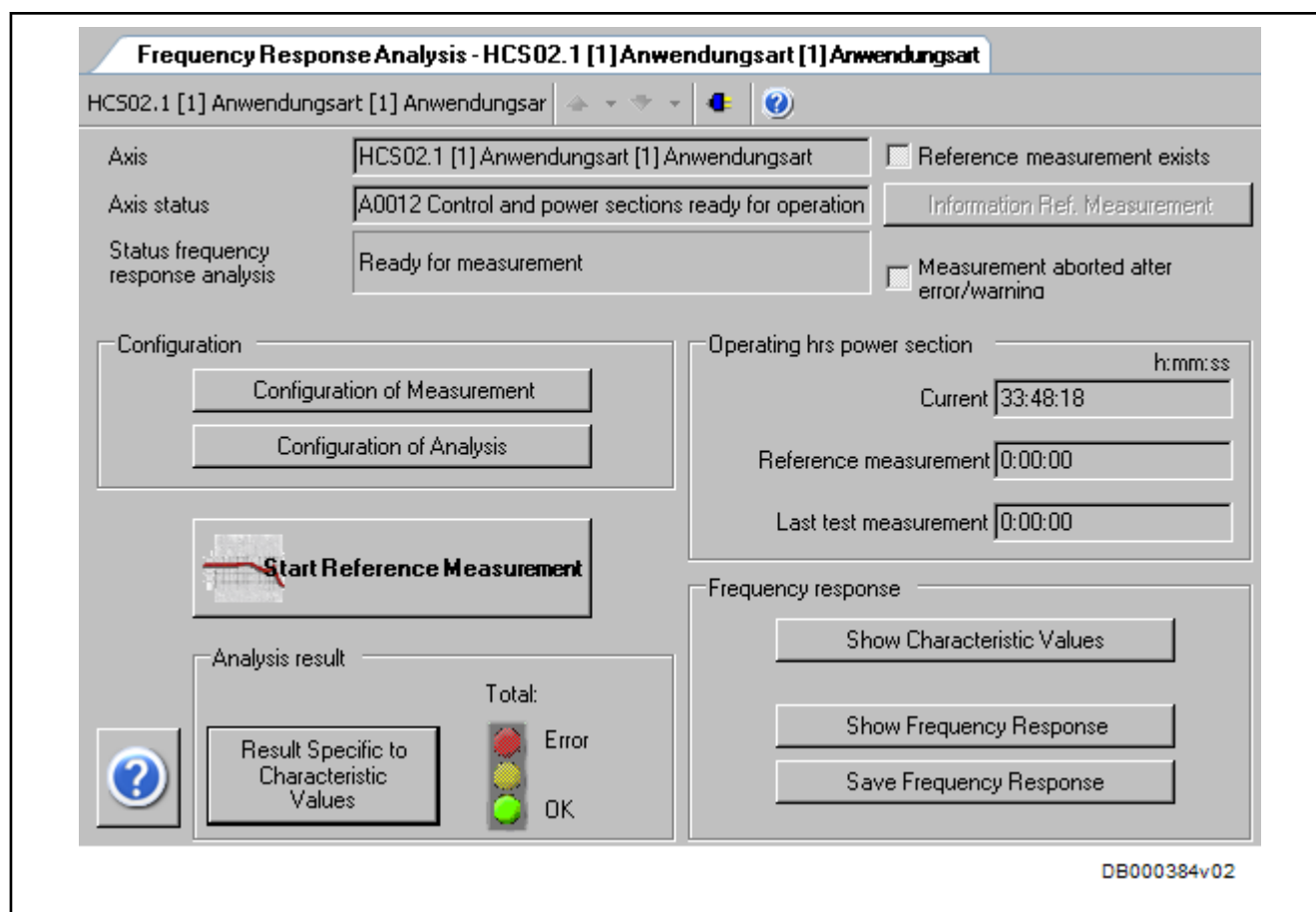


Fig. 8-7: User Interface for Frequency Response Measurement and Analysis

"Reference measurement exists" in the operation dialog shows whether the reference information required for a test measurement exists in the drive.

"Measurement aborted after error/warning" in the operation dialog shows whether the measurement last started (reference measurement or test measurement) was automatically aborted due to a drive error/warning (e.g. E8260) and is therefore invalid.

#### Commissioning Step 1: Selecting and Configuring the Type of Frequency Response



If valid reference data are available, the settings for the stored reference measurement can be displayed by opening the "Information Ref. Measurement" dialog.

1. Via the "Configuration of Measurement" button, open the configuration dialog.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

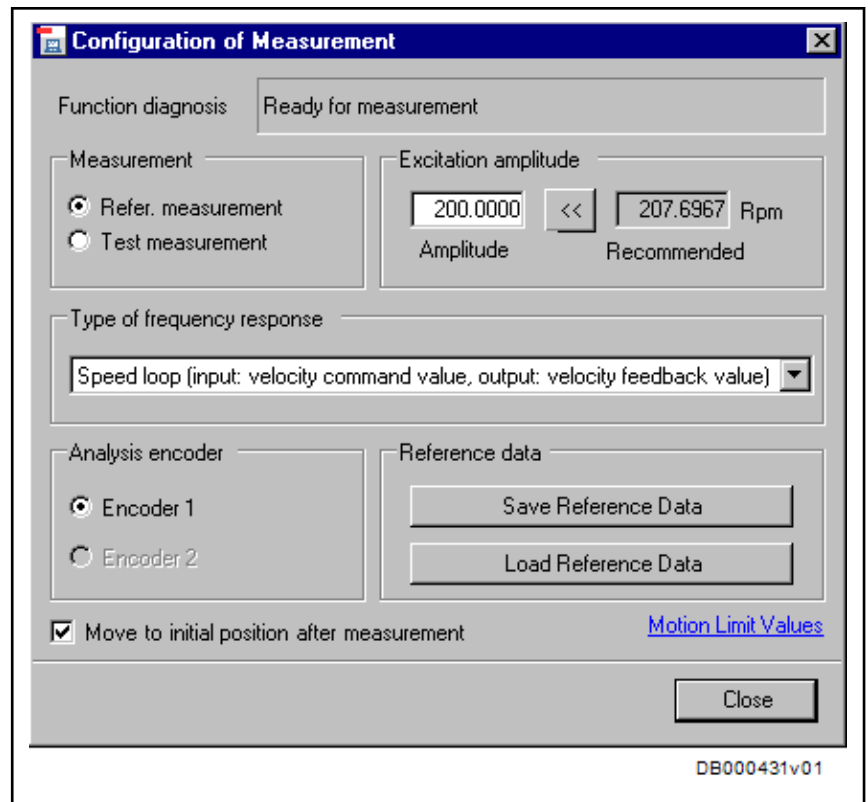


Fig. 8-8: Configuring the Frequency Response Measurement

2. In the "Type of frequency response" section, select one of the possible analyses from the list; you find the drive signals in brackets next to the type of frequency response.



For the drive signals which are hiding behind the individual controlled sections and control loops, see commissioning step 1 of the description "Configuration and Operation via Parameters".



Via the "Motion Limit Values" link, you can limit the travel range of the axis which can result from the random command value generation.

3. When an optional encoder has been connected, you have to decide whether the encoder information of the optional encoder or the information of the motor encoder is to be recorded.
  1. Set a signal amplitude by applying the recommended signal amplitude to the "Amplitude" text field in the "Excitation amplitude" section by means of the "<<" button, or by writing a different value to the text field.
  2. Close the "Configuration of Measurement" dialog.

### Commissioning Step 2: Starting, Saving and Loading the Reference Measurement

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

3.

**WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the reference measurement by activating the "Start Reference Measurement" button on the user interface for frequency response analysis.



**If several reference data are to be used** (e.g., for work with different tools), save the reference data after the corresponding reference measurement ("Configuration of Measurement" dialog, "Save Reference Data" button).

**If the reference data are to be loaded** without executing a new reference measurement (e.g., in the case of product change), activate the "Load Reference Data" button in the "Configuration of Measurement" dialog.

**Commissioning Step 3: Tolerance Windows and Error Threshold**

1. Via the "Configuration of Analysis" button, open the configuration dialog.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

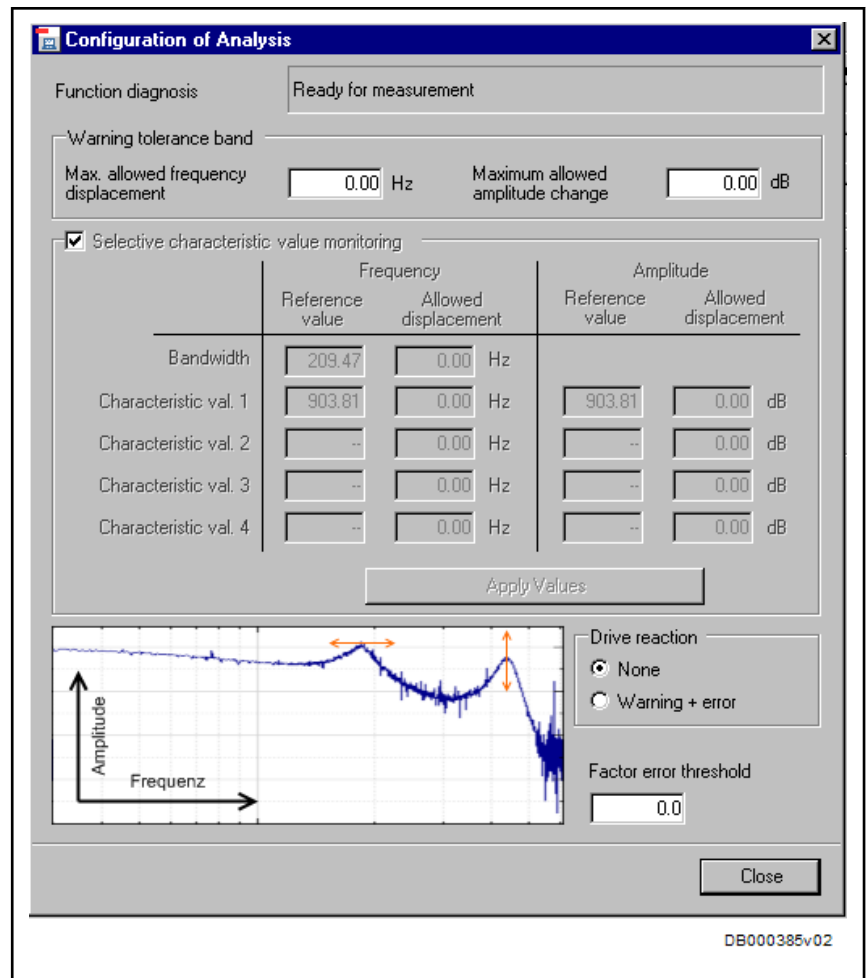


Fig. 8-9: Configuring the Frequency Response Analysis

- When "Selective characteristic value monitoring" has been activated, it is possible to define individual windows for each characteristic value.  
When "Selective characteristic value monitoring" has been deactivated, the "Warning tolerance band" section sets a tolerance band both for the allowed amplitude change and for the allowed frequency displacement between reference measurement and test measurement, which applies to all characteristic values.
- Via "Factor error threshold", you can define an error threshold. With an input greater than "1", all warning tolerance bands are multiplied with this factor and represent an additional error threshold. An input smaller than "1" deactivates the error threshold.

### Commissioning Step 4: Selecting the Type of Diagnosis

In the "Drive reaction" section of the "Configuration of Analysis" dialog, you can select whether a drive diagnosis (E201x / F201x) is to be output at the drive ("Warning + error" option), when a change in characteristic frequency or amplitude is detected during the test measurement, or whether there is **no** drive diagnosis (E201x / F201x) to be output at the drive ("None" option).

### Commissioning Step 5: Starting the Test Measurement

- Close the "Configuration of Analysis" dialog.
- Open the "Configuration of Measurement" dialog by activating the button of the same name in the operation dialog.
- In the "Measurement" section, select "Test measurement".

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

The signal amplitude is automatically set to the value of the stored reference amplitude.



The status of the PLC is output in the "Function diagnosis" field. For example, if the parameter setting of the current test measurement (analysis type, analysis encoder, etc.) does not comply with the reference measurement which was stored, this information is displayed in this field.

4. Close the "Configuration of Measurement" dialog.

5.

**⚠ WARNING**

**Dangerous movements can occur when the next step is carried out! Danger to life, risk of injury, severe bodily harm or material damage can result!**

When you carry out the next step, the extended diagnostic function automatically performs movements of the axis. These movements are absolutely necessary for the diagnosis.

To avoid accidents, bodily harm and/or material damage, please observe the chapter "Protection Against Dangerous Movements" under the main chapter "Safety Instructions for Electric Drives and Controls".



If the "integrated safety technology" is used at the axis, too, you have to take the movements of the axis into account when configuring the integrated safety technology; you thereby avoid that the monitoring functions of integrated safety technology restrict the movements of the axis.

Start the test measurement by activating the "Start Test Measurement" button on the user interface.

### Commissioning Step 6: Displaying the Results

Via the user interface for frequency response measurement and analysis, you can call dialogs which display the results of the frequency response measurement.

- **Prerequisite:** In the "Drive reaction" section of the "Configuration of Analysis" dialog, you have selected that a drive diagnosis (E201x / F201x) is to be output.

In the "Analysis result" section of the user interface for frequency response measurement and analysis, a stop light symbol signals if one of the characteristic values deviates from the reference value and the drive therefore generates a warning or an error.

When an error or a warning has occurred, you can open the selective characteristic value error status via the "Result Specific to Characteristic Values" button:

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

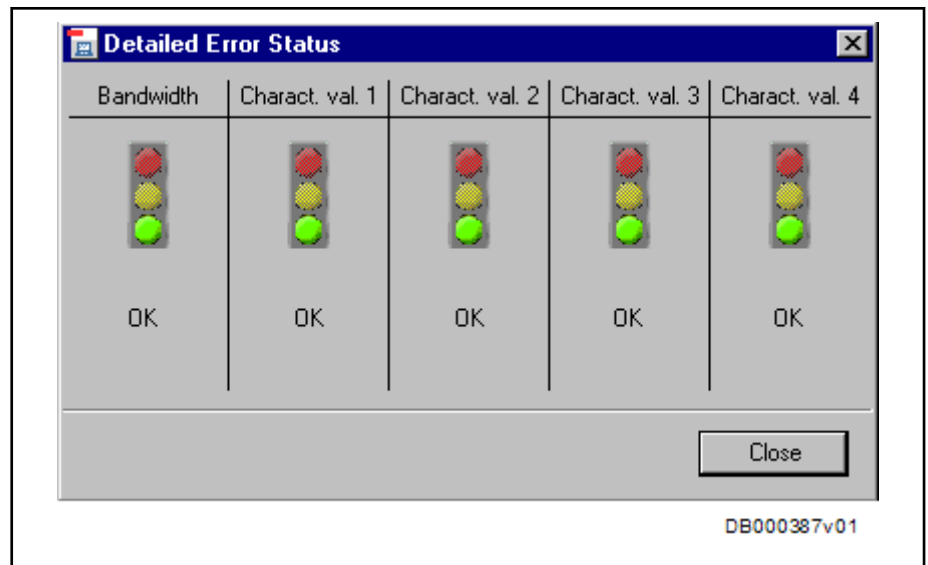


Fig.8-10: Error Evaluation

- When you activate the "Show Characteristic Values" button, a dialog opens in which the recognized characteristic values of the reference measurement are compared to those of the last measurement carried out:

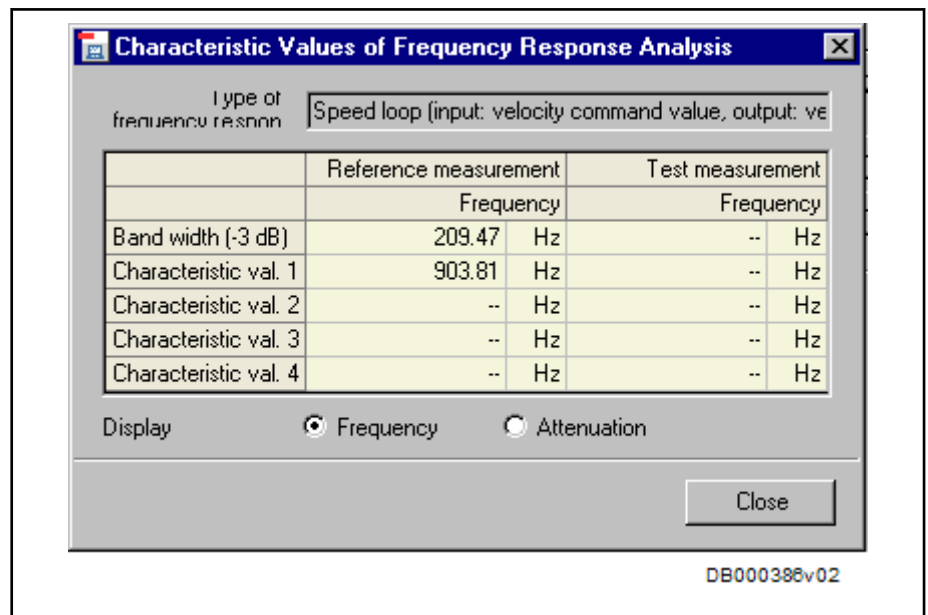


Fig.8-11: Display of Characteristic Values

- Via the "Show Frequency Response" button, the determined Bode diagram can be displayed. It allows a more detailed examination of the determined amplitude and phase responses. In addition, you can save the curves as a parameter file or load curves which have already been saved.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

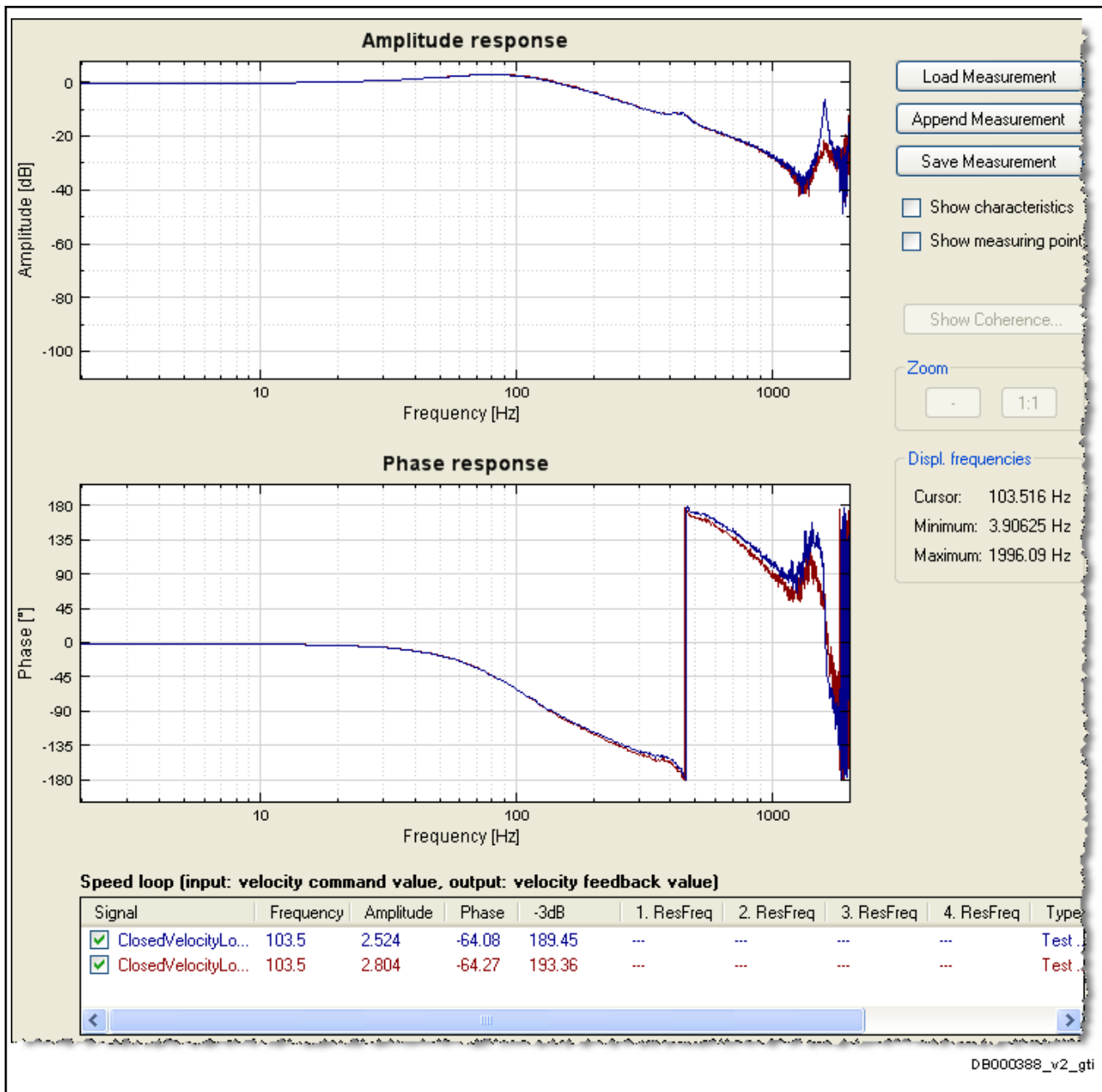


Fig. 8-12: Exemplary Representation of a Frequency Response

With "Append Measurement", you can append a saved measurement to the current measurement for the purpose of comparison.

With "Save Measurement", the currently displayed measurements are saved externally.

## 8.4 Diagnostic and Status Messages

The standard diagnostic message of the drive is used. When this diagnostic message has been parameterized via P-0-1370, bit7, the drive in the case of error generates the warning (E2011/E2012) or the error (F2011/F2012).

The diagnostic and status messages are also available as binary information in P-0-1410 and, in more detailed form, in P-0-1412, and are displayed as text strings in P-0-1387.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

### CAUTION

**Danger of faulty diagnoses by changes made between reference and test measurement!**

⇒ The conditions must be the same when executing the reference and test measurements!

## 8.5 Description of the Parameters of the Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

### 8.5.1 P-0-1155, Command value generator, amplitude

The parameter P-0-1155 is used to set the amplitude of the noise signal (double peak value, peak-to-peak value). The display, i.e. unit and scaling of the parameter, is set according to the assigned target parameter (depending on the selected type of analysis).

To obtain the best result, set this value as high as possible. For orientation see P-0-1381. When the torque limit is exceeded (P-0-1410, bit8 and evaluation of P-0-1387), reduce the amplitude command value.

|                                     |                             |
|-------------------------------------|-----------------------------|
| Min./max. value                     | Depends on target parameter |
| Format                              | DEC_MV                      |
| Unit                                | Depends on target parameter |
| Type                                | Input register              |
| Decimal places                      | Depends on target parameter |
| Buffered when control voltage fails | No                          |

Fig. 8-13: Parameter Attributes

### 8.5.2 P-0-1316, PA: 1st characteristic amplitude - reference measurement

As of firmware MPx05, the parameter P-0-1316 displays the amplitude value of the first determined characteristic value for the reference measurement.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | -/-             |
| Format                              | DEC_OV          |
| Unit                                | dB              |
| Type                                | Output register |
| Decimal places                      | 2               |
| Buffered when control voltage fails | Yes             |

Fig. 8-14: Parameter Attributes

### 8.5.3 P-0-1317, PA: 2nd characteristic amplitude - reference measurement

By analogy to P-0-1316 for the second characteristic amplitude of the reference measurement.

### 8.5.4 P-0-1318, PA: 3rd characteristic amplitude - reference measurement

By analogy to P-0-1316 for the third characteristic amplitude of the reference measurement.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

**8.5.5 P-0-1319, PA: 4th characteristic amplitude - reference measurement**

By analogy to P-0-1316 for the fourth characteristic amplitude of the reference measurement.

**8.5.6 P-0-1320, PA: 1st characteristic amplitude - last measurement**

As of firmware MPx05, the parameter P-0-1320 displays the amplitude value of the first determined characteristic value for the last executed measurement.

|                                            |                 |
|--------------------------------------------|-----------------|
| <b>Min./max. value</b>                     | -/-             |
| <b>Format</b>                              | DEC_MV          |
| <b>Unit</b>                                | dB              |
| <b>Type</b>                                | Output register |
| <b>Decimal places</b>                      | 2               |
| <b>Buffered when control voltage fails</b> | No              |

Fig. 8-15: Parameter Attributes

**8.5.7 P-0-1321, PA: 2nd characteristic amplitude - last measurement**

By analogy to P-0-1320 for the second characteristic amplitude of the last measurement.

**8.5.8 P-0-1322, PA: 3rd characteristic amplitude - last measurement**

By analogy to P-0-1320 for the third characteristic amplitude of the last measurement.

**8.5.9 P-0-1323, PA: 4th characteristic amplitude - last measurement**

By analogy to P-0-1320 for the fourth characteristic amplitude of the last measurement.

**8.5.10 P-0-1368, PA: Characteristic value list of last measurement**

The parameter P-0-1368 is used to provide detailed information on the determined characteristic values of the test measurement. The beginning of the list parameter contains the determined characteristic values. The other elements contain measured values of the amplitude and phase responses.

| List element number | Designation/function                                                                                                                                                                                                                                                      | Comment                              |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 0                   | Operating hours counter of control section                                                                                                                                                                                                                                | [s], at the time of test measurement |
| 1                   | <b>Type of analysis</b><br>0000: Speed control loop<br>0001: Current control loop<br>0010: Position control loop<br>0011: Speed-controlled section<br>0100: Mechanical system frequency response<br>1001: Current loop, flux generating<br>1010: Freely configurable mode | Decimal display                      |

Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| List element number | Designation/function                                                         | Comment                                                                                                            |
|---------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| 2                   | <b>Analysis encoder</b><br>0: Encoder 1<br>1: Encoder 2                      |                                                                                                                    |
| 3                   | Checksum                                                                     | To evaluate whether test measurement may be related to reference measurement.                                      |
| 4                   | Preset noise signal amplitude                                                |                                                                                                                    |
| 5                   | Number of decimal places of element4                                         | The amplitude value entered in element4 must be scaled as DINT value with the decimal places set in element5.      |
| 6-9                 | No function                                                                  |                                                                                                                    |
| 10                  | Frequency bandwidth                                                          | [Hz]                                                                                                               |
| 11                  | Phase bandwidth                                                              | [degrees]                                                                                                          |
| 12-19               | No function                                                                  |                                                                                                                    |
| 20                  | <b>Type characteristic value 1</b><br>1: Resonance point<br>2: Antiresonance |                                                                                                                    |
| 21                  | Frequency characteristic value 1                                             | [Hz]                                                                                                               |
| 22                  | Amplitude characteristic value 1                                             | [dB]                                                                                                               |
| 23                  | Phase characteristic value 1                                                 | [degrees]                                                                                                          |
| 24                  | Coherence characteristic value 1                                             | Value between [0..1]                                                                                               |
| 25-29               | No function                                                                  |                                                                                                                    |
| 30-39               | Details of characteristic value 2                                            | By analogy to the data of characteristic value 1                                                                   |
| 40-49               | Details of characteristic value 3                                            | By analogy to the data of characteristic value 1                                                                   |
| 50-59               | Details of characteristic value 4                                            | By analogy to the data of characteristic value 1                                                                   |
| 60-69               | Details of characteristic value 5                                            | By analogy to the data of characteristic value 1                                                                   |
| 70-79               | Details of characteristic value 6                                            | By analogy to the data of characteristic value 1                                                                   |
| 80-97               | No function                                                                  |                                                                                                                    |
| 98                  | Number of support points for amplitude curve (and phase curve)               | According to the analysis type and performance setting, there is a certain number of support points (4046 or 2048) |
| 99                  | Frequency resolution for the support points                                  | [mHz]                                                                                                              |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| List element number          | Designation/function                | Comment   |
|------------------------------|-------------------------------------|-----------|
| 100-4145<br>or<br>100-2147   | Amplitude curve of test measurement | [dB]      |
| 4146-8192<br>or<br>2148-4195 | Phase curve of test measurement     | [degrees] |

|                                     |                                  |
|-------------------------------------|----------------------------------|
| Min./max. value                     | -                                |
| Format                              | DEC_MV                           |
| Unit                                | See comment on the list elements |
| Type                                | Output register                  |
| Decimal places                      | 2                                |
| Buffered when control voltage fails | No                               |

Fig. 8-16: Parameter Attributes

## 8.5.11 P-0-1370, PA: Configuration

The parameter P-0-1370 is used to configure the frequency response measurement.

| Bit | Designation/function                                                                                       | Comment                                                                                                                                                                                                       |
|-----|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3-0 | No function                                                                                                |                                                                                                                                                                                                               |
| 4   | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement                                             |                                                                                                                                                                                                               |
| 5   | <b>Display mode of the characteristic values</b><br>0: Frequency value<br>1: Amplitude value               | In the individual registers of the determined characteristic values for test and reference measurement, you can select whether the frequency point or the corresponding attenuation value is to be displayed. |
| 6   | No function                                                                                                |                                                                                                                                                                                                               |
| 7   | <b>Reaction</b><br>0: Only message via the status word<br>1: Error AND warning AND message via status word | 0: Diagnostic message only via the bits in P-0-1410 and P-0-1412<br>1: Additional diagnostic message on the display and in S-0-0390, as well as log-book entry                                                |
| 8   | <b>Return behavior</b><br>0: With return motion after each measurement<br>1: No return motion              | In this bit you can set whether the axis is to move back to the start position after a measurement.                                                                                                           |

Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| Bit   | Designation/function                                                                                                                                                                                                                                                              | Comment                                                                                                                                    |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 10/9  | <b>Mode for velocity control loop analysis</b><br>00: Out of standstill<br>01: Positive velocity offset<br>11: Negative velocity offset                                                                                                                                           | To suppress friction effects during the control loop analysis, you can parameterize an offset motion.                                      |
| 11    | <b>Analysis encoder</b><br>0: Encoder 1<br>1: Encoder 2                                                                                                                                                                                                                           | For the analyses of velocity control loop, position control loop and axis frequency response, you can select the desired analysis encoder. |
| 15-12 | No function                                                                                                                                                                                                                                                                       |                                                                                                                                            |
| 19-16 | <b>Type of frequency response</b><br>0000: Speed control loop<br>0001: Current control loop<br>0010: Position control loop<br>0011: Speed-controlled section, $F=v_{\text{encoderx}}/\text{motor torque}$<br>0100: Mechanical system, $F=v_{\text{encoder2}}/v_{\text{encoder1}}$ |                                                                                                                                            |
| 31-20 | No function                                                                                                                                                                                                                                                                       |                                                                                                                                            |

Fig. 8-17: Parameter Structure

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | -/-            |
| Format                              | BIN            |
| Unit                                | None           |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage falls | Yes            |

Fig. 8-18: Parameter Attributes

## 8.5.12 P-0-1371, PA: Tolerance band - error threshold factor

With the parameter P-0-1371 you can define a factor which sets the error thresholds. They result from the multiplication of the corresponding tolerance windows (P-0-1382 and P-0-1383 or from the corresponding list elements in P-0-1389) and P-0-1371.

With a value of 1.2, the difference between warning window and error window is 20%.

If a deviation is detected which exceeds this threshold, either F2011 (for frequency deviations) or F2012 (for attenuation deviations) is output when the drive diagnosis has been parameterized (P-0-1370).

|                 |                |
|-----------------|----------------|
| Min./max. value | 1/-            |
| Format          | DEC_MV         |
| Unit            | -              |
| Type            | Input register |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

|                                     |     |
|-------------------------------------|-----|
| Decimal places                      | 1   |
| Buffered when control voltage fails | Yes |

Fig.8-19: Parameter Attributes

**8.5.13 P-0-1372, PA: Bandwidth - reference measurement**

In the parameter P-0-1372, the bandwidth (-3dB limit) is stored upon successful reference measurement.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/4000          |
| Format                              | DEC_OV          |
| Unit                                | Hz              |
| Type                                | Output register |
| Decimal places                      | 2               |
| Buffered when control voltage fails | Yes             |

Fig.8-20: Parameter Attributes

**8.5.14 P-0-1373, PA: 1st characteristic frequency/amplitude - reference measurement**

The parameter P-0-1373 displays either the first determined characteristic frequency of the reference measurement or its amplitude value. You can change the display with the configuration parameter P-0-1370, bit 5.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     |                 |
| Format                              | DEC_MV          |
| Unit                                | Hz/dB           |
| Type                                | Output register |
| Decimal places                      | 2               |
| Buffered when control voltage fails | Yes             |

**8.5.15 P-0-1374, PA: 2nd characteristic frequency/amplitude - reference measurement**

By analogy to P-0-1373 for the second characteristic amplitude of the reference measurement.

**8.5.16 P-0-1375, PA: 3rd characteristic frequency/amplitude - reference measurement**

By analogy to P-0-1373 for the third characteristic amplitude of the reference measurement.

**8.5.17 P-0-1376, PA: 4th characteristic frequency/amplitude - reference measurement**

By analogy to P-0-1373 for the fourth characteristic amplitude of the reference measurement.

**8.5.18 P-0-1377, PA: Bandwidth - last measurement**

By analogy to P-0-1372 for the frequency response of a test measurement which was executed.

Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

**8.5.19 P-0-1378, PA: 1st characteristic frequency/amplitude - test measurement**

By analogy to P-0-1373 for the first characteristic value of the last measurement.

**8.5.20 P-0-1379, PA: 2nd characteristic frequency/amplitude - test measurement**

By analogy to P-0-1373 for the second characteristic value of the last measurement.

**8.5.21 P-0-1380, PA: 3rd characteristic frequency/amplitude - test measurement**

By analogy to P-0-1373 for the third characteristic value of the last measurement.

**8.5.22 P-0-1381, PA: 4th characteristic frequency/amplitude - test measurement**

By analogy to P-0-1373 for the fourth characteristic value of the last measurement.

**8.5.23 P-0-1382, PA: Tolerance band - amplitude values**

The parameter P-0-1382 is used to set the maximum allowed displacement of the amplitude values related to the corresponding amplitudes of the characteristic reference frequencies (cf. P-0-1389, list elements 200 to 400 for frequency response measurement). If during the test measurement an amplitude value is displaced by more than the value given in P-0-1382, the PLC warning E2012 is output.



If no value or the value "0" is given, those windows are evaluated which can be separately preset for each individual characteristic value in the list parameter P-0-1389.

By inputting the value "0", the monitoring of the individual characteristic values can be deactivated via the list.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_OV         |
| Unit                                | dB             |
| Type                                | Input register |
| Decimal places                      | 2              |
| Buffered when control voltage fails | Yes            |

Fig. 8-21: Parameter Attributes

**8.5.24 P-0-1383, PA: Tolerance band - characteristic frequencies**

The parameter P-0-1383 is used to set the maximum allowed displacement of the characteristic frequencies related to the corresponding characteristic reference frequencies (cf. P-0-1389, list elements 200 to 400 for frequency response measurement). If during the test measurement a frequency is displaced by more than the value given in P-0-1383, the PLC warning E2011 is output.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)



If no value or the value "0" is given, those windows are evaluated which can be separately preset for each individual characteristic value and the bandwidth in the list parameter P-0-1389.

By inputting the value "0", the monitoring of the individual characteristic values and of the bandwidth can be deactivated via the list.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_OV         |
| Unit                                | Hz             |
| Type                                | Input register |
| Decimal places                      | 2              |
| Buffered when control voltage fails | Yes            |

Fig. 8-22: Parameter Attributes

## 8.5.25 P-0-1384, PA: Operating hours - reference measurement

In the parameter P-0-1384, the operating hours count at the last determination of the **characteristic reference values** is entered.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | Seconds         |
| Type                                | Output register |
| Decimal places                      | 1               |
| Buffered when control voltage fails | Yes             |

Fig. 8-23: Parameter Attributes

## 8.5.26 P-0-1385, PA: Operating hours - test measurement

In the parameter P-0-1385, the operating hours count at the last execution of a **test measurement** is entered.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | Seconds         |
| Type                                | Output register |
| Decimal places                      | 1               |
| Buffered when control voltage fails | Yes             |

Fig. 8-24: Parameter Attributes

## 8.5.27 P-0-1387, PA: Status text

The parameter P-0-1387 is used to output the status text / diagnostic message text of the PLC and to signal incorrect settings.

|                 |       |
|-----------------|-------|
| Min./max. value | -/-   |
| Format          | ASCII |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

|                                            |                 |
|--------------------------------------------|-----------------|
| <b>Unit</b>                                | -               |
| <b>Type</b>                                | Output register |
| <b>Decimal places</b>                      | -               |
| <b>Buffered when control voltage fails</b> | No              |

Fig. 8-25: Parameter Attributes

### 8.5.28 P-0-1389, PA: Reference data

The elements 200 to 399 of the list parameter P-0-1389 are used to store the characteristic values and configurations of the reference measurement.

| List element number | Designation/function                                                                                                                                                                                                                                                      | Comment                                                                                                             |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 200                 | Operating hours counter of control section                                                                                                                                                                                                                                | [s], at the time of reference measurement                                                                           |
| 201                 | <b>Type of analysis</b><br>0000: Speed control loop<br>0001: Current control loop<br>0010: Position control loop<br>0011: Speed-controlled section<br>0100: Mechanical system frequency response<br>1001: Current loop, flux generating<br>1010: Freely configurable mode | Decimal display                                                                                                     |
| 202                 | <b>Analysis encoder</b><br>0: Encoder 1<br>1: Encoder 2                                                                                                                                                                                                                   |                                                                                                                     |
| 203                 | Checksum                                                                                                                                                                                                                                                                  |                                                                                                                     |
| 204                 | Preset noise signal amplitude                                                                                                                                                                                                                                             | P-0-1155 for the measurement                                                                                        |
| 205                 | Number of decimal places of element 204                                                                                                                                                                                                                                   | The amplitude value entered in element 204 must be scaled as DINT value with the decimal places set in element 205. |
| 210                 | Frequency bandwidth                                                                                                                                                                                                                                                       | [Hz]                                                                                                                |
| 211                 | Phase bandwidth                                                                                                                                                                                                                                                           | [degrees]                                                                                                           |
| 212-219             | Reserved, bandwidth information                                                                                                                                                                                                                                           |                                                                                                                     |
| 220                 | Type characteristic value 1<br>0: Resonance; 1: Antiresonance                                                                                                                                                                                                             |                                                                                                                     |
| 221                 | Frequency characteristic value 1                                                                                                                                                                                                                                          | [Hz]                                                                                                                |
| 222                 | Amplitude characteristic value 1                                                                                                                                                                                                                                          | [dB]                                                                                                                |
| 223                 | Phase characteristic value 1                                                                                                                                                                                                                                              | [degrees]                                                                                                           |
| 224                 | Coherence characteristic value 1                                                                                                                                                                                                                                          | Value between [0..1]                                                                                                |
| 225-229             | Reserved, details of characteristic value 1                                                                                                                                                                                                                               |                                                                                                                     |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| List element number | Designation/function                                             | Comment                                                                           |
|---------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 230-239             | Details of characteristic value 2                                | By analogy to the data of characteristic value 1                                  |
| 240-249             | Details of characteristic value 3                                | By analogy to the data of characteristic value 1                                  |
| 250-259             | Details of characteristic value 4                                | By analogy to the data of characteristic value 1                                  |
| 260-269             | Details of characteristic value 5                                | By analogy to the data of characteristic value 1                                  |
| 270-279             | Details of characteristic value 6                                | By analogy to the data of characteristic value 1                                  |
| 300                 | No function                                                      |                                                                                   |
| 301                 | Tolerance window bandwidth                                       | If no value is set in P-0-1383, this value applies to the bandwidth.              |
| 302-309             | Reserved, tolerances of the bandwidth                            |                                                                                   |
| 310                 | Tolerance window amplitude values characteristic value 1         | If no value is set in P-0-1382, this value applies to the characteristic value 1. |
| 311                 | Tolerance window characteristic frequency characteristic value 1 | If no value is set in P-0-1383, this value applies to the characteristic value 1. |
| 312-319             | Reserved, tolerances of characteristic value 1                   |                                                                                   |
| 320                 | Tolerance window amplitude values characteristic value 2         | If no value is set in P-0-1382, this value applies to the characteristic value 2. |
| 321                 | Tolerance window characteristic frequency characteristic value 2 | If no value is set in P-0-1383, this value applies to the characteristic value 2. |
| 322-329             | Reserved, tolerances of characteristic value 2                   |                                                                                   |
| 330                 | Tolerance window amplitude values characteristic value 3         | If no value is set in P-0-1382, this value applies to the characteristic value 3. |
| 331                 | Tolerance window characteristic frequency characteristic value 3 | If no value is set in P-0-1383, this value applies to the characteristic value 3. |
| 332-339             | Reserved, tolerances of characteristic value 3                   |                                                                                   |
| 340                 | Tolerance window amplitude values characteristic value 4         | If no value is set in P-0-1382, this value applies to the characteristic value 4. |
| 341                 | Tolerance window characteristic frequency characteristic value 4 | If no value is set in P-0-1383, this value applies to the characteristic value 4. |
| 342-349             | Reserved, tolerances of characteristic value 4                   |                                                                                   |
| 350                 | Tolerance window amplitude values characteristic value 5         | If no value is set in P-0-1382, this value applies to the characteristic value 5. |
| 351                 | Tolerance window characteristic frequency characteristic value 5 | If no value is set in P-0-1383, this value applies to the characteristic value 5. |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| List element number | Designation/function                                             | Comment                                                                           |
|---------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 352-359             | Reserved, tolerances of characteristic value 5                   |                                                                                   |
| 360                 | Tolerance window amplitude values characteristic value 6         | If no value is set in P-0-1382, this value applies to the characteristic value 6. |
| 361                 | Tolerance window characteristic frequency characteristic value 6 | If no value is set in P-0-1383, this value applies to the characteristic value 6. |
| 362-369             | Reserved, tolerances of characteristic value 6                   |                                                                                   |

|                                     |                                  |
|-------------------------------------|----------------------------------|
| Min./max. value                     | -/-                              |
| Format                              | DEC_MV                           |
| Unit                                | See comment on the list elements |
| Type                                | Output register                  |
| Decimal places                      | 2                                |
| Buffered when control voltage fails | Yes                              |

Fig. 8-26: Parameter Attributes

### 8.5.29 P-0-1390, PA: Control word

The parameter P-0-1390 is used to control the frequency response measurement/analysis.

| Bit  | Designation/function | Comment                 |
|------|----------------------|-------------------------|
| 1    | Start                | Called by positive edge |
| 0    | No function          |                         |
| 2    | Stop/abortion        | Called by positive edge |
| 4-15 | No function          |                         |

Fig. 8-27: Parameter Structure

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | -/-            |
| Format                              | BIN            |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | No             |

Fig. 8-28: Parameter Attributes

### 8.5.30 P-0-1410, PA: Status word

The parameter P-0-1410 is used as status word for the frequency response measurement/analysis and makes available the important status bits and states to the higher-level control unit.

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

| Bit   | Designation/function                                                                                                      | Comment                                                                                                                                  |
|-------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | No function                                                                                                               |                                                                                                                                          |
| 1     | Ready                                                                                                                     | Frequency response analysis can be started                                                                                               |
| 2     | Active                                                                                                                    | Measurement and analysis running                                                                                                         |
| 3     | <b>Reference available</b><br>0: No reference values<br>1: Reference values available                                     |                                                                                                                                          |
| 4     | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement                                                            |                                                                                                                                          |
| 5     | No function                                                                                                               |                                                                                                                                          |
| 6     | <b>Error status</b><br>0: No error<br>1: Error                                                                            | A displacement which is outside of the error tolerance has been detected.                                                                |
| 7     | Attenuation amplitude change of at least of characteristic value with regard to reference                                 | Warning E2012 or error F2012 is output                                                                                                   |
| 8     | Characteristic frequency displacement of at least of characteristic value with regard to reference                        | Warning E2011 or error F2011 is output                                                                                                   |
| 9     | Abortion due to drive warning/error                                                                                       | For example, torque limit value exceeded. Explicit display in "P-0-1387, Status text"                                                    |
| 10    | 0: Amplitude command value valid<br>1: Parameterized amplitude command value equals "0"                                   | It is only possible to trigger a measurement, if a value unequal "0" has been entered in "P-0-1155, Command value generator, amplitude". |
| 11-13 | No function                                                                                                               |                                                                                                                                          |
| 14    | <b>Check of analysis type</b><br>0: Configuration of analysis type valid<br>1: Configuration of analysis type invalid     | If an incorrect configuration is set via P-0-1370 for the next measurement, this is displayed in this bit.                               |
| 15    | <b>Checksum verification</b><br>0: Checksums of test and reference measurements are matching<br>1: Checksums do not match |                                                                                                                                          |

Fig. 8-29: Parameter Structure

|                        |                 |
|------------------------|-----------------|
| <b>Min./max. value</b> | -/-             |
| <b>Format</b>          | BIN             |
| <b>Unit</b>            | None            |
| <b>Type</b>            | Output register |

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

|                                     |      |
|-------------------------------------|------|
| Decimal places                      | None |
| Buffered when control voltage fails | No   |

Fig. 8-30: Parameter Attributes

### 8.5.31 P-0-1412, PA: Error/warning status

The parameter P-0-1412 contains the exact error/warning status of the comparison of test measurement and reference measurement as regards the individual characteristic values.

| Bit   | Designation/function                                                                                                                                                  | Comment                                                                                                                                                                                  |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | <b>Status bandwidth</b><br>0: OK<br>1: Frequency outside of window                                                                                                    | This bit indicates whether the bandwidth is outside of the warning window. Bit 2 displays whether an error is present (error window can be defined via P-0-1371).                        |
| 1     | <b>Error/warning status bandwidth</b><br>0: No error<br>1: Error                                                                                                      | Signals whether the parameterizable error tolerance (P-0-1371) has been exceeded.                                                                                                        |
| 3,2   | <b>Status characteristic value 1</b><br>00: OK<br>01: Frequency outside of window<br>10: Amplitude outside of window<br>11: Frequency and amplitude outside of window | This bit indicates whether the characteristic value is outside of the warning window. The following bit displays whether an error is present (error window can be defined via P-0-1371). |
| 4     | <b>Error/warning characteristic value 1</b><br>0: No error<br>1: Error                                                                                                | Signals whether a displacement outside of the defined error thresholds and thereby an error is present.                                                                                  |
| 7-5   | <b>Status of characteristic value 2</b>                                                                                                                               | By analogy to the bits 4-2 for characteristic value 1                                                                                                                                    |
| 10-8  | <b>Status of characteristic value 3</b>                                                                                                                               | By analogy to the bits 4-2 for characteristic value 1                                                                                                                                    |
| 13-11 | <b>Status of characteristic value 4</b>                                                                                                                               | By analogy to the bits 4-2 for characteristic value 1                                                                                                                                    |
| 15,14 | No function                                                                                                                                                           |                                                                                                                                                                                          |

Fig. 8-31: Parameter Structure

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | -/-             |
| Format                              | BIN             |
| Unit                                | None            |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig. 8-32: Parameter Attributes

## Frequency Response Measurement and Analysis (FWS\_MLDPBP\_FAGxxx\_02Vxx\_D0\_MP0x)

**8.5.32 P-0-1413, PA: Amplitude command value ideal - integral**

In parameter P-0-1413, a command value amplitude for the test measurement is suggested so that limitations do not become active with noise excitation, when the strongest possible excitation of the axis is to be achieved at the same time. This parameter displays the integral component of the determined amplitude value. The unit of the parameters depends on the selected analysis type and the scaling set on the user side. It corresponds to the scaling of the target parameter for the noise signal or of "P-0-1155, Command value generator, amplitude".

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_MV          |
| Unit                                | Cf. P-0-1155    |
| Type                                | Output register |
| Decimal places                      | 0               |
| Buffered when control voltage fails | No              |

Fig. 8-33: Parameter Attributes

**8.5.33 P-0-1414, PA: Amplitude command value ideal - decimal places**

The parameter P-0-1414 is used to display the decimal places of the suggested amplitude.



It is mostly sufficient to evaluate the integral component (P-0-1413) of the suggested amplitude.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_MV          |
| Unit                                | Cf. P-0-1155    |
| Type                                | Output register |
| Decimal places                      | 0               |
| Buffered when control voltage fails | No              |

Fig. 8-34: Parameter Attributes

## 9 Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

### 9.1 Brief Description

Envelope curve monitoring allows monitoring a freely configurable signal to find out whether two defined tolerance bands are exceeded.

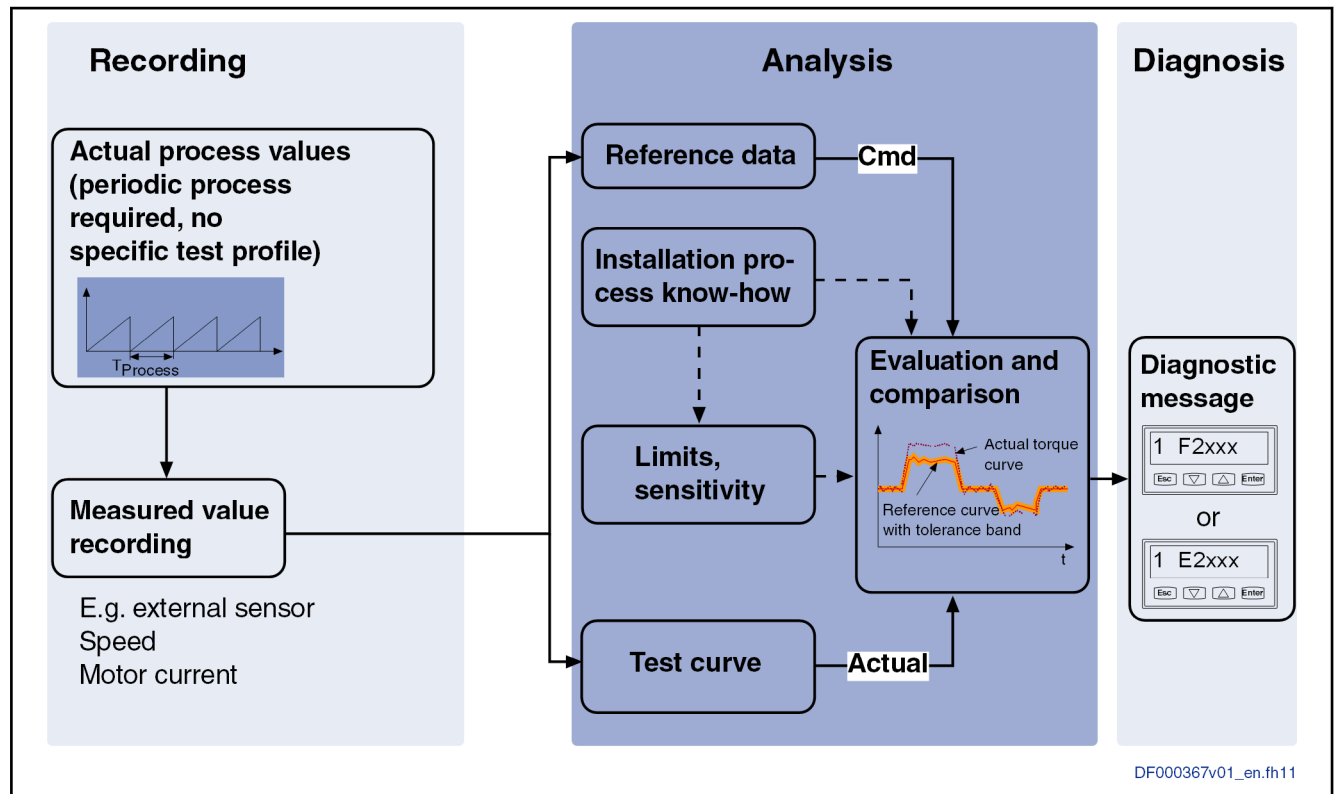


Fig.9-1: Overview of Functions of Envelope Curve Monitoring

#### Requirements of Use

To use the extended diagnostic functions, the software, firmware and hardware requirements must have been fulfilled (see "Required Components").

To use the extended diagnostic function "envelope curve monitoring", the PLC project "FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x" must in addition have been loaded and activated in the drive (see "How to Load Technology Functions to the Drive").

#### Fields of Application

The extended diagnostic function "envelope curve monitoring" is a monitoring function which can be used to check the mechanical drive system or the entire operating process for mechanical and electrical changes during operation ("online method").



Using the function requires a cyclically recurring travel profile (e.g., cam mode, positioning block mode, ...).

According to the measuring signal and mechanical system, different mechanical and electrical changes can be diagnosed by means of the envelope curve method. What kind of change is monitored and diagnosed and in which quality, depends on the measuring signal.

If the torque is monitored, for example, the mechanical system can be checked for blocking; if the encoder difference is monitored when the direc-

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

tion of rotation is reversed, occurring backlash, for example, can be diagnosed.

**Functional Features**

The "envelope curve monitoring" has the following features:

- No additional sensors are required (available drive sensors are used); if necessary, it is possible to evaluate additional sensors via analog inputs.
- The function allows checking different mechanical features in a test run ("offline method"). In running operation, the monitoring function can be activated in the background at any time. At the beginning you once have to start a specific reference run. Afterwards, the test measurements can be triggered over and over again so that cyclic monitoring is possible in conjunction with the oscilloscope trigger.
- The "envelope curve monitoring" is divided into 2 steps:
  - Step 1: Execution of a reference measurement in running operation during which the "actual" or "good" state of the mechanical drive system is determined.
  - Step 2: Execution of the cyclic test measurement later on in operation in order to permanently compare the state of the mechanical drive system to the state at the time of reference measurement.
- Freely configurable measuring signal for envelope curve monitoring (e.g., motor current, lag error, motor temperature, external sensor, ...)
- Freely configurable trigger signals (e.g., master axis angle, positioning block number, actual position value, motor current)
- Freely selectable sampling rate (62.5µs to 8s) and number of measured values (max. 1000) within the scope of the drive-internal oscilloscope function
- Monitoring section in overall cycle to be freely defined via a trigger level and the number of measured values
- Freely definable tolerance bands (positive and negative) and sensitivities for monitoring
- Parameterizable reaction (error, warning, binary signal) when values exceed the tolerance bands between reference and test state

**Limitations of the Function**

The function has the following limitations:

- Only one mechanical drive system can be monitored.
- Only one signal can be monitored. If several signals are to be monitored, this must be done one after the other.
- The monitoring is only suited for cyclic (periodic) processes with unchanging load conditions and positioning data.
- Between reference measurement and the cyclic test measurements, positioning data and parameters influencing the control behavior or scaling of the drive mustn't be changed, because otherwise there will be faulty diagnoses.
- Changes in the ambient conditions (temperature, load, ...) can have an effect on the test signal and cause faulty diagnoses.
- A maximum of 1000 measured values can be recorded and monitored.

**Pertinent Parameters**

The following parameters are used in conjunction with the extended diagnostic function "envelope curve monitoring". (The parameter names correspond to the respective significances for the diagnostic functions and not to the actual parameter names which are displayed, for example, in IndraWorks.)

- P-0-1368, PA: Measuring curves

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

- P-0-1370, PA: Configuration
- P-0-1371, PA: Factor tolerance band 2, signal 1
- P-0-1372, PA: Absolute tolerance positive
- P-0-1373, PA: Absolute tolerance negative
- P-0-1374, PA: Sensitivity
- P-0-1375, PA: Relative tolerance positive
- P-0-1376, PA: Relative tolerance negative
- P-0-1377, PA: Max. number of deviations - tolerance 1, signal 1
- P-0-1378, PA: Max. number of deviations - tolerance 2, signal 1
- P-0-1384, PA: Operating hours - reference measurement
- P-0-1385, PA: Operating hours - test measurement
- P-0-1387, PA: Status text
- P-0-1389, PA: Reference data
- P-0-1390, PA: Control word
- P-0-1410, PA: Status word



As the oscilloscope function is used for measurement and analysis, see Functional Description of firmware for details on how to use/parameterize the oscilloscope function.



The average value filter for display can be used for filtering the measured values. For its functional principle and parameterization, see Functional Description of firmware.

### Pertinent Diagnostic Messages

The following diagnostic messages are used in conjunction with the function; they appear on the display of the drive and in "S-0-0390, Diagnostic message number":

- F2011
- E2011



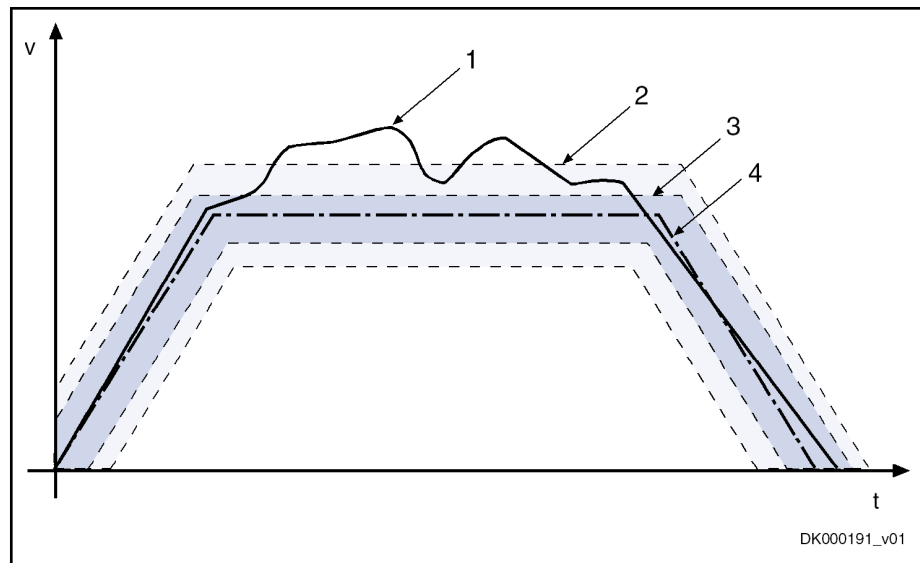
The diagnostic messages F2011 and E2011 are only output when the corresponding tolerance deviation has occurred during a test measurement and the error reaction has been parameterized in P-0-1370 (bit7 has been set).

When the tolerance bands 1 and 2 are exceeded, this is always displayed in P-0-1410 (bit 7, 8).

## 9.2 Functional Description

The figure below illustrates the functional principle of the monitoring method; a reference curve which was recorded and stored is cyclically compared to the current measured values (actual values).

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)



- 1 Signal curve test measurement
- 2 Tolerance band 2
- 3 Tolerance band 1
- 4 Signal curve reference measurement

Fig.9-2: Reference/Test Curves and Tolerance Band 1/Tolerance Band 2

#### Functional Steps

The diagnostic function is divided into the steps "reference measurement" and "test measurement":

- **Reference measurement**

In the first step, the "actual" or "good" state of the mechanical drive system is recorded and stored; this ideally takes place after successful commissioning, optimization and when the mechanical drive system has run in/warmed up. The curve of the signal recorded with the drive-internal oscilloscope function is stored as reference (curve).



The operating company of the machine or the machine manufacturer has to assess the mechanical drive system as "good", this assessment is not a functionality of the "Productivity Agent".

- **Test measurement**

In the second step in running operation, the current measured values are cyclically compared to the previously stored reference curve. Depending on freely definable tolerance bands / envelope curves and sensitivities (evaluation criteria) for the selected signal, a warning or error message is generated when the values exceed the tolerance bands, and output takes place in P-0-1410.



With P-0-1389, list element number 1023 (checksum)="1", it is prevented that the checksum verification is carried out before each test measurement.

*Fig.9-3: States and Transitions for the Envelope Curve Monitoring*

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

## 9.3 Notes on Commissioning and Operation

### 9.3.1 General Information on Commissioning

**Initial Situation** The successful commissioning of the extended diagnostic function "envelope curve monitoring" requires the following initial situation:

- The drive has been commissioned, i.e. it is operable.
- The communication between control unit and drive exists.
- The installation has run in and all operation parameters have reached their stationary status.
- The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
- The PLC project "FWS\_MLDPBP\_SCHxxx\_02Vxx\_D0\_MP0x" has been loaded and activated for the firmware version at hand (see "How to Load Technology Functions to the Drive").
- During the reference and test measurements, the ambient conditions (e.g. temperature) should possibly be the same to keep the external influences on the diagnosis quality at the lowest possible level.

**Overview of Required Individual Steps for Commissioning**

The commissioning of the extended diagnostic function "envelope curve monitoring" consists of the following steps:

**Configuring the function**

1. Select and configure the signal to be monitored (e.g., motor current, speed, lag error, ...)
2.
  - a) Record the reference curve (via P-0-1390) and, if necessary, save the current reference values (of P-0-1389) or
  - b) Load already determined reference values (via P-0-1389).
3. Enter the tolerance values in P-0-1372, P-0-1373, P-0-1375 and P-0-1376
4. Set the allowed number of measuring points in direct succession outside of the tolerance bands (sensitivity) in P-0-1374
5. Set the factor between threshold 1 and threshold 2 with P-0-1371

**Operating/using the function**

The function is used permanently, also later in operation and this implies triggering a reference or test measurement or adjusting tolerance bands and sensitivities; thus, the operation/use of the function is divided into the following steps which must be repeated, if required:

1. Start or activate (cyclically) the test measurement (via P-0-1390)
2. Display and evaluate the results with P-0-1377, P-0-1378 and P-0-1389

**Parameter Interface to Configure and Operate the Function**

Apart from a cyclically configurable control and status word, there are other parameters available to configure and operate the function; these parameters can be accessed via the acyclic channel. The following interface parameters are supported:

- Status information on the entire drive system
- Counts of operating hours counters
- Deviation of test measurement from reference measurement (cf. P-0-1371 to P-0-1378)
- Display of the name of the technology function (cf. P-0-1361)
- Display of the status text and diagnostic message text (cf. P-0-1387) and of many configuration parameters

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)



All parameters and PLC registers allow data exchange of a higher-level PLC or control unit with the drive.

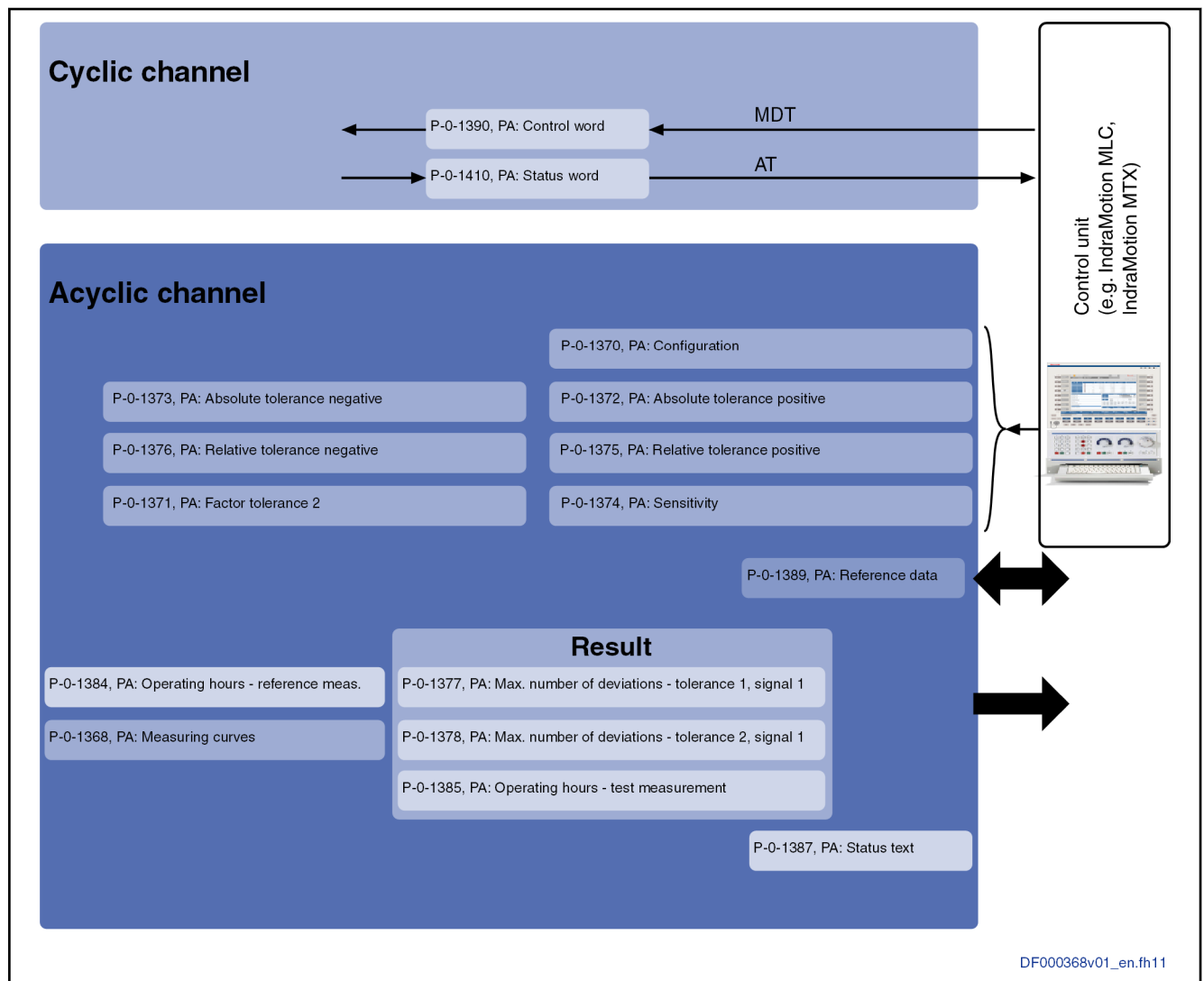


Fig.9-4: Overview of Parameters for the Envelope Curve Monitoring

### 9.3.2 Configuration and Operation via Parameters

#### Commissioning Step 1: Selecting the Measuring Signal

Within the drive-integrated oscilloscope function, the user can freely parameterize the measuring signal, the number of measured values and the time resolution. The selected signal can be smoothed by means of the average value filter for display.

The following aspects have to be taken into account:

- The settings made for the reference measurement must be used for the following test measurements, too. Otherwise, an error message is output (checksum wrong; P-0-1410; P-0-1387), when the checksum verification is active.
- When the measuring motion and/or the measuring signal are changed, this requires carrying out a new reference measurement.
- Mechanical changes at the machine (e.g., additional loads or changes in acceleration) require carrying out a new reference measurement.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

- An exact and reproducible trigger point (e.g., binary signal, command value) is necessary to record and evaluate test curves with the highest possible degree of comparability.
- When the envelope curve monitoring of the "Productivity Agent" is active, the integrated oscilloscope function cannot be used for other purposes.

**Commissioning Step 2a: Recording the Reference Curve**

To execute a reference measurement, carry out the following steps:

1. In P-0-1370, set with bit4="1" that the next signal recording is used as reference measurement.
2. Setting bit0="1" of P-0-1390 enables the functionality and allows starting a measurement.  
In P-0-1410, bit1 signals that the technology function is ready for starting the reference measurement.
3. A positive edge on bit1 of P-0-1390 starts the drive-internal oscilloscope. The actual measured value recording for the reference measurement starts with the trigger signal. A running measurement can be aborted by means of P-0-1390 by a rising edge on bit2, or by removing the "Enable" bit (bit0).

The successful start of the oscilloscope function is acknowledged in P-0-1410, bit2. After the recording has been completed, bit2 goes to "0" again. In addition, P-0-1410, bit3="1", signals that a reference curve is available and test measurements can be started.

In P-0-1384, the time of the operating hours counter, at which the reference curve was recorded, is stored upon completed reference measurement.

Upon successful reference data recording, all important reference data are available in the list parameter P-0-1389. The elements 0 to 999 contain the maximum of 1000 measured values of the actual reference curve. Element 1022 contains the operating hours count at which the reference measurement was executed. Element 1023 contains the corresponding checksum. These data are retained in the parameter, even after the drive has been switched off and on again, and do not have to be stored externally.



If several reference curves are required (e.g., due to different workpieces etc.), the respective reference data from P-0-1389 must be stored outside of the drive and selectively loaded to the drive before each test measurement. Apart from reference curve and checksum, it is recommended that you save the oscilloscope, filter and, if necessary, controller settings. This means that you should save all parameter values which were changed from reference measurement to reference measurement.

If the tolerance bands and sensitivities change together with the reference curves, these settings, too, should be saved together with the reference data.

**Commissioning Step 2b: Loading the Reference Curve**

At any time, you can subsequently load the reference data to the drive without a new reference measurement being required. This might be necessary, for example, in the case of product or tool change, when different reference curves/settings are to be stored. The externally saved reference information from the list parameter P-0-1389 (incl. operating hours count and checksum) and possibly saved oscilloscope and drive settings only have to be written to

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

the corresponding drive parameters. When this is done, they immediately become effective and are used for the following test measurements.

By means of the checksum in P-0-1389, element 1023, a check is run during a following test measurement to find out whether the current (possibly loaded) oscilloscope settings for the test measurement comply with those of the loaded reference measurement. If "1" is entered in this element, the checksum is not verified before the following test measurement is started. The operating hours count can optionally be entered in element 1022 of the list parameter P-0-1389. This value is only used to display the operating hours count at which the loaded reference measurement was executed (in addition, it is directly copied to P-0-1384).



A reference import (only list parameter P-0-1389!) can also take place during a test measurement which has already been started and is running. The loaded reference data only become active for the following test measurement, not for the one which has already been started.

It is only possible to make available the reference data of **one** reference measurement in the drive; it is impossible to simultaneously save several reference measurements in the drive, this must be done externally. In this case, load the respective reference data separately to the drive.

### Commissioning Step 3: Setting the Tolerance Bands

With the following parameters, lay two freely definable tolerance bands around the reference curve:

- P-0-1371, PA: Factor tolerance band 2, signal 1
- P-0-1372, PA: Absolute tolerance positive
- P-0-1373, PA: Absolute tolerance negative
- P-0-1375, PA: Relative tolerance positive
- P-0-1376, PA: Relative tolerance negative



By means of P-0-1371, the tolerance band 2 is automatically set from the tolerance band 1 defined with P-0-1372, P-0-1373, P-0-1375 and P-0-1376.

The tolerance bands around the reference curve result from the following tolerance calculations for each measured value of the reference curve:

$$\text{Tolerance band } 1_{\text{positive}} = \text{Reference value (x)} + \text{P-0-1372} + \text{Reference value (x)} \cdot \frac{\text{P-0-1375}}{100}$$

Fig. 9-5: Tolerance Band 1, Positive

$$\text{Tolerance band } 1_{\text{negative}} = \text{Reference value (x)} + \text{P-0-1373} + \text{Reference value (x)} \cdot \frac{\text{P-0-1376}}{100}$$

Fig. 9-6: Tolerance Band 1, Negative

## Envelope Curve Monitoring (FWS\_MLDPaX\_SCH\_02Vxx\_D0\_MP0x)

$$\text{Tolerance band } 2_{\text{positive}} = \text{Reference value (x)} + \text{P-0-1371} \cdot \left( \text{P-0-1372} + \text{Reference value (x)} \cdot \frac{\text{P-0-1375}}{100} \right)$$

Fig.9-7: Tolerance Band 2, Positive

$$\text{Tolerance band } 2_{\text{negative}} = \text{Reference value (x)} + \text{P-0-1371} \cdot \left( \text{P-0-1373} + \text{Reference value (x)} \cdot \frac{\text{P-0-1376}}{100} \right)$$

Fig.9-8: Tolerance Band 2, Negative

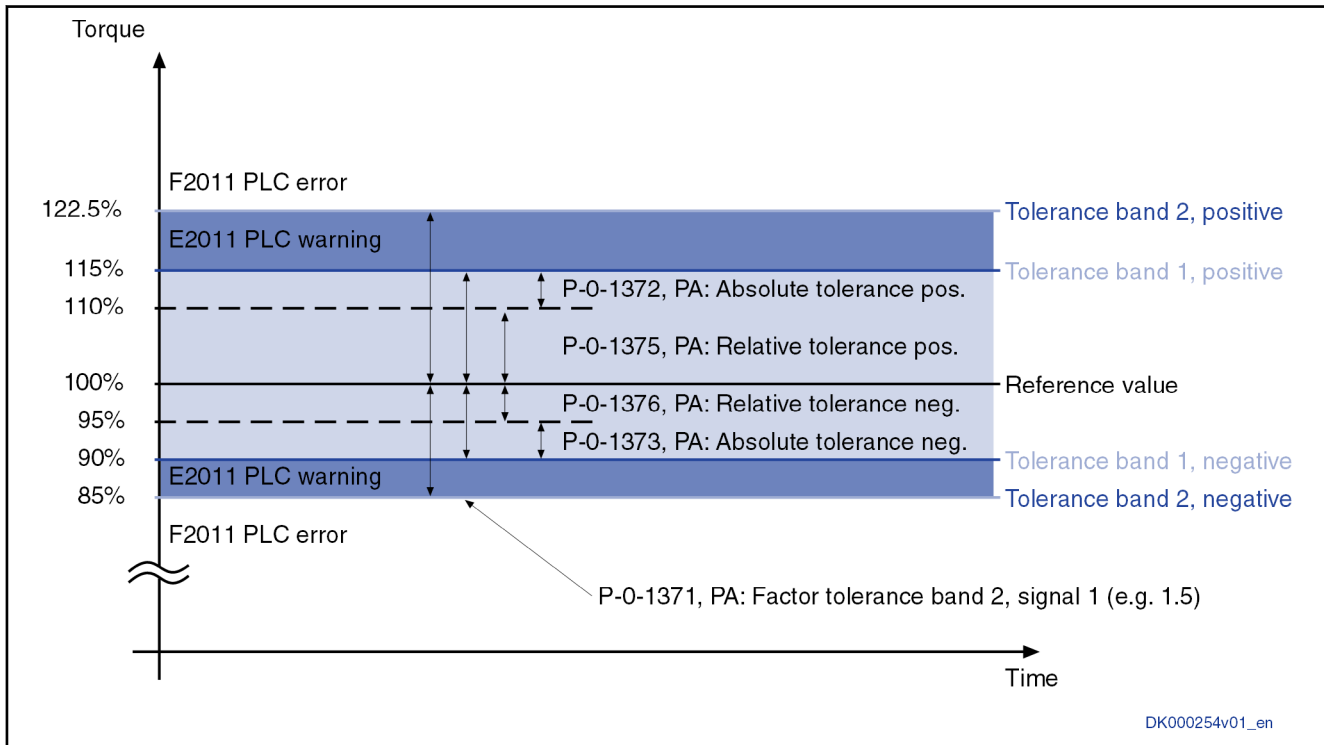


Fig.9-9: Defining the Two Tolerance Bands (for a Constant Reference Curve in this Case)



If the test curve has a deviation from the reference curve greater than the tolerance band, bits depending on the defined sensitivity are set in P-0-1410, or an error/warning is generated:

- Tolerance band 1 exceeded: P-0-1410, bit7; warning E2011
- Tolerance band 2 exceeded: P-0-1410, bit8; error F2011

## Commissioning Step 4: Setting the Sensitivity

Via the parameter P-0-1374, set the sensitivity. The sensitivity defines the minimum of measured values in succession which must be outside of the tolerance band so that a violation of the tolerance band is output. The value applies to the tolerance bands 1 and 2.

By means of the sensitivity, it is possible to display only deviations from the reference curve which last for a longer time. In addition, the sensitivity can be used to avoid reactions to inaccuracies in the measuring signal (e.g. noise) or when the oscilloscope function is triggered.

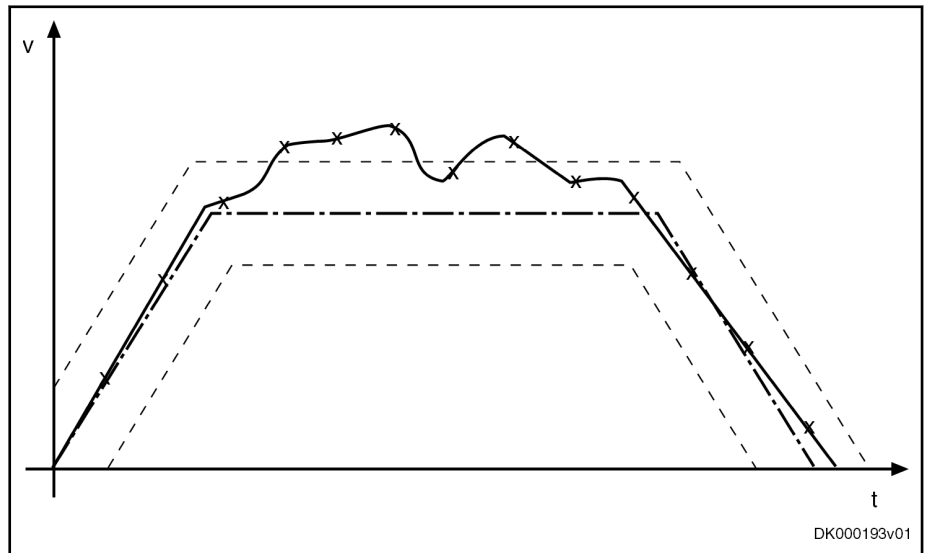
Independent of the value in P-0-1374, the currently determined maximum number of measured values, which in succession are outside of a tolerance band, is displayed in P-0-1378 and P-0-1377 after each test measurement.

DK000254v01\_en

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

**Example:** The value for sensitivity entered in P-0-1374 is "7". This means that during a test measurement, at least 7 measured values in direct succession must be outside of a tolerance band so that a deviation is diagnosed.

When the tolerance band 1 is exceeded several times with the test signal (see figure below), and not more than a maximum of 3 measured values in direct succession are outside of the tolerance, there isn't any deviation detected. The parameter P-0-1377, however, displays "3". This means that a maximum of 3 measured values in succession are outside of the tolerance band 1 at one (or several) point(s) of the last test curve.

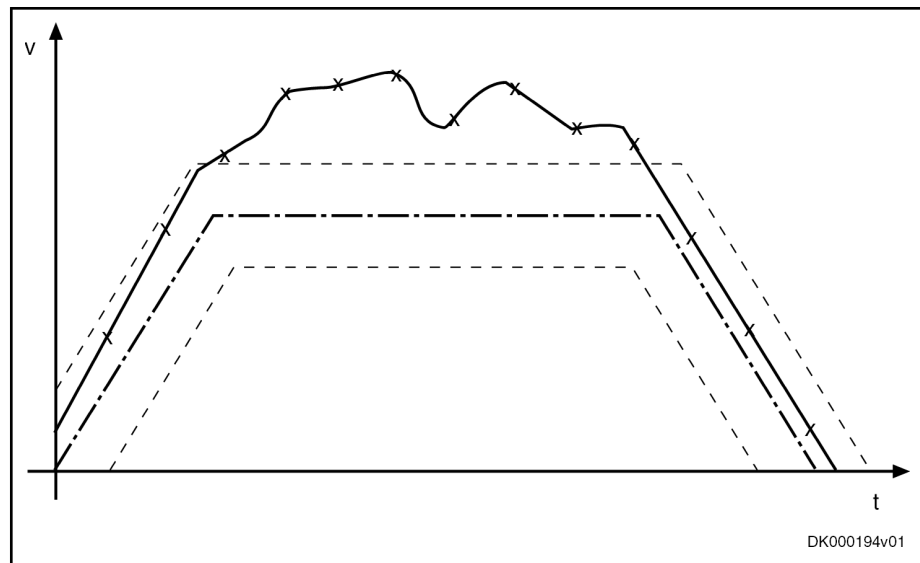


|                  |                                    |
|------------------|------------------------------------|
| Dashed line:     | Tolerance band 1                   |
| Dash-dot line:   | Signal curve reference measurement |
| Continuous line: | Signal curve test measurement      |
| x:               | Measuring point                    |

*Fig. 9-10: Test Signal without Deviation Diagnosed*

If 8 measured values in succession at one point are outside of the tolerance band 1 (see figure below), this is diagnosed as deviation and output accordingly. In this case, the parameter P-0-1377 contains the value "8".

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)



|                  |                                    |
|------------------|------------------------------------|
| Dashed line:     | Tolerance band 1                   |
| Dash-dot line:   | Signal curve reference measurement |
| Continuous line: | Signal curve test measurement      |
| x:               | Measuring point                    |

Fig. 9-11: Test Signal with Deviation Diagnosed

**Commissioning Step 5: Activating the Cyclic Test Measurement**

As prerequisite for executing a test measurement, a reference curve must be available in the drive for the envelope curve monitoring function (P-0-1410, bit3).

The test measurement is carried out in the following steps:

1. By setting bit 4="0" (test measurement) in P-0-1370, select that the next signal recording is used as test measurement.

The successful selection is signaled back in bit4 of P-0-1410.

2. Setting bit0 of P-0-1390 enables the functionality and allows starting a measurement.

The oscilloscope, filter and controller settings must comply with those of the active reference measurement. This is monitored by means of the checksum entered in the parameter P-0-1389, element 1023. If a deviation of the current oscilloscope settings from the ones at reference curve recording is detected by means of the checksum, this is displayed in P-0-1410, bit15.

P-0-1410, bit1, signals that the technology function is ready to start the test measurement.



The value in P-0-1371 must be greater than or equal to "1", otherwise the test measurement cannot be started. This is displayed in P-0-1410 with bit1="0" and bit14="1".

3. Start the test measurement via positive edge on bit1 of P-0-1390. Thereby, the measured value recording does not begin immediately, but it is only the drive-internal oscilloscope which is started and waits for the trigger.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

The successful start of the oscilloscope function is acknowledged in P-0-1410, bit2. A running measurement or evaluation can be aborted by a rising edge on bit2 of P-0-1390 or by removing the "Enable" bit (bit0) of P-0-1390.

During the measured value recording and evaluation of the test curve, bit2 of P-0-1410 is set. After the evaluation of the measured values has been completed, the bit goes to "0" again. The results of the comparison between reference and test curve, in consideration of the parameterized tolerance bands and sensitivities, are now output (see "[Commissioning Step 6: Evaluating and Displaying the Results](#)").

In parameter P-0-1385, the time of the operating hours counter, at which the test curve was recorded, is stored and displayed after the recording and evaluation of the test curve has been completed. If required, store this value externally together with the data of the corresponding reference curve.

**⚠ CAUTION**

**Danger of faulty diagnoses by changes made between reference and test measurement!**

⇒ Between reference measurement and the cyclic test measurements, positioning data and parameters influencing the control behavior or scaling of the drive mustn't be changed, because otherwise there will be faulty diagnoses.

⇒ Changes in the ambient conditions (temperature, load, ...) can have an effect on the test signal and cause faulty diagnoses.

⇒ You have to make sure for the test measurement that the oscilloscope, filter and controller settings comply with the ones of the corresponding reference measurement; for this purpose, you can use the checksum (P-0-1389, element 1023). If the oscilloscope settings and reference number for the test measurement do not comply with those of the reference measurement, the checksum is invalid and the test measurement cannot be started. This is displayed in P-0-1410 with the bits1="0" and 15="1". Exception: P-0-1389, element 1023, has been set to "1". In this case, the checksum verification does not take place and it is always possible to start a test measurement.

**Commissioning Step 6: Evaluating and Displaying the Results**

After the test measurement and the corresponding evaluation have been completed (negative edge on bit2 of P-0-1410), the result of envelope curve monitoring is written to the following parameters:

- P-0-1368, PA: Measuring curves
- P-0-1377, PA: Max. number of deviations - tolerance 1, signal 1
- P-0-1378, PA: Max. number of deviations - tolerance 2, signal 1
- P-0-1387, PA: Status text
- P-0-1410, PA: Status word
- As regards the evaluation and display of the results, it is additionally possible
  - to evaluate "S-0-0390, Diagnostic message number",
  - read the display of the drive,
  - evaluate the "class 1 diagnostics" or "class 2 diagnostics" bit in the corresponding status word of the drive, or
  - read the logbook entry of the drive.

To use these standard mechanisms of the drive, bit7 in P-0-1370 must have been set. In this case, the warning E2011 is generated in the drive when the tolerance band 1 is exceeded, and the error F2011 is generated in the drive

## Envelope Curve Monitoring (FWS\_MLDPaX\_SCH\_02Vxx\_D0\_MP0x)

## Graphic Evaluation and Visualization

when the tolerance band 2 is exceeded. Otherwise, it is only the bits 7 and 8 in P-0-1410 which are set according to the exceeded tolerance bands.

After a **test measurement** has been completed, the signal and tolerance curves on which the test measurement was based are made available in the list parameter P-0-1368. After a **reference measurement**, this parameter only contains the reference curve (elements 0 to 999). All other data are deleted. Upon completed test measurement, the test signal curve is contained in the elements 5000 to 5999. The number of recorded measuring points of a signal is displayed in element 8191. The tolerance bands have been entered in the elements 1000 to 4999. By means of these data, the curves can be displayed/stored after each test measurement.

### 9.3.3 Configuration and Operation by Means of IndraWorks

When the extended diagnostic function "envelope curve monitoring" has been loaded to the axis by means of IndraWorks (see "How to Load Technology Functions to the Drive"), the user interface of envelope curve monitoring can be opened in the "Technology Functions" window via the "Dialog ..." button.

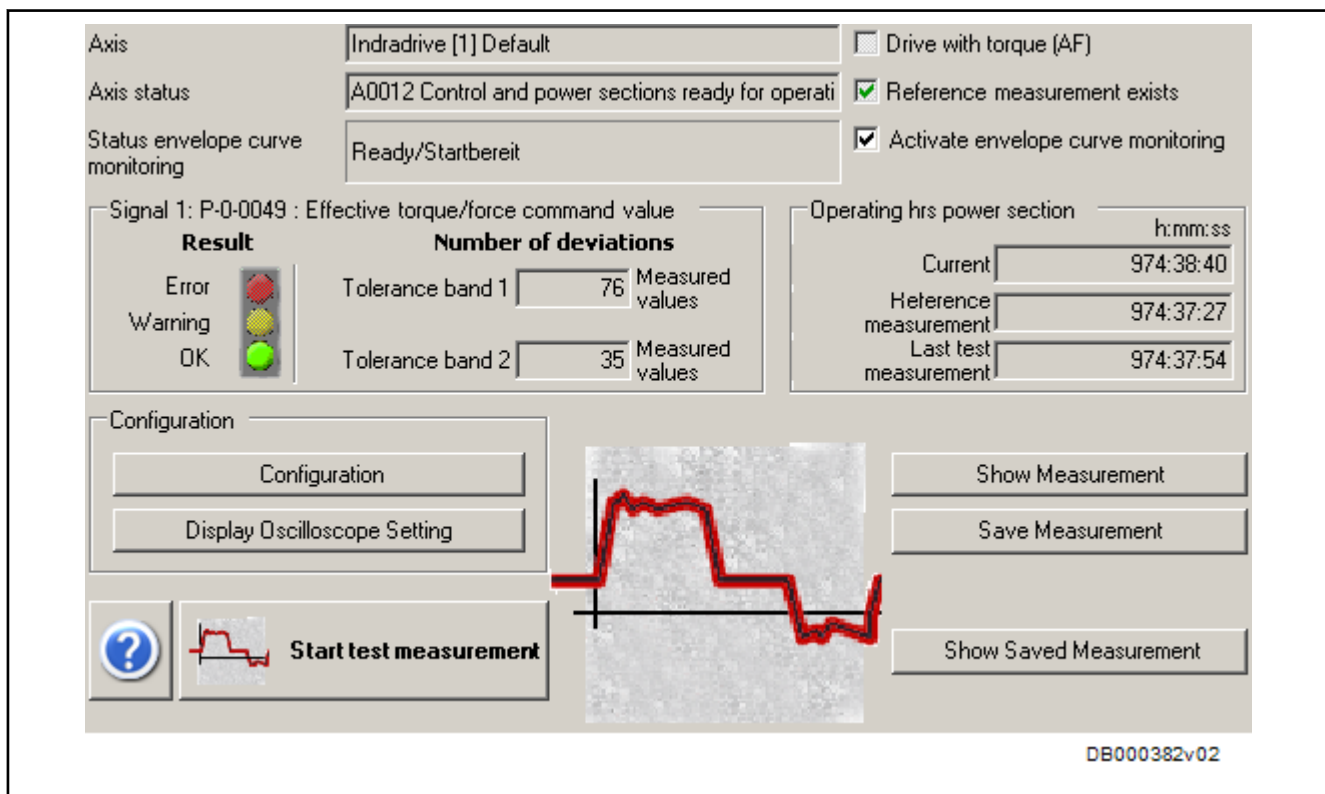


Fig. 9-12: IndraWorks Dialog to Operate the Envelope Curve Monitoring

#### Commissioning Step 1: Selecting the Measuring Signal

The measuring signal, trigger signal/trigger signal settings, number of measured values and time resolution must be configured by means of the drive-integrated oscilloscope function. The selected signal can be smoothed by means of the average value filter for display.

# Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

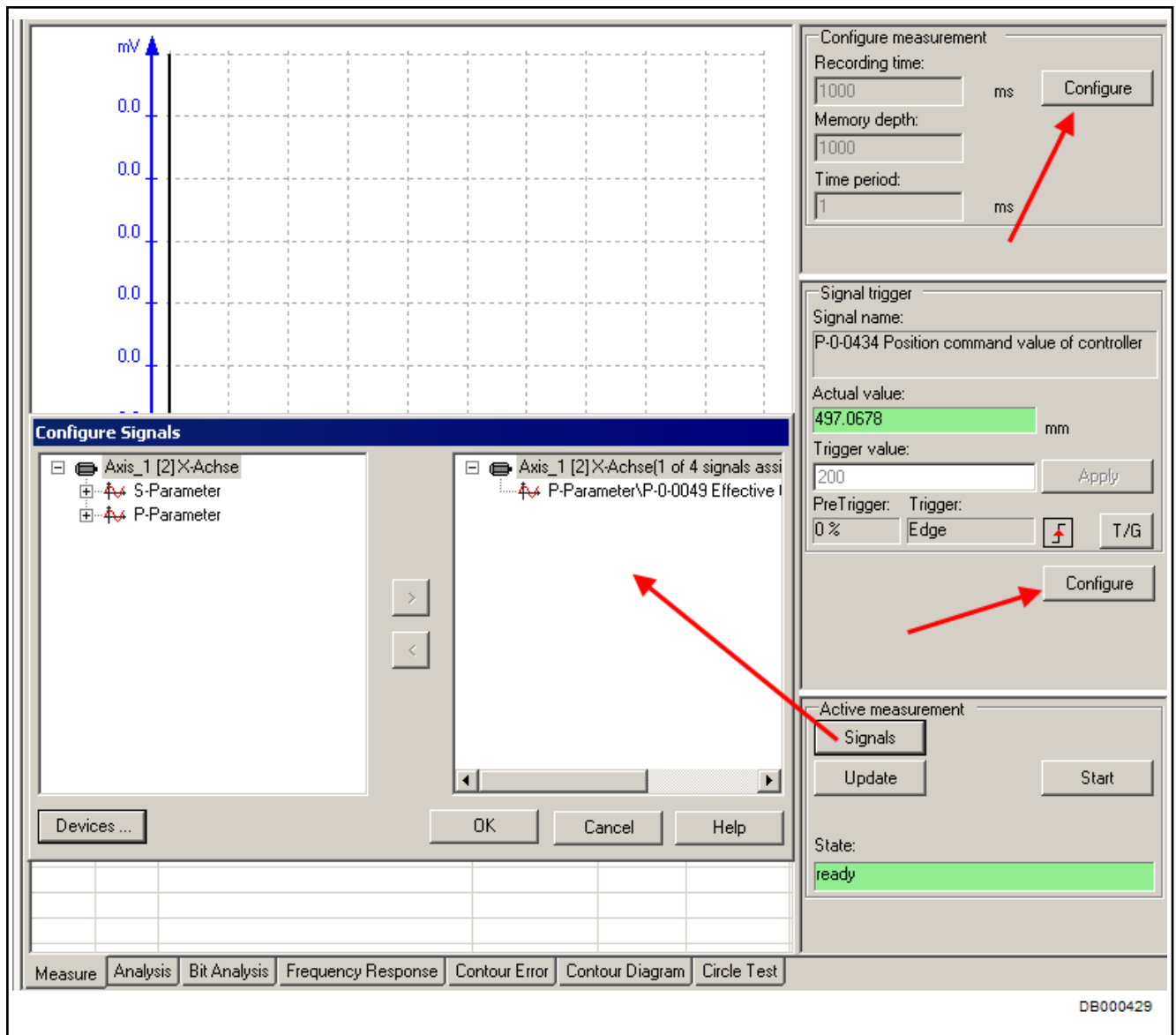


Fig.9-13: Configuring the Drive-Integrated Oscilloscope

The following aspects have to be taken into account:

- The signal recorded with the oscilloscope function is afterwards recorded and monitored in the same way by the envelope curve monitoring.
- A maximum of 1000 measured values can be monitored.
- The settings made for the reference measurement must be used for the following test measurements, too. Otherwise, the error message "Checksum wrong" is output when the checksum verification is active.
- When the measuring motion and/or the measuring signal are changed, this automatically requires carrying out a new reference measurement.
- Mechanical changes at the machine (e.g., additional loads or changes in acceleration) require carrying out a new reference measurement.
- An exact and reproducible trigger point (e.g., binary signal, command value) is necessary to record and evaluate test curves with the highest possible degree of comparability.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

- When the envelope curve monitoring of the "Productivity Agent" is active, the integrated oscilloscope function cannot be used for other purposes.



With the "Display Oscilloscope Setting" button in the operation dialog, the current settings can be displayed and checked; the settings cannot be changed at this point. The displayed settings are valid for the next measurement.

## Commissioning Step 2a: Recording the Reference Curve

The screenshot shows the 'Envelope Curve Monitoring' dialog box. It contains the following elements:

- Axis:** Indradrive [1] Default
- Axis status:** A0012 Control and power sections ready for operation
- Status envelope curve monitoring:** Ready/Startbereit
- Checkboxes:**
  - ☐ Drive with torque (AF)
  - ☒ Reference measurement exists
  - ☒ Activate envelope curve monitoring
- Signal 1: P-0-0049 : Effective torque/force command value**
  - Result:** Error (red), Warning (yellow), OK (green)
  - Number of deviations:**
    - Tolerance band 1: 76 Measured values
    - Tolerance band 2: 35 Measured values
- Operating hrs power section:** h:mm:ss
  - Current: 974:38:40
  - Reference measurement: 974:37:27
  - Last test measurement: 974:37:54
- Configuration:**
  - Configuration button
  - Display Oscilloscope Setting button
- Start test measurement:** A button with a question mark icon and a small waveform icon.
- Measurement Display:** A central area showing a red waveform on a grid.
- Buttons:** Show Measurement, Save Measurement, Show Saved Measurement.
- Footer:** DB000382v02

Fig.9-14: IndraWorks Dialog to Operate the Envelope Curve Monitoring

1. Tick the "Activate envelope curve monitoring" check box.
2. Activate the "Configuration" button.

The dialog for configuring the envelope curve monitoring opens.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

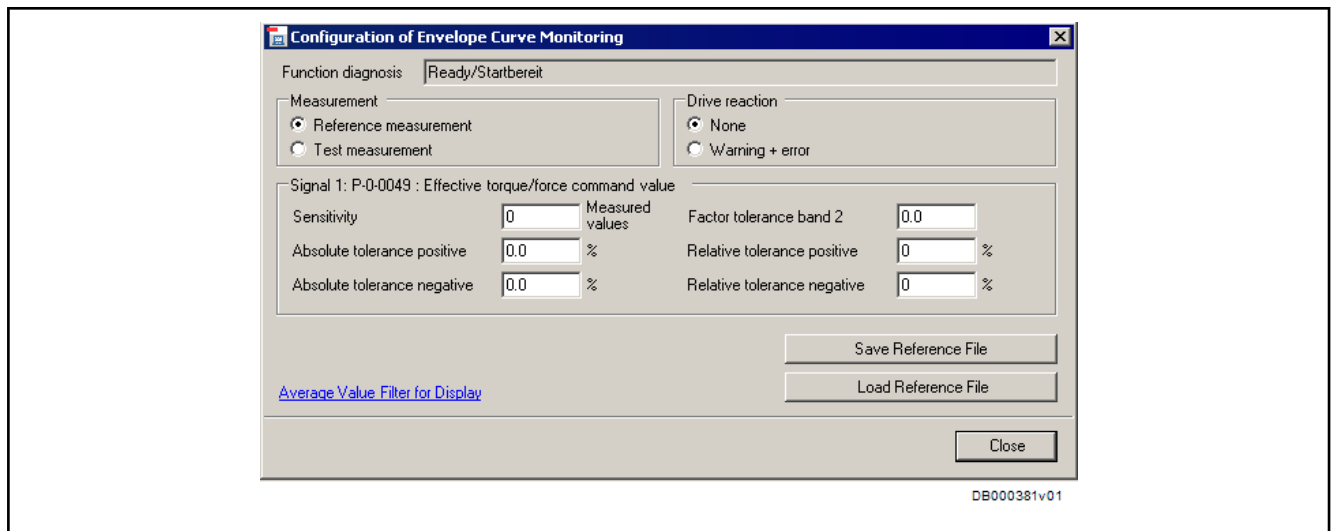


Fig.9-15: IndraWorks Dialog to Configure the Envelope Curve Monitoring

3. Select "Reference measurement".
4. Go to the operation dialog by activating the "Close" button.
5. To start the reference measurement (the drive-internal oscilloscope), activate the "Start Reference Measurement" button in the operation dialog.

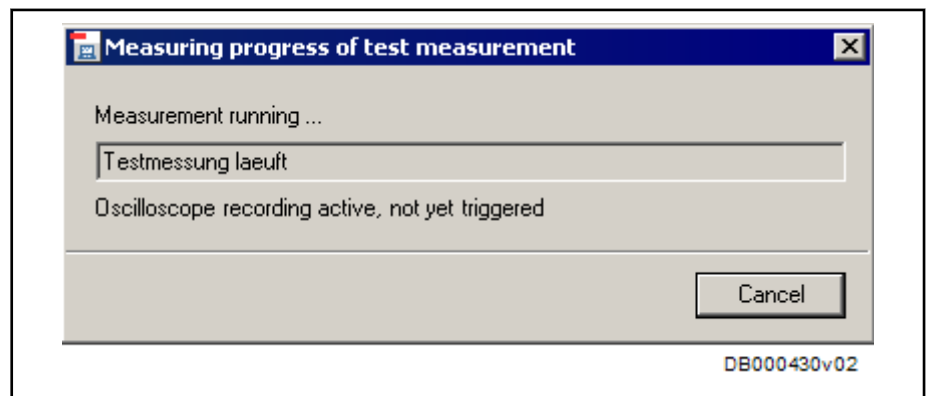


Fig.9-16: Status of Measurement (in this Case Test Measurement) and Status of Drive-Internal Oscilloscope Function



The actual measured value recording / the recording of the reference curve only starts when the trigger signal has been reached!



Any running measurement can be aborted by activating the "Cancel" button.

The successful start of the oscilloscope function is displayed with the "Measurement running" status text.

After the recording has been completed, the "Reference measurement exists" check box is ticked in the operation dialog to signal that a reference curve is available and test measurements can be started.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)



If several reference curves are required (e.g., due to different workpieces, etc.), the reference data must be stored outside of the drive (⇒ "Save Reference Data" button in the configuration dialog) and selectively loaded to the drive before each test measurement (⇒ "Load Reference Data" button in the configuration dialog).

**Commissioning Step 2b: Loading the Reference Curve**

At any time, you can subsequently load the reference data to the drive without a new reference measurement being required. This might be necessary, for example, in the case of product or tool change, when different reference curves/settings are to be stored.

By activating the "Load Reference Data" button in the configuration dialog, an externally saved reference measurement can be stored in the drive for the next test measurement. (This overwrites the previous reference data in the drive!)



It is only possible to make available the reference data of **one** reference measurement in the drive; it is impossible to simultaneously save several reference measurements in the drive, this must be done externally. In this case, load the respective reference data separately to the drive.

**Commissioning Step 3: Setting the Tolerance Bands**

1. In the operation dialog of envelope curve monitoring, activate the "Configuration" button to call the "Configuration of Envelope Curve Monitoring" dialog.

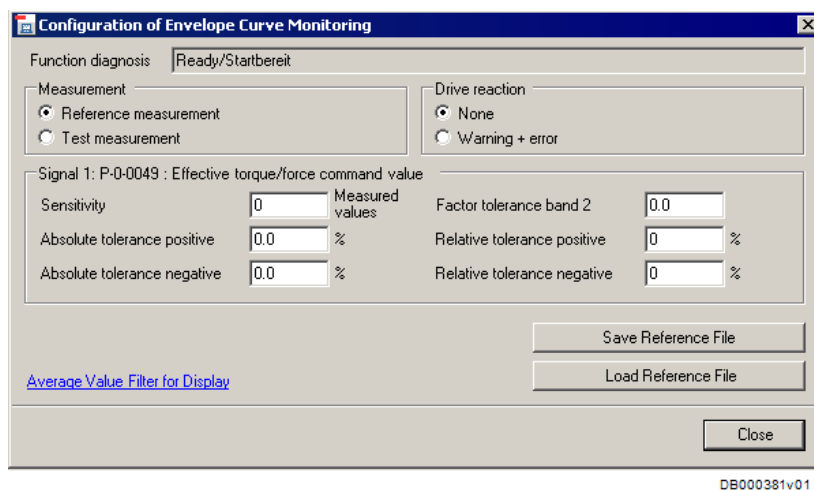


Fig.9-17: IndraWorks Dialog to Configure the Envelope Curve Monitoring

2. In the text fields of the section "Signal 1: Name of measuring signal", enter values to define two tolerance bands around the reference curve.

Absolute and relative tolerance (pos. and neg.) are added to a tolerance band 1. With "Factor tolerance band 2", the tolerance band 2 is generated by multiplication with tolerance band 1 (see also "[Commissioning Step 3: Setting the Tolerance Bands](#)").

**Commissioning Step 4: Setting the Sensitivity**

To set the minimum of measured values in succession which must be outside of the tolerance band so that the violation of a tolerance band is output, enter a value in the "Configuration of Envelope Curve Monitoring" dialog, "Sensitivity" text field.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

See also "[Commissioning Step 4: Setting the Sensitivity](#)".



To set the tolerance bands and the sensitivity, it is useful to execute several test measurements in succession and consider the determined deviations.

#### Commissioning Step 5: Setting the Drive Reaction

In the "Drive reaction" section, you can select "None" or "Warning+error":

- If you have selected "None", deviations are only displayed in the status word P-0-1410.
- If you have selected "Warning+error", the drive additionally reacts with the warning E2011 (with deviation of tolerance band 1) or the error F2011 (with deviation of tolerance band 2).

#### Commissioning Step 6: Activating the Test Measurement

1. Select "Test measurement" in the configuration dialog.
2. If all settings are correct, you can start the next test measurement in the operation dialog via "Start Test Measurement" (otherwise, the button is not active; in this case check status text or configuration).

A running measurement can be terminated via the "Cancel" button (cf. reference measurement).

#### Commissioning Step 7: Evaluating and Displaying the Results

Upon completed test measurement, the determined deviations of tolerance bands 1 and 2 are displayed in the operation dialog. Exceeded tolerance bands and sensitivities are represented as a stop light. In the operation dialog, you can store the current measurement externally via "Save Measurement", with the required information, such as tolerance bands, reference and test curves, deviations etc. The measurement stored in this way can at any time be displayed via "Show Saved Measurement".

With "Show Measurement", the information and curves of the last test measurement are shown in the display dialog. The display dialog shows the individual curves and the deviations.

With "Append Test Curve", you can append a saved measurement to the current measurement for the purpose of comparison. With "Save Measurement", the currently displayed measurements are saved externally.

The cursor value of the tolerance limits 1 and 2 shows the positive and negative limit values.

## Envelope Curve Monitoring (FWS\_MLDPaX\_SCH\_02Vxx\_D0\_MP0x)

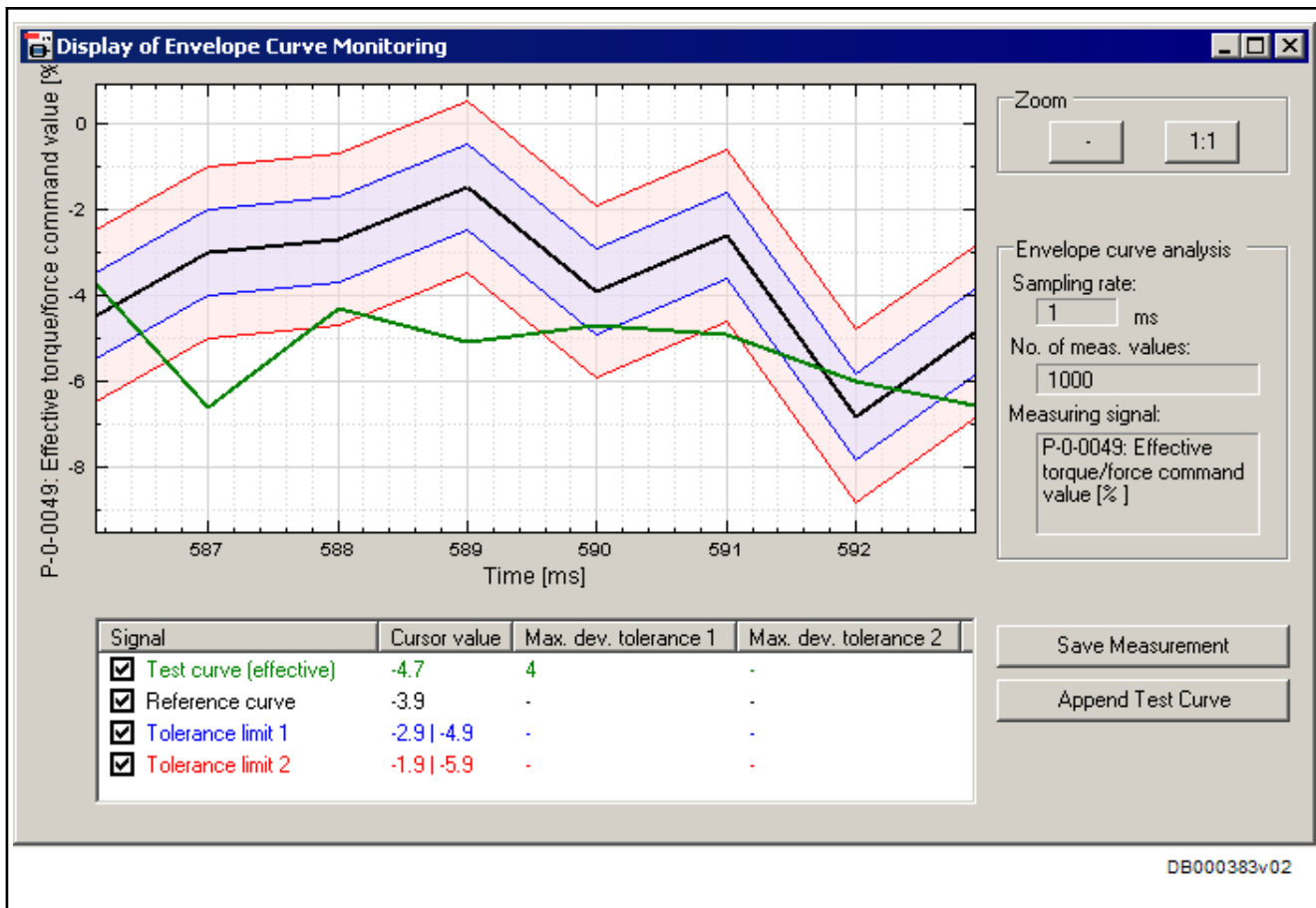


Fig. 9-18: IndraWorks Dialog to Display the Envelope Curve Monitoring

## 9.4 Diagnostic and Status Messages

### Status or Diagnostic Text

The diagnostic and status messages are available as bit information in P-0-1410 and are displayed as text strings in P-0-1387.

In P-0-1387, the last status or last diagnosis, which was determined by the technology function, is displayed. Here, the status of the envelope curve monitoring function is permanently output.

### Status Word

The monitoring result is available as bit information (bit7 and 8) in P-0-1410.

Independent of the parameterized sensitivity in P-0-1374, the display with regard to the maximum number of measured values in succession outside of the tolerance band takes place after each test measurement.

The maximum number of measured values in direct succession outside of tolerance band 1 during the test measurement is displayed in P-0-1377. The values for tolerance band 2 are displayed in P-0-1378.



An error always causes an error reaction and has to be cleared again. In the case of a warning, the drive can still be normally operated. The warning will persist until a repeated test run, during which no error is detected, or a repeated reference measurement is carried out!

The results of evaluation are only available after the entire test measurement has been completed.

Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

## 9.5 Description of the Parameters of the Envelope Curve Monitoring (FWS\_MLDPBP\_SCHxxx\_02Vxx\_D0\_MP0x)

### 9.5.1 P-0-1368, PA: Measuring curves

In the list parameter P-0-1368, the signal curves on which the diagnosis is based are output upon completed test measurement.

| List number  | element | Designation/function                                                                                                                                                                                                                                                                                          | Comment                                                                                                |
|--------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| 0 to 999     |         | Reference curve                                                                                                                                                                                                                                                                                               |                                                                                                        |
| 1000 to 1999 |         | Tolerance 1, positive                                                                                                                                                                                                                                                                                         |                                                                                                        |
| 2000 to 2999 |         | Tolerance 1, negative                                                                                                                                                                                                                                                                                         |                                                                                                        |
| 3000 to 3999 |         | Tolerance 2, positive                                                                                                                                                                                                                                                                                         |                                                                                                        |
| 4000 to 4999 |         | Tolerance 2, negative                                                                                                                                                                                                                                                                                         |                                                                                                        |
| 5000 to 5999 |         | Test curve                                                                                                                                                                                                                                                                                                    |                                                                                                        |
| 8191         |         | Number of measured values which were selected for the test measurement in the drive-internal oscilloscope. It shows how many of the maximum of 1000 measured values were used for the reference and test measurements. Accordingly, the elements for the graphic representation of the curves are to be read. | Read the value as DINT, ignore the comma (e.g.: value in #8191: 0,0100; meaning: 100 measured values). |

Fig.9-19: Parameter Structure

|                                     |                                                                                                                                                                                               |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Min./max. value                     | -/-                                                                                                                                                                                           |
| Format                              | Element 0 to 5999: DEC_MV<br>Element 8191: DEC_OV                                                                                                                                             |
| Unit                                | Like measuring signal selected in oscilloscope function                                                                                                                                       |
| Type                                | List register with 8192 elements (4 bytes each)<br>Element 0 to 5999: Output register for signal curves after test measurement<br>Element 8191: Output register for number of measured values |
| Decimal places                      | Element 0 to 5999: Like measuring signal selected in oscilloscope function<br>Element 8191: 0                                                                                                 |
| Buffered when control voltage fails | No                                                                                                                                                                                            |

Fig.9-20: Parameter Attributes

### 9.5.2 P-0-1370, PA: Configuration

The parameter P-0-1370 is used to configure the envelope curve monitoring.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

| Bit  | Designation/function                                                                                                                                                                                 | Comment                                                                                                                                          |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 0-3  | No function                                                                                                                                                                                          |                                                                                                                                                  |
| 4    | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement                                                                                                                                       |                                                                                                                                                  |
| 6    | Reserved                                                                                                                                                                                             |                                                                                                                                                  |
| 7    | <b>Reaction</b><br>0: Only message via the status word<br>1: Error AND warning AND message via status word<br>Warning: Tolerance band 1 exceeded (E2011)<br>Error: Tolerance band 2 exceeded (F2011) | 0: Diagnostic message only via the bits in P-0-1410<br>1: Additional diagnostic message on the display and in S-0-0390, as well as logbook entry |
| 8-31 | No function                                                                                                                                                                                          |                                                                                                                                                  |

Fig.9-21: Parameter Structure

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | -/-            |
| Format                              | BIN            |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig.9-22: Parameter Attributes



The display format for this parameter can be individually adjusted with the list element 0 of "P-0-1386, PLC display format Global Register".

## 9.5.3 P-0-1371, PA: Factor tolerance band 2, signal 1

With the parameter P-0-1371 you can define a factor which sets the tolerance band 2. The tolerance band 2 results from the multiplication of tolerance band 1 and "P-0-1371, Factor tolerance band 2".

With a value of 1.2, the difference between tolerance band 1 and 2 is 20%.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 1/-            |
| Format                              | DEC_MV         |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | 1              |
| Buffered when control voltage fails | Yes            |

Fig.9-23: Parameter Attributes

## 9.5.4 P-0-1372, PA: Absolute tolerance positive

The value entered in P-0-1372 is added to each measured value of the reference signal and thereby represents an absolute upper limit (positive related

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

to the reference value). The value relates to the unit of signal1 selected in the drive-internal oscilloscope.

|                                     |                                                         |
|-------------------------------------|---------------------------------------------------------|
| Min./max. value                     | 0/-                                                     |
| Format                              | DEC_MV                                                  |
| Unit                                | -                                                       |
| Type                                | Input register                                          |
| Decimal places                      | Like measuring signal selected in oscilloscope function |
| Buffered when control voltage fails | Yes                                                     |

Fig.9-24: Parameter Attributes

### 9.5.5 P-0-1373, PA: Absolute tolerance negative

The value entered in P-0-1373 is subtracted from each measured value of the reference signal and thereby represents an absolute lower limit (negative related to the reference value). Thus, the value relates to the unit of signal1 selected in the drive-internal oscilloscope.

|                                     |                                                         |
|-------------------------------------|---------------------------------------------------------|
| Min./max. value                     | 0/-                                                     |
| Format                              | DEC_MV                                                  |
| Unit                                | -                                                       |
| Type                                | Input register                                          |
| Decimal places                      | Like measuring signal selected in oscilloscope function |
| Buffered when control voltage fails | Yes                                                     |

Fig.9-25: Parameter Attributes

### 9.5.6 P-0-1374, PA: Sensitivity

The value entered in P-0-1374 sets the maximum number of measuring points which in direct succession may be outside of the specified tolerance limits 1 and 2, without exceeding the respective tolerance band being detected and output.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_MV         |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig.9-26: Parameter Attributes

### 9.5.7 P-0-1375, PA: Relative tolerance positive

With the value entered in P-0-1375, a relative upper limit (positive related to the reference value) is generated. The value relates to the respective measured value of the reference signal.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_MV         |
| Unit                                | %              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig.9-27: Parameter Attributes

## 9.5.8 P-0-1376, PA: Relative tolerance negative

With the value entered in P-0-1376, a relative lower limit (negative related to the reference value) is generated. The value relates to the respective measured value of the reference signal.

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/-            |
| Format                              | DEC_MV         |
| Unit                                | %              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig.9-28: Parameter Attributes

## 9.5.9 P-0-1377, PA: Max. number of deviations - tolerance 1, signal 1

Upon a test measurement, the parameter P-0-1377 displays the maximum number of measured values in direct succession which are outside of the tolerance band 1.

If the tolerance band 1 has been exceeded at three points by 8, 14 and 22 measuring points in succession, the value 22 is displayed.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_MV          |
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | Yes             |

Fig.9-29: Parameter Attributes

## 9.5.10 P-0-1378, PA: Max. number of deviations - tolerance 2, signal 1

Upon a test measurement, the parameter P-0-1378 displays the maximum number of measured values in direct succession which are outside of the tolerance band 2. If the tolerance band 2 has been exceeded at three points by 8, 14 and 22 measuring points in succession, the value 22 is displayed.

|                 |        |
|-----------------|--------|
| Min./max. value | 0/-    |
| Format          | DEC_MV |
| Unit            | -      |

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

|                                     |                 |
|-------------------------------------|-----------------|
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | Yes             |

Fig. 9-30: Parameter Attributes

### 9.5.11 P-0-1384, PA: Operating hours - reference measurement

The parameter P-0-1384 is a register; it displays the operating hour of the power section at which the reference measurement was executed.



In the case of a reference download via P-0-1389, the corresponding value from the list element 1022 of P-0-1389 is entered.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | Second          |
| Type                                | Output register |
| Decimal places                      | 1               |
| Buffered when control voltage fails | Yes             |

Fig. 9-31: Parameter Attributes

### 9.5.12 P-0-1385, PA: Operating hours - test measurement

The parameter P-0-1385 is a register; it displays the operating hour of the power section at which the last test measurement was executed.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/-             |
| Format                              | DEC_OV          |
| Unit                                | Second          |
| Type                                | Output register |
| Decimal places                      | 1               |
| Buffered when control voltage fails | Yes             |

Fig. 9-32: Parameter Attributes

### 9.5.13 P-0-1387, PA: Status text

The parameter P-0-1387 is used to output the status during envelope curve monitoring in the form of a text.

For example, "Ready/Startbereit" or "Testmessung laeuft" (Test measurement running).

|                 |                 |
|-----------------|-----------------|
| Min./max. value | -/-             |
| Format          | ASCII           |
| Unit            | -               |
| Type            | Output register |

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

|                                     |     |
|-------------------------------------|-----|
| Decimal places                      | -   |
| Buffered when control voltage fails | Yes |

Fig.9-33: Parameter Attributes

## 9.5.14 P-0-1389, PA: Reference data

The list parameter P-0-1389 is used to exchange the reference data. Upon successful reference measurement, the corresponding reference data are entered and thus can be read via P-0-1389 and stored. If the reference data are to be changed, the corresponding data have to be entered in P-0-1389 before the test measurement starts.

| List number | element | Designation/function                                                                                                                                                                              | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0 to 999    |         | Reference curve                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1022        |         | Operating hours count of reference measurement                                                                                                                                                    | By means of this value, the operating hours count corresponding to the reference measurement can be displayed in P-0-1384 even after the reference import, when several reference measurements are used (e.g. due to product change). After a reference measurement, this list element contains the same values as P-0-1384.<br><br><b>NOTE:</b> The operating hours count entered in P-0-1389 is not used for the checksum generation during the reference measurement. If a value unequal zero has been entered in this parameter, it is supposed that a reference measurement exists (was recorded/loaded). |
| 1023        |         | Display of checksum regarding settings of oscilloscope function (at reference measurement) / entering checksum regarding settings of oscilloscope function (when loading a reference measurement) | <b>NOTE:</b> When the checksums do not match, it is impossible to execute the test measurement.<br><br>With the value "1", the verification of the checksum can be deactivated before each test measurement.                                                                                                                                                                                                                                                                                                                                                                                                   |

Fig.9-34: Parameter Structure

|                 |                                                                                                                      |
|-----------------|----------------------------------------------------------------------------------------------------------------------|
| Min./max. value | Element 0 to 999: -/<br>Element 1022: 0/<br>Element 1023: -/                                                         |
| Format          | DEC_MV                                                                                                               |
| Unit            | Element 0 to 999: Like measuring signal selected in oscilloscope function<br>Element 1022: Second<br>Element 1023: - |

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

|                                            |                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Type</b>                                | List register with 1024 elements (4 bytes each)<br><br>Element 0 to 999: Output register for reference data after reference measurement, optional input register for reference data before test measurement<br><br>Element 1022: Output register/ input register (when loading a reference before test measurement) |
| <b>Decimal places</b>                      | Element 0 to 999: Like measuring signal selected in oscilloscope function<br><br>Element 1022: 1<br>Element 1023: None                                                                                                                                                                                              |
| <b>Buffered when control voltage fails</b> | Element 0 to 999: Yes<br><br>Element 1022: No<br>Element 1023: Yes                                                                                                                                                                                                                                                  |

Fig.9-35: Parameter Attributes

### 9.5.15 P-0-1390, PA: Control word

The parameter P-0-1390 is used to control the envelope curve monitoring.

| Bit  | Designation/function | Comment                                                           |
|------|----------------------|-------------------------------------------------------------------|
| 0    | Enable               | Static enabling of envelope curve monitoring                      |
| 1    | Start                | (Called by 0-1 edge) Start of reference and test measurements     |
| 2    | Stop/abortion        | (Called by 0-1 edge) Abortion of a started measurement/monitoring |
| 3-15 | No function          |                                                                   |

Fig.9-36: Parameter Structure

|                                            |                |
|--------------------------------------------|----------------|
| <b>Min./max. value</b>                     | -/-            |
| <b>Format</b>                              | BIN            |
| <b>Unit</b>                                | -              |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | None           |
| <b>Buffered when control voltage fails</b> | No             |

Fig.9-37: Parameter Attributes

### 9.5.16 P-0-1410, PA: Status Word

The parameter P-0-1410 provides the status of the envelope curve monitoring and is used for communication with a higher-level control unit.

## Envelope Curve Monitoring (FWS\_MLDPAx\_SCH\_02Vxx\_D0\_MP0x)

| Bit  | Designation/function                                           | Comment                                                                                                                                               |
|------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | Enable                                                         | Envelope curve monitoring enabled                                                                                                                     |
| 1    | Ready                                                          | Ready to start the measurement/monitoring                                                                                                             |
| 2    | Active                                                         | Measurement/monitoring running                                                                                                                        |
| 3    | Reference available                                            | Reference curve has been stored (contained in P-0-1389)                                                                                               |
| 4    | <b>Mode</b><br>0: Test measurement<br>1: Reference measurement |                                                                                                                                                       |
| 5-6  | Reserved                                                       |                                                                                                                                                       |
| 7    | Tolerance 1 exceeded                                           | According to sensitivity which has been set                                                                                                           |
| 8    | Tolerance 2 exceeded                                           | According to sensitivity which has been set                                                                                                           |
| 9-13 | No function                                                    |                                                                                                                                                       |
| 14   | 0: Factor threshold 2 $\geq$ 1<br>1: Factor threshold 2 $<$ 1  | Validation check for calculating tolerance 2                                                                                                          |
| 15   | Reference data invalid                                         | By means of the checksum (P-0-1389, element 1023), the current oscilloscope settings were detected not to match the ones of the reference measurement |

Fig.9-38: Parameter Structure

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | -/-             |
| Format                              | BIN             |
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig.9-39: Parameter Attributes

# 10 Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

## 10.1 Brief Description

The collision monitoring is an online monitoring function which allows detecting mechanical collision in a mechanical drive system.

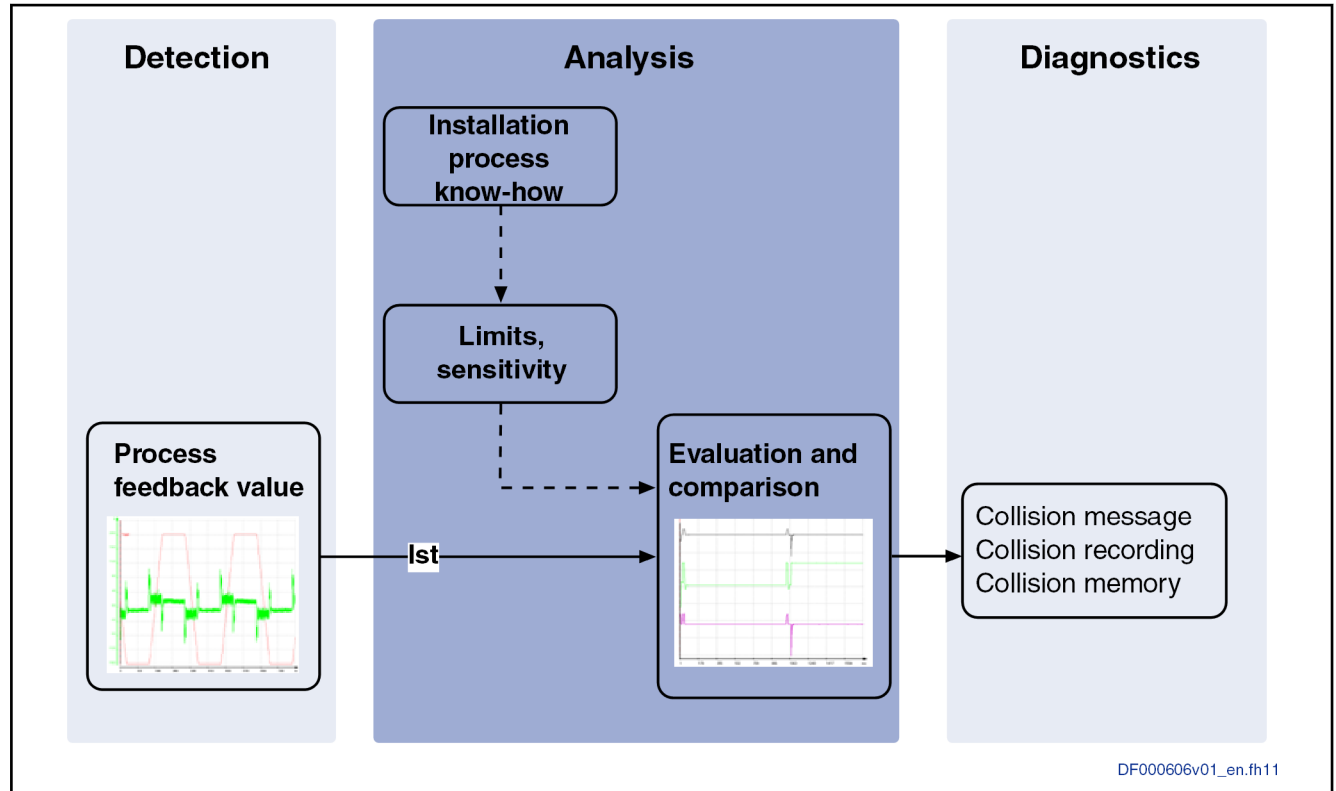


Fig. 10-1: Overview of Functions of Collision Monitoring

### Requirements of Use

To use the extended diagnostic functions, the software, firmware and hardware requirements must have been fulfilled (see "Required Components").

To use the extended technology function "collision monitoring", the PLC project "FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07" must in addition have been loaded and activated in the drive (see "How to Load Technology Functions to the Drive").

### Fields of Application

The extended technology function "collision monitoring" is a monitoring function that can be used to check a mechanical drive system with regard to mechanical collision during operation ("online method").

### Functional Features

The "collision monitoring" basically has two features:

- Collision detection in running operation ("online method")
- Documentation of a collision and of the corresponding conditions (operating hours of motor, power section and control section; position, velocity and torque/force feedback values)

The following points additionally apply:

- Up to 146 collisions can be documented
- The sensitivity can be freely set via a parameterizable collision threshold

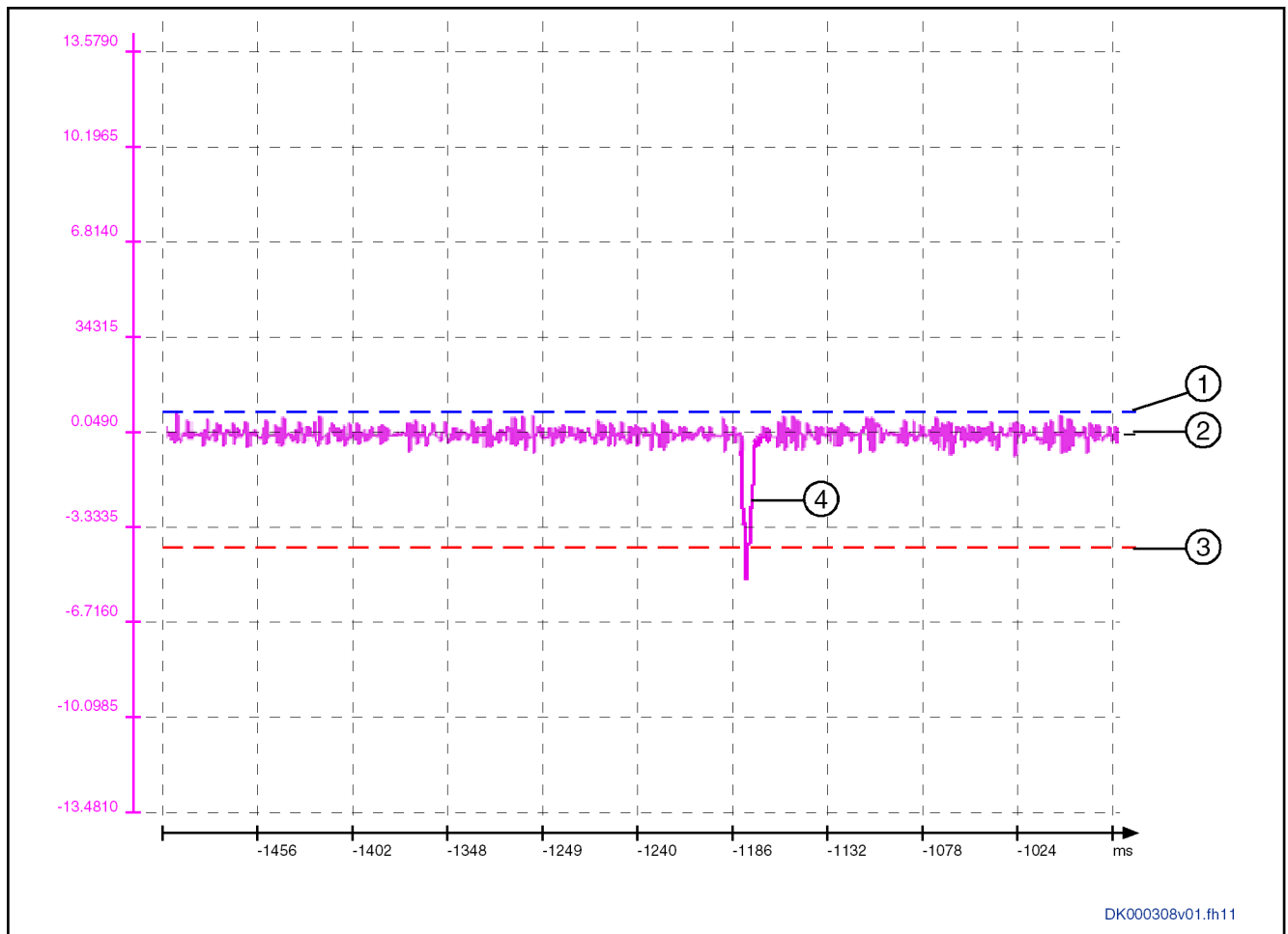
## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

|                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      | <ul style="list-style-type: none"> <li>• The threshold is captured in operation and automatically adjusted to the maximum load</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Limitations of the Function</b>   | <p>The function has the following limitations:</p> <ul style="list-style-type: none"> <li>• Only one mechanical drive system can be monitored.</li> <li>• A maximum of 146 collisions can be documented.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Pertinent Parameters</b>          | <p>The following parameters are used in conjunction with the extended technology function "collision monitoring". (The parameter names correspond to the respective significances for the diagnostic functions and not to the actual parameter names which are displayed, for example, in IndraWorks.)</p> <ul style="list-style-type: none"> <li>• P-0-1311, Collision monitoring: Input list</li> <li>• P-0-1312, Collision monitoring: Collision recorder</li> <li>• P-0-1370, Collision monitoring: Config word</li> <li>• P-0-1375, Collision monitoring: Maximum value</li> <li>• P-0-1378, Collision monitoring: Collision counter</li> <li>• P-0-1387, Collision monitoring: Status text</li> <li>• P-0-1410, Collision monitoring: Function status word</li> </ul> |
| <b>Pertinent Diagnostic Messages</b> | <ul style="list-style-type: none"> <li>• When a collision has been detected, this is always displayed in P-0-1410 (bit 4) and in the status text in P-0-1387.</li> <li>• When factors and thresholds have been incorrectly parameterized, this is displayed in P-0-1410 (bit 2) and in the status text in P-0-1387, too.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## 10.2 Functional Description

The figure below illustrates the functional principle of the monitoring method, the current actual value of the product of torque/force and acceleration being cyclically compared to the collision threshold.

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)



- 1 Maximum process value of  $T \cdot a$
- 2 Signal  $T \cdot a$
- 3 Collision threshold ( $-1 \cdot$  maximum process value  $\cdot$  sensitivity factor)
- 4 At this point, a collision is detected

Fig. 10-2: Signal Overview of Collision Monitoring

The function monitors the product of torque/force and acceleration in running operation. When the value of the product falls below the value of the collision threshold, a collision is detected. The collision threshold is calculated by negative multiplication of the maximum value for  $T \times a$  occurring in operation with the sensitivity factor that can be freely selected. Thus, the collision threshold adjusts to the maximum load occurring in operation.



To get a better estimation of the value of  $T \times a$  in running operation, the function can be operated in enabled but deactivated form. Thereby, the required values are recorded and the maximum product of the process is output; evaluation and collision detection do not take place when this is done.

## 10.3 Notes on Commissioning and Operation

### 10.3.1 General Information on Commissioning

**Initial Situation** The successful commissioning of the extended diagnostic function "collision monitoring" requires the following initial situation:

- The drive has been commissioned, i.e. it is operable.

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

**Overview of Required Individual Steps for Commissioning**

- The communication between control unit and drive exists.
- The installation has run in and all operation parameters have reached their stationary status.
- The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
- The PLC project "FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP0x" has been loaded and activated for the firmware version at hand (see "How to Load Technology Functions to the Drive").

The commissioning of the extended technology function "collision monitoring" consists of the following steps:

**Configuring the function**

1. Enabling of the function via bit 0 of the config word (cf. P-0-1370)
2. Parameterization of sensitivity factor and start threshold



The function must be initialized with a start threshold to exclude incorrect collision detection due to transient oscillation processes in the first cycle. In the first cycle, this value is written to the parameter of the maximum product of torque/force and acceleration. When the maximum process value exceeds the initialization value, the process value is applied from the second cycle onward.

In this way, a manual collision threshold is parameterized in the first cycle. This threshold should be slightly below the process value so that the adaptive collision threshold of the process is applied from the second cycle onward.



For a better appraisal of the maximum product of torque/force and acceleration occurring in the process, the process can only be run in the enabled state of the function. In doing so, the process can be run through with deactivated collision detection and the maximum product is output without an evaluation taking place.

**Operating/using the function**

The function is used permanently, also in running operation. Thus, the operation/use of the function is divided into the following steps:

1. Activation of the function via bit 1 of the config word (cf. P-0-1370)



At this point, the collision monitoring is active and monitors the drive for collisions.

2. Display of the function status via the function status word (cf. P-0-1410) and the status text (cf. P-0-1387)

**Parameter Interface to Configure and Operate the Function**

Apart from a cyclically configurable control and status word, there are other parameters available to configure and operate the function; these parameters are also accessed via the acyclic channel. The following interface parameters are supported:

- Configuration parameter (cf. P-0-1311)
- Collision recorder (cf. P-0-1312)
- Maximum process product from  $T \cdot a$  (cf. P-0-1375)
- Collision counter (cf. P-0-1378)

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

- Status text of the function (cf. P-0-1387)

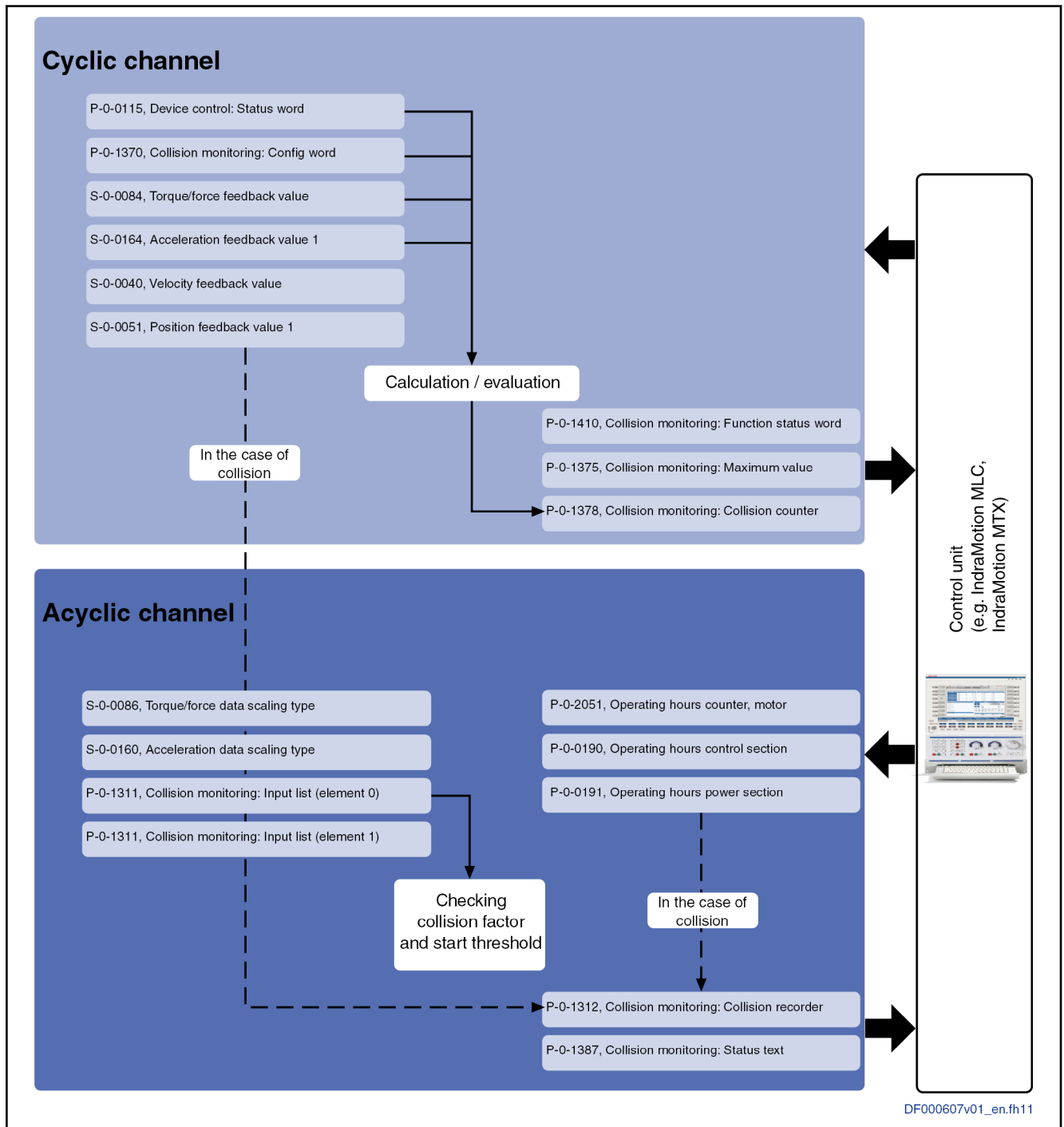


Fig. 10-3: Parameter Overview

### 10.3.2 Configuration and Operation via Parameters

Before activating the function, configure the collision threshold.

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

## Commissioning Step 1: Configuring the "Collision Monitoring" Function

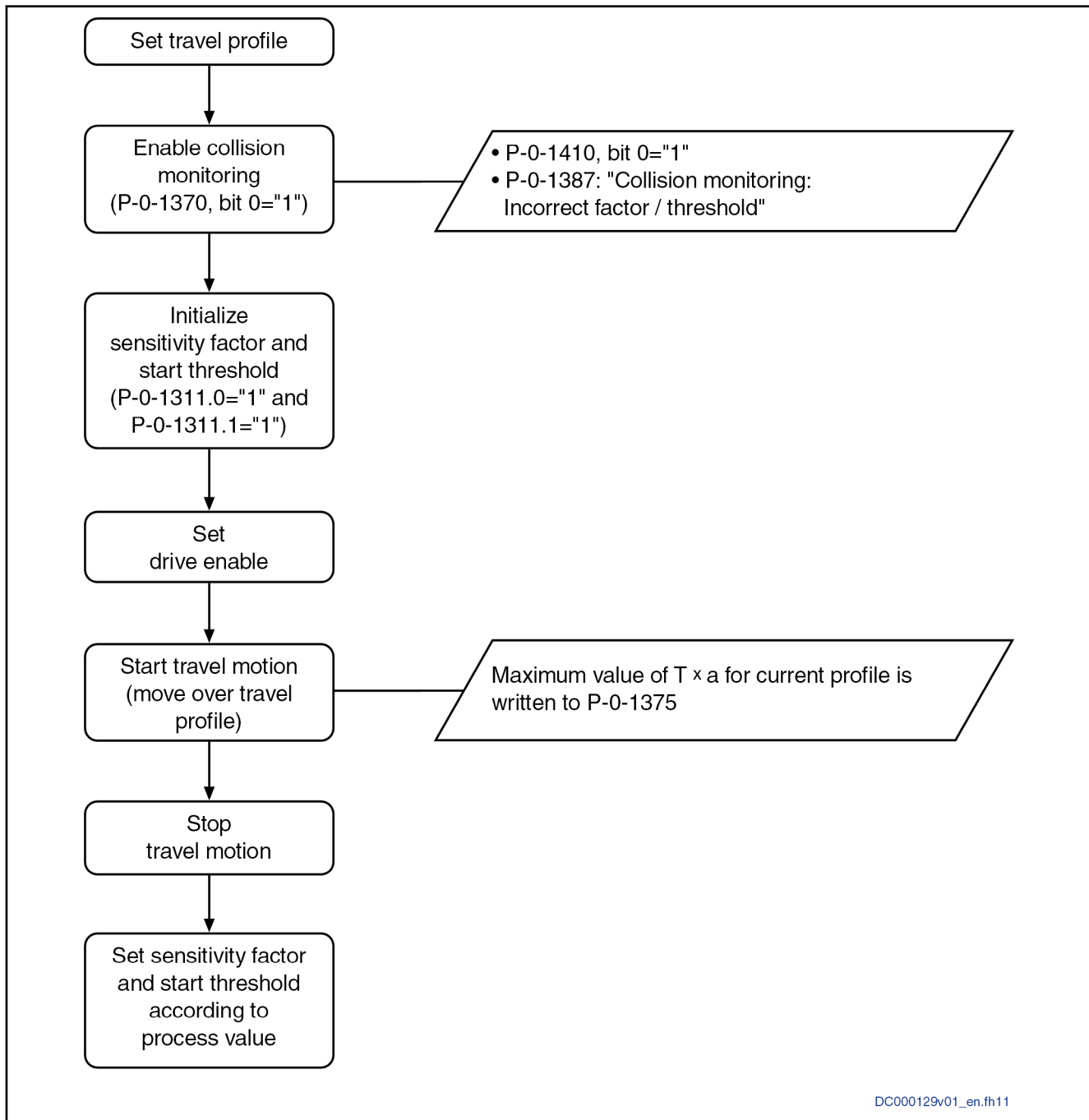


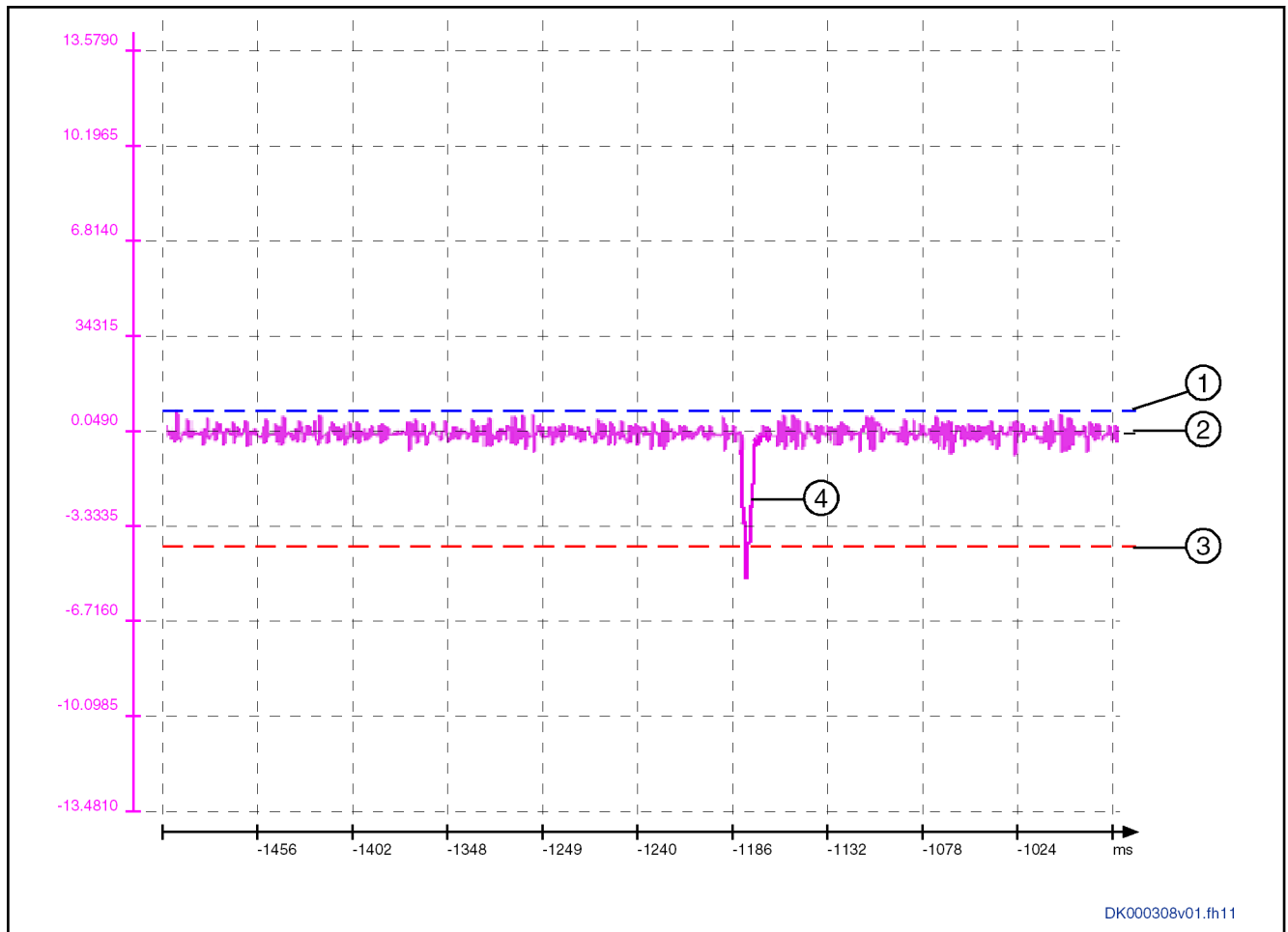
Fig. 10-4: Configuring the "Collision Monitoring" Function

To configure the function, proceed as follows:

1. Enable the function: Set bit 0 to the value "1" in the config word P-0-1370.
2. Parameterize the collision threshold: Parameterize a sensitivity factor and a start threshold in the input list P-0-1311. In doing so, take the following aspects into account:
  - The collision threshold is calculated as follows:
    - $-1 \times \text{maximum process value} \times \text{sensitivity factor}$
    - $-1 \times \text{P-0-1375} \times \text{P-0-1311.0}$

Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

- Set the start threshold in list element 0 of P-0-1311
- Set the sensitivity factor in list element 1 of P-0-1311
- Sensitivity factor and start threshold must be greater than "0".



- |   |                                                                                                                                          |
|---|------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | P-0-1375 (maximum process value: $T \times a$ )                                                                                          |
| 2 | $S-0-0048 \times S-0-0164$ (signal: $T \times a$ )                                                                                       |
| 3 | $-1 \times P-0-1375 \times P-0-1311.0$ (collision threshold: $-1 \times \text{maximum process value} \times \text{sensitivity factor}$ ) |
| 4 | At this point, a collision is detected                                                                                                   |

Fig. 10-5: Parameterizing the Collision Threshold

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)



- The start threshold is used to exclude incorrect collision detection with transient oscillation processes around the zero position. This value is written to the parameter P-0-1375 in the first program cycle. If the actual product from S-0-0084 and S-0-0164 is greater than the parameterized start threshold in the running process, the value at the beginning applied from the start threshold is overwritten in P-0-1375.
  - For an easier estimation of the maximum product from S-0-0084 and S-0-0164 occurring in the process, a "test run" can be carried out. For this purpose, the process must be run through in the enabled mode (P-0-1370, bit 0="1", bit 1="0"). After the initialization of the sensitivity factor and start threshold with the value "1" (to avoid the error message "Collision monitoring: Incorrect factor / threshold" in P-0-1387 and bit 2 in the function status word P-0-1410), the maximum product value is now displayed in the parameter P-0-1375.
  - The start threshold value now selected should be below the value displayed in P-0-1375. The value parameterized for the sensitivity factor should be useful and comply with the process. (The commissioning engineer is responsible for a useful estimation.)
-

Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

Commissioning Step 2: Activating and Using the "Collision Monitoring" Function

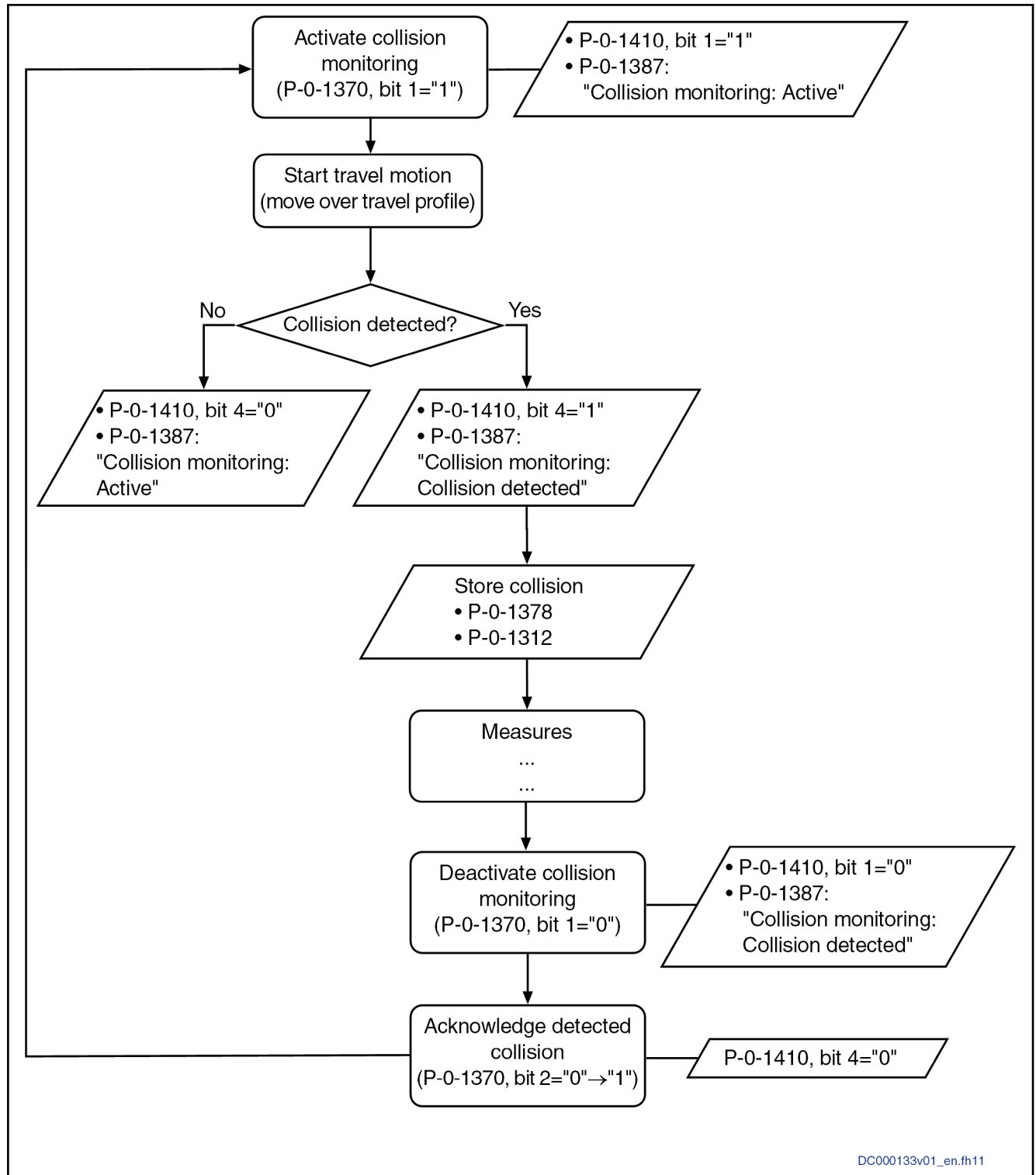


Fig. 10-6: Activating and Using the "Collision Monitoring" Function

After the function has been enabled (bit 0 and bit 2 in P-0-1410 have been set, P-0-1387 shows "Collision monitoring: Ready"), the function can be activated:

1. Setting P-0-1370 bit 1="1" activates the function.

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)



As soon as drive enable has been set (drive is in control, display shows "AF"), the collision monitoring is active.

In the function status word P-0-1410, the bits 0-2 have been set, the status in P-0-1387 shows "Collision monitoring: Active".

In the collision recorder, every activation and deactivation (with the corresponding time stamp and axis state) is entered as indicator (1) and (0) (see description of the parameter P-0-1312).

**Detecting a Collision**

If the function in running operation observes that the value has fallen below the collision threshold, it detects a collision in the mechanical drive system.

This causes the following reactions in the drive:

- Bit 4 in the function status word P-0-1410 is set.
- Status message "Collision monitoring: Collision detected!" in P-0-1387.
- Entry in collision counter P-0-1378.
- Collision parameters P-0-2051, P-0-0191, P-0-0190, S-0-0051, S-0-0040, S-0-0084 are entered in collision recorder with indicator for collision (2).

**NOTICE**

**The collision monitoring function is a mere diagnostic function! Even if a collision is detected, the PLC does not take control over drive!**

To avoid further damage, the function status word P-0-1410 should be evaluated and the drive shut down in an appropriate way.

**Acknowledging a Collision**

When the function detects a collision, the drive can nevertheless continue moving. The collision monitoring, however, is no longer active. Reactivating the function requires the following steps:

1. Deactivate the function via bit 1 in the config word P-0-1370 (set bit 1="0").
2. Acknowledge the detected collision by a rising edge at bit 2 in the config word P-0-1370 (set bit 2="0"→"1").

The function is now ready for being reactivated (see [Commissioning Step 2: Activating and Using the Function](#)). In the function status word P-0-1410, the collision bit (bit 4) was set to "0" again. The status in P-0-1387 is: "Collision monitoring: Ready".



Acknowledging a detected collision only confirms the last detected collision. The entries in the collision counter P-0-1378 and in the collision recorder P-0-1312 are not deleted!

**Clearing the Collision Recorder**

Via the parameter P-0-1370, the collision memory can be cleared. A rising edge (transition "0"→"1") at bit 14 with the function having been enabled and deactivated, clears the collision memory.

Resetting the collision recorder also deletes the number of detected collisions in P-0-1378. After the collision recorder was reset, it is impossible to subsequently diagnose collisions which had taken place.

### 10.3.3 Configuration and Operation by Means of IndraWorks

The configuration and operation of the extended diagnostic function "collision monitoring" by means of IndraWorks is in preparation.

## 10.4 Diagnostic and Status Messages

The diagnostic and status messages are available as bit information in P-0-1410 and are displayed as text strings in P-0-1387.

**Status or Diagnostic Text** In P-0-1387, the last status or last diagnosis, which was determined by the technology function, is displayed. Here, the status of the collision monitoring function is permanently output.

**Status Word** The monitoring result is available in P-0-1410 as bit information (bit 0 to bit 4).

**Collision Recorder** When the function has been enabled, every event is entered in parameter P-0-1312 with the corresponding event indicator. Up to 146 events are stored in this parameter in consecutive order (the most recent event is always on top).

There are 3 types of events:

1. Activation of the monitoring function (indicator = 1)
2. Deactivation of the monitoring function (indicator = 0)
3. Detection of a collision (indicator = 2)

Each event is stored with a time stamp (operating hours of motor, power section and control section) and the corresponding drive feedback values (position, velocity and torque/force). Consequently, each event entry consists of 7 elements:

- The first element always is the event indicator.
- The next 3 elements are the operating hours of motor, power section and control section.
- The following 3 elements contain the feedback values for position, velocity and torque/force at the time of the event.

The collision recorder is buffered in case voltage fails, i.e. its data are retained. Emptying the memory requires a reset (cf. ["Clearing the Collision Recorder" on page 140](#)).

## 10.5 Description of the Parameters of the Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

### 10.5.1 P-0-1311, Collision monitoring: Input list

In the list parameter P-0-1311, the configuration values for the sensitivity factor and the start threshold must be entered. To commission the collision monitoring function correctly, both values must be greater than "0".

| Element | Significance/function |
|---------|-----------------------|
| 0       | Sensitivity factor    |
| 1       | Start threshold       |

Fig. 10-7: Parameter Structure

|                 |                              |
|-----------------|------------------------------|
| Min./max. value | 0/-                          |
| Format          | DEC                          |
| Unit            | Element 0: -<br>Element 1: - |

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

|                                            |                |
|--------------------------------------------|----------------|
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | Two            |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 10-8: Parameter Attributes

## 10.5.2 P-0-1312, Collision monitoring: Collision recorder

When the function has been enabled, every event is entered in the list parameter P-0-1312 with the corresponding event indicator. Up to 146 events are stored in this parameter in consecutive order (the most recent event is always on top).

There are 3 types of events:

1. Activation of the monitoring function (indicator = 1)
2. Deactivation of the monitoring function (indicator = 0)
3. Detection of a collision (indicator = 2)

Each event is stored with the indicator, a time stamp and the current drive feedback values.

| <b>Element</b> | <b>Significance/function</b>                                 |
|----------------|--------------------------------------------------------------|
| 0              | Event indicator of event 1 (0,1 or 2)                        |
| 1              | Operating hours of the motor at event 1 (P-0-2051)           |
| 2              | Operating hours of the power section at event 1 (P-0-0191)   |
| 3              | Operating hours of the control section at event 1 (P-0-0191) |
| 4              | Position at event 1 (S-0-0051)                               |
| 5              | Velocity at event 1 (S-0-0040)                               |
| 6              | Torque/force at event 1 (S-0-0084)                           |
| 7              | Event indicator of event 2 (0,1 or 2)                        |
| 8              | ... according to element 1 at event 2                        |
| 9              | ...                                                          |

Fig. 10-9: Parameter Structure

|                                            |                                                                  |
|--------------------------------------------|------------------------------------------------------------------|
| <b>Min./max. value</b>                     | -/-                                                              |
| <b>Format</b>                              | DEC                                                              |
| <b>Unit</b>                                | Element 0: -<br>Element 1-3: s<br>Element 4-6: Scaling-dependent |
| <b>Type</b>                                | Output register                                                  |
| <b>Decimal places</b>                      | Two                                                              |
| <b>Buffered when control voltage fails</b> | Yes                                                              |

Fig. 10-10: Parameter Attributes

## 10.5.3 P-0-1370, Collision monitoring: Config word

The parameter P-0-1370 is used to control the "collision monitoring" function. All functionalities can be operated via this parameter.

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

| Bit   | Designation/function | Comment                                                                              |
|-------|----------------------|--------------------------------------------------------------------------------------|
| 0     | Enable               | Static enabling of collision monitoring                                              |
| 1     | Active               | Activation of collision monitoring<br>0: Deactivate function<br>1: Activate function |
| 2     | Acknowledge          | Acknowledge a detected collision<br>(Called by positive edge)                        |
| 3-13  | -                    | No function                                                                          |
| 14    | Reset                | Clear the collision recorder by a positive edge                                      |
| 15-31 | -                    | No function                                                                          |

Fig. 10-11: Parameter Structure

|                                     |                |
|-------------------------------------|----------------|
| Min./max. value                     | 0/16385        |
| Format                              | BIN            |
| Unit                                | -              |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 10-12: Parameter Attributes

### 10.5.4 P-0-1375, Collision monitoring: Maximum value

The parameter P-0-1375 displays the current maximum process value of the product of "S-0-0084, Torque/force feedback value" and "S-0-0164, Acceleration feedback value 1".

|                                     |                   |
|-------------------------------------|-------------------|
| Min./max. value                     | -/-               |
| Format                              | DEC               |
| Unit                                | Scaling-dependent |
| Type                                | Output register   |
| Decimal places                      | Two               |
| Buffered when control voltage fails | Yes               |

Fig. 10-13: Parameter Attributes

### 10.5.5 P-0-1378, Collision monitoring: Collision counter

The parameter P-0-1378 displays the current number of detected collisions. This parameter, too, is deleted when the parameter "P-0-1312, Collision monitoring: Collision recorder" is reset.

|                 |                 |
|-----------------|-----------------|
| Min./max. value | 0/-             |
| Format          | DEC             |
| Unit            | -               |
| Type            | Output register |

## Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

|                                     |      |
|-------------------------------------|------|
| Decimal places                      | None |
| Buffered when control voltage fails | Yes  |

Fig. 10-14: Parameter Attributes

## 10.5.6 P-0-1387, Collision monitoring: Status text

The parameter P-0-1387 displays the current status of collision monitoring in the form of a text.

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | -/-             |
| Format                              | ASCII           |
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | Yes             |

Fig. 10-15: Parameter Attributes

## 10.5.7 P-0-1410, Collision monitoring: Function status word

The parameter P-0-1410 provides the current status of collision monitoring in the form of a bit string.

| Bit   | Designation/function | Comment                                                                                                                        |
|-------|----------------------|--------------------------------------------------------------------------------------------------------------------------------|
| 0     | Enable               | Collision monitoring enabled?<br>0: Function not enabled<br>1: Function enabled                                                |
| 1     | Active               | Collision monitoring active?<br>0: Function deactivated<br>1: Function active                                                  |
| 2     | Threshold test       | Values for sensitivity factor and start threshold correctly set?<br>0: Values not input correctly<br>1: Values input correctly |
| 3     | -                    | No function                                                                                                                    |
| 4     | Collision            | Collision detected?<br>0: No collision detected<br>1: Collision detected                                                       |
| 15-31 | -                    | No function                                                                                                                    |

Fig. 10-16: Parameter Structure

|                 |                 |
|-----------------|-----------------|
| Min./max. value | 0/23            |
| Format          | DEC             |
| Unit            | -               |
| Type            | Output register |

Collision Monitoring (FWS\_MLDTFx\_SCM\_01Vxx\_D0\_MP07)

|                                     |      |
|-------------------------------------|------|
| Decimal places                      | None |
| Buffered when control voltage fails | No   |

*Fig. 10-17: Parameter Attributes*



# 11 Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

## 11.1 Brief Description

The "vibration damping and avoiding" function is a method which intervenes in the production process in order to increase the productivity of a machine and the product quality. Likewise, a longer life cycle of the machine and of its mechanical system is achieved by reducing mechanical stress.

This can be accomplished by filtering the command value profile and by actively damping the vibration of the mechanical system.

**Requirements of Use** To use the extended diagnostic functions, the software, firmware and hardware requirements must have been fulfilled (see "Required Components").

To use the "vibration damping and avoiding" function, the PLC project "FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x" must in addition have been loaded and activated in the drive (see "How to Load Technology Functions to the Drive").

**Fields of Application** The "vibration damping and avoiding" function can be used wherever low-frequency vibrations, which have a negative influence on the production cycle, are excited in a machine or its Tool Center Point due to the mechanical structure or the ambient conditions. According to the design and the work flow of the machine, different configurations of vibration avoiding and/or vibration damping can be used.

- **Vibration Avoiding (VA):**
  - Filtering of the command value profile preset by a higher-level control unit.
  - Filter parameterization by means of the mechanical vibration and damping behavior.
  - Filter type and command value profile (position or velocity) can be configured.
- **Vibration Damping (VD):**
  - Active damping of mechanical or system vibrations < 150 Hz by intervening in the control structure of the drive.
  - Damping is possible without and with additional sensors (acceleration sensor or optional position encoder).
  - PI(D-T1) controller structure with feedback and command value generation that can be configured in different ways.
  - Target parameters for the controller output can be set.
  - It is possible to suppress the machine's fundamental vibration that does not have any influence on the quality of the production process.
  - The system vibration can be captured by external sensors or in sensorless form by drive-internal signals.

**Limitations of the Function** The "vibration damping and avoiding" function has the following limitations:

- Sensorless control with vibration damping is only possible if the parasitic vibration has an impact on the mechanical drive system. The quality of control depends on the degree of the impact.
- Using vibration avoiding implies that the control unit can write its cyclic command values to any parameter.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

- Modulo axes:
  - When using vibration damping, there is a restriction concerning the selection for command value generation (see subchapter on vibration damping).
  - The command value filters for vibration avoiding mustn't be parameterized in the operation mode "cyclic position control".

**Pertinent Parameters** The lists below contain the parameters used in conjunction with the "vibration damping and avoiding" function.

**General:**

- P-0-1370, Config word
- P-0-1410, Status word
- P-0-1328, Error diagnosis Error ID
- P-0-1329, Error diagnosis Error Ident: Table
- P-0-1330, Error diagnosis Error Ident: Additional 1
- P-0-1331, Error diagnosis Error Ident: Additional 2
- P-0-1387, Error text display

**Vibration damping:**

- P-0-1371, VD - PI(D-T1) controller proportional gain
- P-0-1372, VD - PI(D-T1) controller integral-action time [ms]
- P-0-1373, VD - PI(D-T1) controller derivative action time [ms]
- P-0-1374, VD - PI(D-T1) controller smoothing time constant, D-component [us]
- P-0-1375, VD - PI(D-T1) controller limitation
- P-0-1376, VD - Control loop, high pass limit frequency [Hz]
- P-0-1377, VD - Control loop, low pass limit frequency [Hz]
- P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz]
- P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]
- P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz]
- P-0-1381, Acceleration feedback value band-stop filter, center frequency [Hz]
- P-0-1382, Acceleration feedback value band-stop filter, bandwidth [Hz]
- P-0-1383, Acceleration command value delay [ms]
- P-0-1316, Sensor input, input filter time constant [ms]
- P-0-1317, Sensor input, analog input offset [V]
- P-0-1318, Analog input, sensor dead zone (bipolar) [V]
- P-0-1319, Sensor sensitivity (incl. amplifier ) [mV/g] or [mV/(rad/s²)]
- P-0-1320, Sensor distance to pivot [mm]
- P-0-1321, Torque/force feedback value scaling factor [gm²] or [kg]

**Important display parameters for commissioning:**

- P-0-1272, Adjusted feedback signal before the summation point
- P-0-1273, Control difference after the summation point
- P-0-1277, Control difference after high-pass and low-pass filtering
- P-0-1278, Controller output after limitation
- P-0-1279, Adjusted command signal before the summation point

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

### Vibration avoiding:

- P-0-1300, VA - NC position command value
- P-0-1301, VA - NC velocity command value
- P-0-1324, VA - Position command value band-stop filter, center frequency [Hz]
- P-0-1325, VA - Position command value band-stop filter, bandwidth [Hz]
- P-0-1326, VA - Position command value anti-vibration, characteristic frequency [Hz]
- P-0-1327, VA - Position command value anti-vibration, damping degree

### Pertinent Diagnostic Messages

- E2011 Changing the config word not allowed in AF
- E2012 Limitation of controller output is active (see P-0-1375)

## 11.2 "Vibration Avoiding" (VA)

### 11.2.1 Functional Description

The figure below illustrates the functional principle of "vibration damping and avoiding". The two functions "vibration avoiding" and "vibration damping" can be activated individually or together.

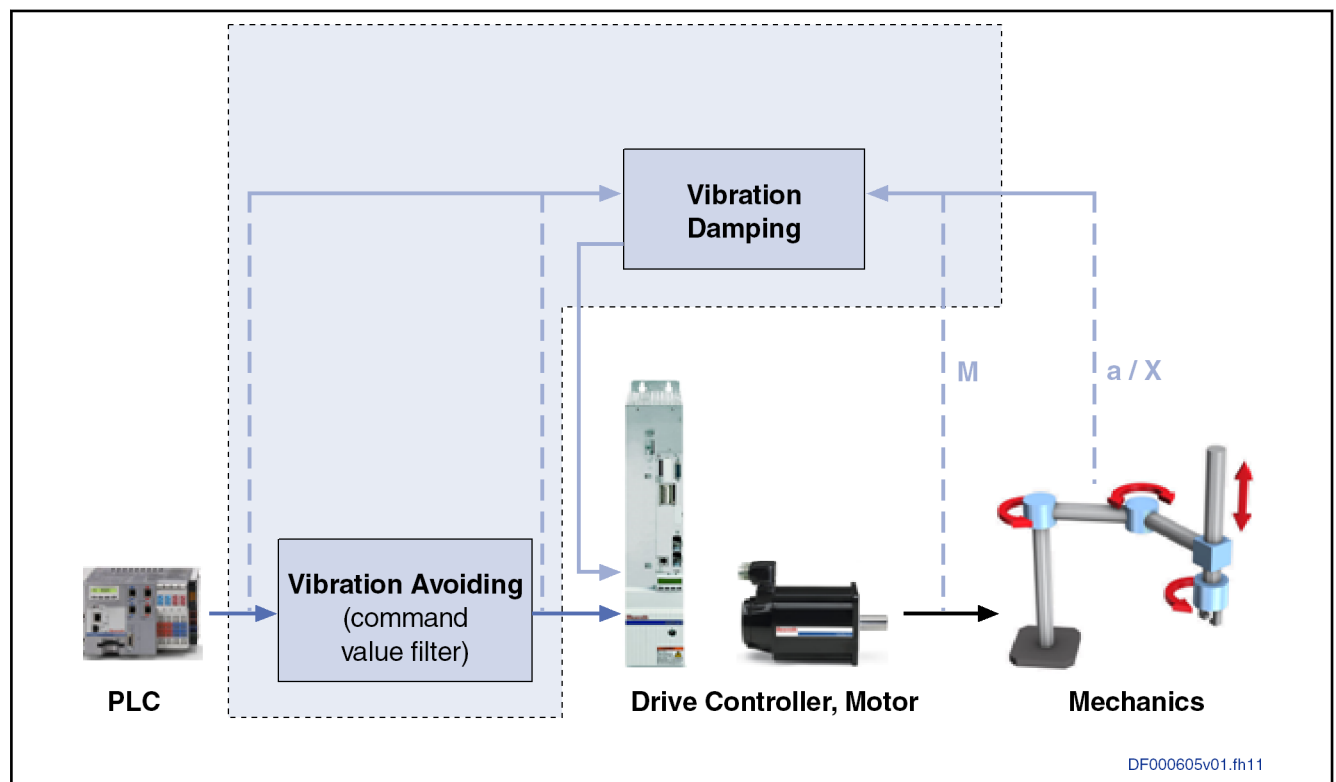


Fig. 11-1: Functional Principle of "Vibration Damping and Avoiding"

### Vibration Avoiding

The preset position profile or velocity profile can be pre-filtered so that a certain frequency is no longer excited by the filtered profile. Via the config word P-0-1370, vibration avoiding can be activated.

In case **position command values** are preset, the higher-level control unit must write these values to the parameter P-0-1300, VA - NC position command value.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

In case **velocity command values** are preset, the higher-level control unit must write these values to the parameter P-0-1301, VA - NC velocity command value.

Besides, the parameter (P-0-1300/P-0-1301) must be included in the cyclic protocol and the actual parameter for the cyclic command value input (S-0-0047 for the position command value and S-0-0036 for the velocity command value) must be removed. If vibration avoiding and thereby the filter is to be temporarily deactivated in the following operation of the technology function, this can be configured via the parameter P-0-1370. In this case, the transmitted command value becomes active in the drive in unfiltered form with a delay of one NC cycle. Commissioning the pre-filter requires knowledge of the parasitic system vibration. Therefore, the torque/force feedback value (S-0-0084) must be recorded in an appropriate way, if necessary, or the vibration of the mechanical system must be captured with an external sensor, if the impact of the vibration on the torque curve in the drive does not show.

The mechanical system can also be excited to vibrate by an external force. In this case, the filter parameters result from the analysis of the vibration.



For an exemplary analysis of the vibration and determination of the characteristic values, see the chapter "Configuration and Operation of Vibration Avoiding by Means of IndraWorks".

**Anti-vibration filter:**

To use the anti-vibration filter (by default, the filter is set when you activate vibration avoiding via the IndraWorks dialog), the two filter parameters P-0-1326, VA - Position command value anti-vibration, characteristic frequency [Hz] and P-0-1327, VA - Position command value anti-vibration, damping degree must be determined and set. With the anti-vibration filter, the preset characteristic frequency and all multiple frequencies are filtered out. For the remaining frequency range, there is no PT1-behavior as is the case with the ordinary average value filters. On this account, this filter has a higher contour precision than an average value filter.

**NOTICE**

Possible property damage caused by jump in command value input, when P-0-1326 or P-0-1327 are adjusted with the filter having been activated and while the axis is in motion.

Only adjust P-0-1326 or P-0-1327 when the filter is inactive.

**Rejection filter:**

The rejection filter must be parameterized via the config word P-0-1370. For this filter, the two filter parameters "P-0-1324, VA - Position command value band-stop filter, center frequency [Hz]" and "P-0-1325, VA - Position command value band-stop filter, bandwidth [Hz]" must be determined and set. The frequency behavior of this filter is similar to the behavior of the anti-vibration filter. With the entered bandwidth, the rejection filter, however, only filters out the center frequency and not the multiples of the command profile. The rejection filter does not have a PT1-behavior for the remaining frequency range either.

The center frequency [Hz] of the filter can be determined in the same way as the characteristic frequency of the anti-vibration filter. As a rule of thumb, set

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

the bandwidth to the 1.5-fold value of the determined center frequency. Then you can optimize these values by "trial and error".

### 11.2.2 Notes on Commissioning and Operation

#### General Information

- Initial Situation** The successful commissioning of the "vibration damping and avoiding" function requires the following initial situation:
- The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
  - The PLC project "FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x" has been loaded and activated for the firmware version at hand (see "How to Load Technology Functions to the Drive").

#### Overview of Required Individual Steps for Commissioning the Vibration Avoiding

##### Configuring the function

1. In the cyclic protocol, the parameter P-0-1300 (when presetting **position command values**) [or P-0-1301 (when presetting **velocity command values**)] must be parameterized as the target parameter for command value input and the standard target parameter S-0-0047 (or S-0-0036) must be removed.
2. In accordance with the desired filter type, the following parameters must be set:
  - "P-0-1324, VA - Position command value band-stop filter, center frequency [Hz]" and "P-0-1325, VA - Position command value band-stop filter, bandwidth [Hz]" (rejection filter)
  - "P-0-1326, VA - Position command value anti-vibration, characteristic frequency [Hz]" and "P-0-1327, VA - Position command value anti-vibration, damping degree [-]" (anti-vibration filter)
3. In the config word, the desired filter is activated via the bits 19 and 18, and the setting of the command value input (bits 17 and 16) in the cyclic protocol is confirmed.

##### Operating/using the function

As soon as the function has been configured, it is always active. If there is an error in the configuration of the command value filter, the received command values are routed in unfiltered form with a delay of one NC cycle.

#### Configuration and Operation of Vibration Avoiding by Means of IndraWorks

When the extended axis control "vibration damping and avoiding" has been loaded to the axis by means of IndraWorks (see "How to Load Technology Functions to the Drive"), the user interface can be opened in the technology functions window via the "Dialog ..." button.

#### Commissioning Step 1: Adjusting the Cyclic Protocol

## Vibration Damping and Avoiding (FWS\_MLDPaX\_VDA\_01Vxx\_D0\_MP0x)

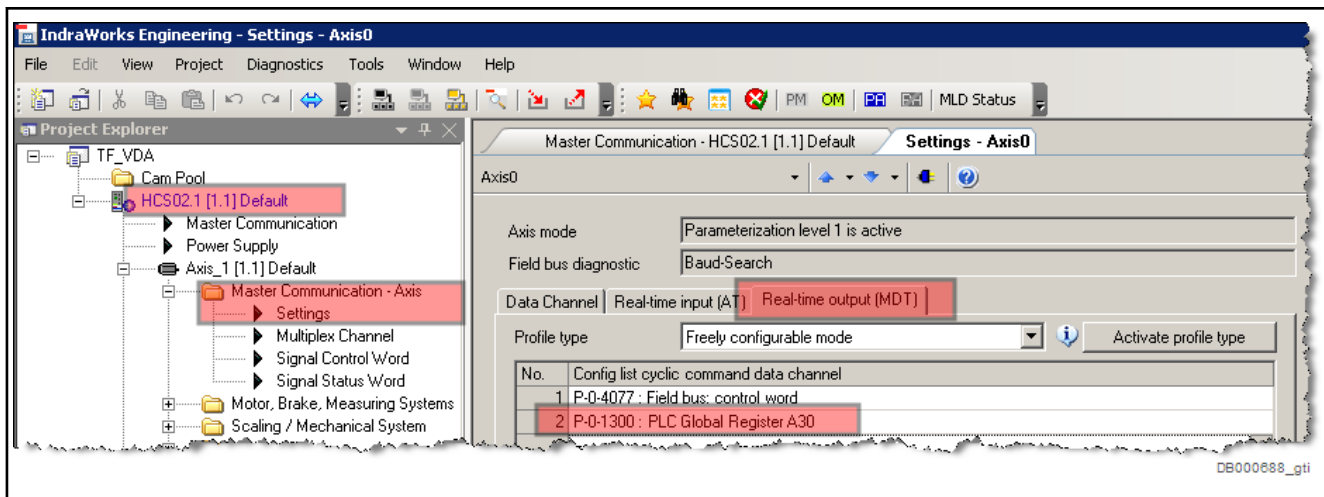


Fig. 11-2: Configuring the Cyclic Data Transmission

The screenshot shows how to call the dialog for configuring the cyclic data transfer and how to extend the cyclic telegram in the "PROFIBUS" example by the parameter "P-0-1300, VA - NC position command value".

## Commissioning Step 2: Selecting and Parameterizing the Filter

1.

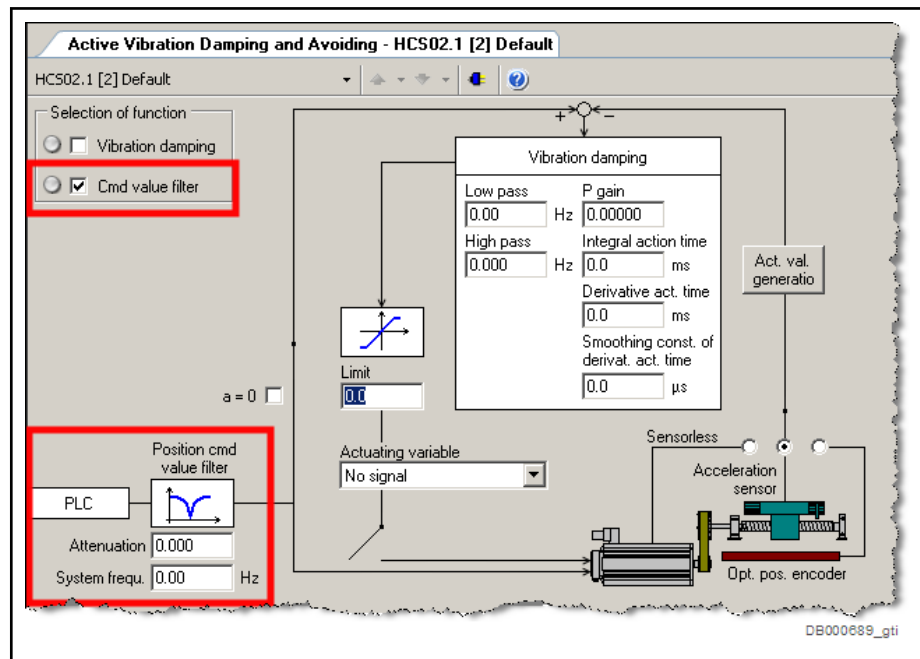


Fig. 11-3: Dialog for Vibration Damping and Avoiding

In the highlighted part of the dialog, you can enter the system frequency [Hz] and the damping for the anti-vibration filter, once the command value filter has been activated via the corresponding check box.

## 2. Calculating the filter parameters:

By means of the following exemplary acceleration measurement at the mechanical system, the parameters for the command value filter can be determined:

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

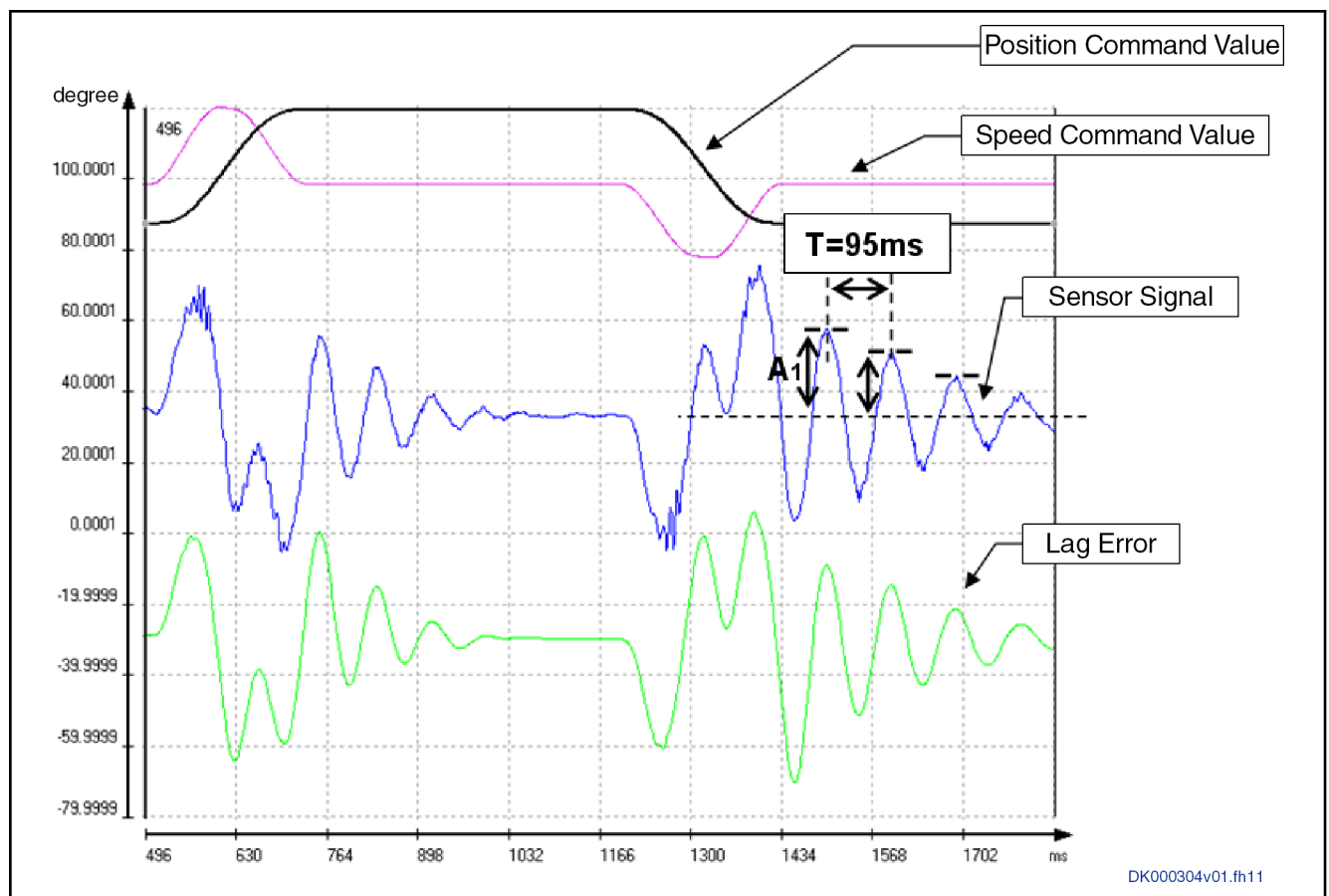


Fig. 11-4: Calculating the Filter Parameters

The frequency of the vibration can be read out by means of the vibration period and must be entered in the parameter P-0-1326 in [Hz]. The damping of the system can be calculated by means of the amplitude values of successive vibrations. The corresponding formula is:

$$D = \frac{\ln \left( \frac{A_i}{A_{i+1}} \right)}{\sqrt{4\pi^2 + \ln \left( \frac{A_i}{A_{i+1}} \right)^2}}$$

By means of "trial and error", a practicable method can be used in this case, too, by entering a start value of P-0-1327 = 0.1 and subsequently testing the effect on the system by adjusting the value between 0.7 and 0.01.

The vibration in the above figure has a frequency of approximately 10.5 Hz. This frequency has an effect on the velocity feedback value and position feedback value, too. The resulting settings for the anti-vibration filter are as follows:

- System frequency (P-0-1326) =  $1 / T = 1 / 0.095 \text{ s} = 10.5 \text{ Hz}$
- Damping (P-0-1327) = 0.1

The damping degree results from the amplitude change of the vibration in the case of a step response. It is possible to start with a

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

value of 0.1. With active command value filter, the damping value can be subsequently optimized.



When the filter type is changed via the parameter "P-0-1370, Config word", the resulting parameters for the rejection filter are as follows:

"P-0-1324, VA - Position command value band-stop filter, center frequency" =  $1 / T = 1 / 0.095s = 10.5Hz$

"P-0-1325, VA - Position command value band-stop filter, band-width" =  $1.5 * \text{center frequency} = 15.8Hz$

It is impossible to enter the values by means of the dialog, they must be entered via individual parameters.

#### Commissioning Step 3: Activating the Command Value Filter

When using the IndraWorks dialog (see "Commissioning Step 2"), you do not need to make any settings in the config word P-0-1370, the command value filter was automatically activated.

### Configuration and Operation of Vibration Avoiding via Parameters

#### Commissioning Step 1: Adjusting the Cyclic Protocol

1. When the primary operation mode "cyclic position control" has been activated, the parameter P-0-1300 instead of the parameter "S-0-0047, Position command value" must be included in the cyclic protocol of the respective master communication. When the "velocity control" mode is used, the parameter P-0-1301 instead of the parameter "S-0-0036, Velocity command value" must be included in the cyclic protocol.
2. The original parameter (S-0-0047 or S-0-0036) must be removed from the protocol.

#### Commissioning Step 2: Selecting and Parameterizing the Filter

1. You can choose between two different filters which have a better contour accuracy as compared to the drive-integrated position command average value filter (P-0-0041/P-0-0042). The two filter have only a few differences and must be selected for each application by means of their effectivity. Basically, it is recommended that you use the anti-vibration filter.
2. With the help of a measurement at the load (by means of an acceleration sensor or optional position encoder) or a measurement of the torque/force feedback value of the drive, the filters can be parameterized.



The chapter "Configuration and Operation of Vibration Avoiding by Means of IndraWorks" shows an exemplary calculation of the filter parameters.

#### Commissioning Step 3: Activating the Filter

1. Via the parameter "P-0-1370, Config word", bits 17 and 16, set the parameter to which the cyclic command values are written.
2. Via the parameter "P-0-1370, Config word", bits 19 and 18, set which filter is active.

## 11.3 "Vibration Damping" (VD)

### 11.3.1 Functional Description

The figure below illustrates the functional principle of "vibration damping and avoiding". The two functions "vibration avoiding" and "vibration damping" can be activated individually or together.

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

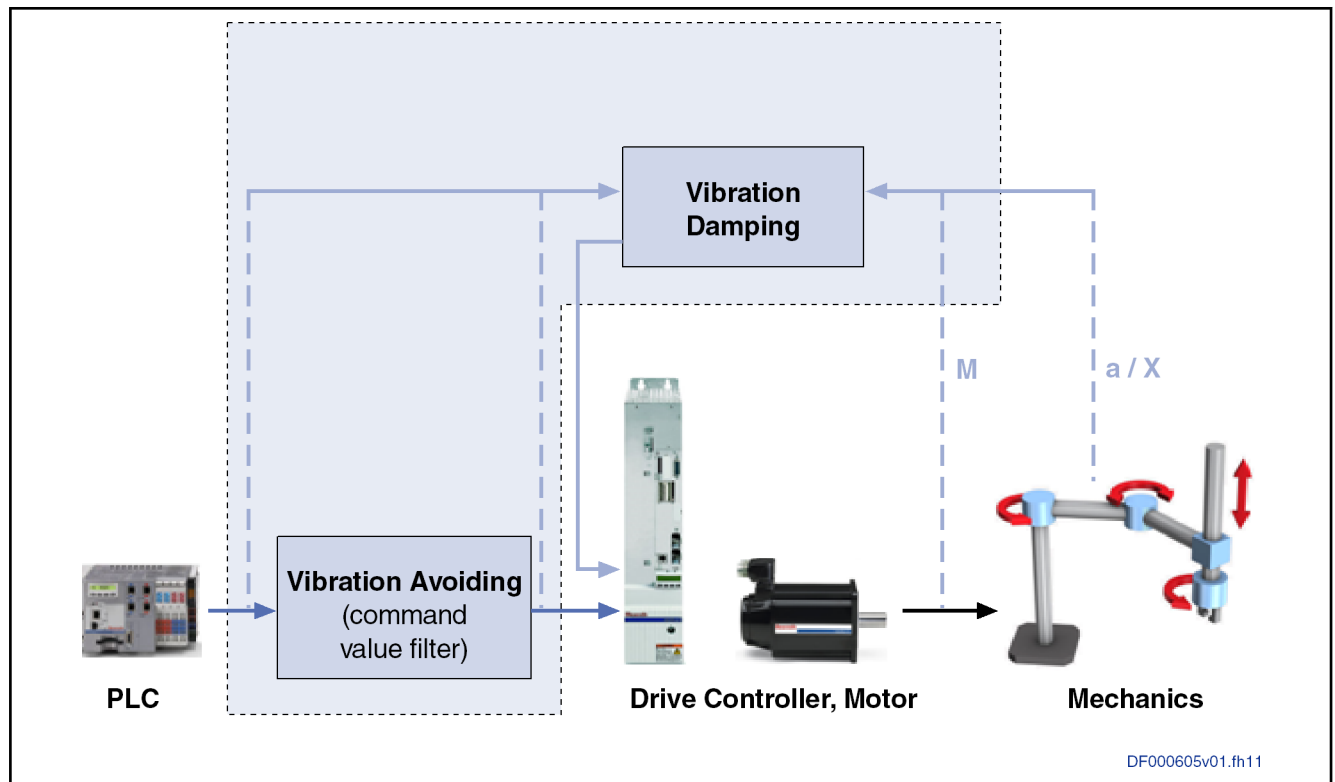


Fig. 11-5: Functional Principle of "Vibration Damping and Avoiding"

#### Vibration Damping

The function of vibration damping can be used for applications in which low-frequency vibrations (<150 Hz) of the mechanical system occur. In these applications, it is possible to compensate for influences such as external disturbances which cannot be damped by a prefilter or a low-pass filter in the control loop. Low-frequency vibrations often can also be caused when the connection of the mechanical system is flexible or when the mass inertias during positioning are mismatched. When trying to eliminate this behavior by adjusting the control loop parameters for position control and velocity control, the typical cascade structure of drive control can easily become unstable and the unwanted vibration can only be minimized by reducing the dynamic response of the control loop. The additional control loop of active vibration damping improves the control behavior, especially for systems characterized by the flexible connection of the load. Both the pieces of information of an optional sensor and the torque/force feedback value of drive control can be used as a feedback for control, if the application-related requirements have been complied with for this purpose.

Optional sensors are:

- Acceleration sensor
- Second position measuring system (on the load side)

Requirements of torque/force feedback value feedback (sensorless):

- Rigid connection between the vibrating mechanical system and the motor
- Quality of control depends on how strong the effect of the vibration is on the motor side, i.e. how weak the damping of the vibration by the mechanical connection is.

When using an optional sensor, the sensor should be installed as near as possible to the point in the mechanical system that is to be damped (usually

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

the Tool Center Point). Just like the feedback, the command value generation for active vibration damping can be configured in different ways and thereby adjusted to the application-related conditions. Numerous digital filters allow sufficiently adjusting the signals and eliminating the machine's fundamental vibrations.

**Command value generation:**

Different signal sources can be configured as command values for the "vibration damping" function. The command vibration contained in the command value input can be determined from the following parameters:

- "P-0-0434, Position command value of controller" (only in position control; not possible as signal source for modulo axes)
- "P-0-0454, Velocity feedforward actual value" (only in position control)
- "P-0-0455, Acceleration feedforward actual value"
- "P-0-0048, Effective velocity command value" (only in velocity control)
- Command vibration = "0"

Furthermore, it is possible to delay the command value by a certain time in milliseconds before it is used as an active command value in control.

**Feedback value generation:**

Depending on the application-related requirements, control section type and available optional modules, different signal sources can be configured for the feedback value:

- Acceleration sensor
  - Analog input 1 (control section)
  - Analog input 2 (control section)
  - Analog input 3 (optional module "MA1")
  - Analog input 4 (optional module "MA1")
- Optional encoders
  - Acceleration feedback value 2 (S-0-0195)
  - Velocity feedback value 2 (S-0-0156)
- Sensorless
  - Torque/force feedback value (S-0-0084)

When an acceleration sensor is used, the following settings must be made:

- Sensor connected to analog input 1-4
- Configuration for sensor connection and sensor sensitivity

When an optional position measuring system is used, it must be configured as an optional encoder at the drive controller.

The other optional and required settings for using a sensor are described in the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks".

Furthermore, a filter is provided to adjust the feedback value signal with an additional sensor (acceleration or position); the machine's fundamental vibrations can be filtered out with this filter. With a flexible structure of the machine housing, low-frequency vibration can occur; although it is to be captured by the sensor that is employed, the vibration is not to be used to compensate the parasitic vibrations.

**Control:**

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

To compensate the unwanted parasitic vibrations, a PI(D-T1) controller structure with a controller output limitation can be configured. The chapter "Notes on Commissioning and Operation" contains simple instructions on how to parameterize which parts of this structure.

Configurable target parameters for the controller output of control:

- P-0-0059, Additive position command value, controller
- S-0-0037, Additive velocity command value
- S-0-0081, Additive torque/force command value
- S-0-0000, Dummy parameter (controller output consequently has no effect)

The resulting controller output can be preset as an additive command value at the different points of the typical cascade structure of drive control; this is more or less successful at these points (according to the application, you have to determine the most effective point at which the command value takes effect, if necessary by "trial and error"). After the summation point of command value and feedback value, a sufficient number of filters can be parameterized for the calculated control difference in order to improve the signal quality and consequently the quality of control according to the circumstances.

Parameterizable filters:

- P-0-1376, VD - Control loop, high pass limit frequency [Hz]
- P-0-1377, VD - Control loop, low pass limit frequency [Hz]
- P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz]
- P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]
- P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz]

## 11.3.2 Notes on Commissioning and Operation

### General Information

**Initial Situation** The successful commissioning of the "vibration damping and avoiding" function requires the following initial situation:

- The functional package "ML" has been enabled so that the drive-integrated PLC can be used.
- The PLC project "FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x" has been loaded and activated for the firmware version at hand (see "How to Load Technology Functions to the Drive").

### Overview of Required Individual Steps for Commissioning the Vibration Damping

#### Configuring the function

1. Configuring and Adjusting the Feedback Value Signal
2. Configuring and Adjusting the Command Value Signal
3. Parameterizing the Controller and the Required Filters
  - Controller settings
  - Target parameters for the calculated controller output
4. Activating the Controller via the Config Word
5. Optimizing the Controller and Filter Settings

#### Operating/using the function

As soon as the function has been activated via the config word, it is always active as long as there does not occur any configuration error. When a con-

Vibration Damping and Avoiding (FWS\_MLDPa<sub>x</sub>\_VDA\_01Vxx\_D0\_MP0x)

figuration error is present, the controller output is set to "0". Compensating the vibration is only possible when the drive is with torque (AF, AH).



Below, the individual steps will be described in detail and the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" will explain these steps.

## Configuration and Operation of Vibration Damping by Means of IndraWorks

### Commissioning Step 1: Configuring and Adjusting the Feedback Value Signal

In the highlighted part of the dialog in the figure below, select the signal source which is used for feedback value generation. If an additional sensor is used, you must specify whether it is an optional position encoder or an acceleration sensor.

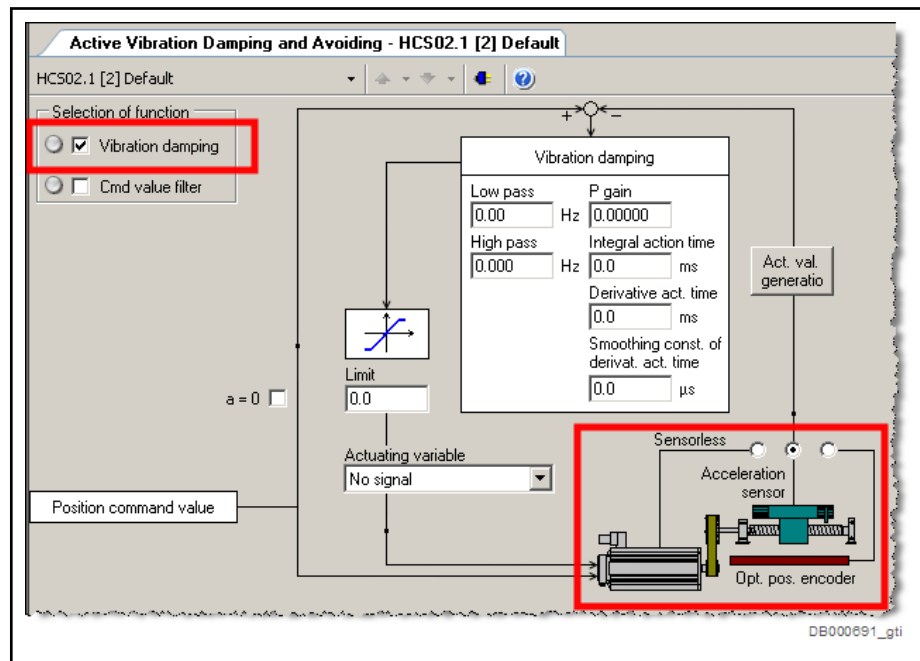


Fig.11-6: Configuring and Adjusting the Feedback Value Signal

### Acceleration sensor

1. Structure of the sensor system, mounting and orientation of the acceleration sensor at a position in the vibrating mechanical system. Afterwards, the voltage output of the sensor system must be connected to one of the possible interfaces for the analog input.



- The type of control section and the optional modules used determine which analog input interface (1-4) is available.
- The allowed voltage range for the selected analog input must be complied with.

See also Functional Description of firmware "Analog Inputs"

2. When the "Acceleration sensor" is selected, the "Act. val. generation" button appears; via this button you can get to a subordinate dialog.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

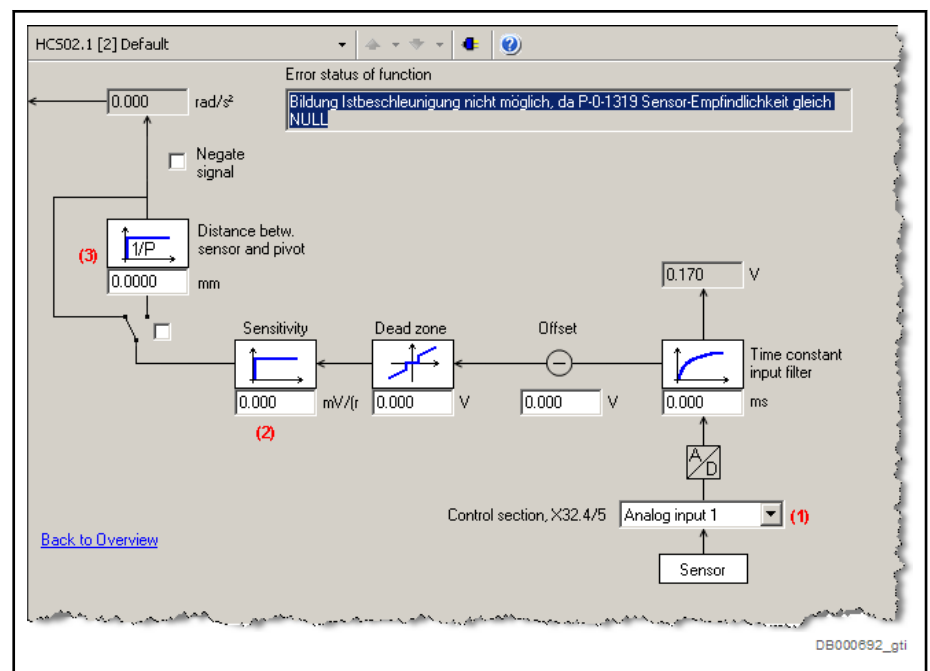


Fig. 11-7: Feedback Value Generation

Via the drop down list (1), select the analog input to which the sensor output is connected.

3. Under "Sensitivity" (2), enter the sensor sensitivity [mV/g] / [mV/(rad/s²)], i.e. the conversion factor for the voltage value at the analog input in accordance with the sensor system.

Example:

- Sensitivity of sensor (according to data sheet), e.g.: 100 mV/g (note: 1 m/s²=0.1019 g)
- Measuring amplifier / coupler: Gain = 20

Thus, the value "2000" must be entered in the "Sensitivity" field (20\*100 mV/g=2000 mV/g).

4. Acceleration sensors can either capture an angular acceleration (e.g. Ferraris sensor in [mV / (rad/s²)]) or a linear acceleration. However, think of the case in which, due to application-related conditions, a sensor measuring a linear acceleration has been mounted to the mechanical system, but the axis carries out rotary motions. In this case, the difference in the linear/rotary orientation must be taken into account under (3). In the "Distance betw. sensor and pivot" field, you must enter the distance in [mm].
5. In the "Time constant input filter" field, you can specify the filter time constant [ms] for a digital low-pass filter of the analog input and thus of the sensor signal. It is recommended that you specify the time constant as described in the following example:

The vibration to be compensated has a frequency of  $f=1/T=10.9$  Hz. All higher frequencies can be regarded as interference frequencies and are to be filtered out without considerably influencing the 6.9 Hz in amplitude and phase.

The filter time constant is calculated as follows:  $T_{\text{Filter}} = 1000 / (2 \cdot \pi \cdot 3 \cdot f) = 4.9$  ms

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)



If several frequencies are to be compensated, the highest frequency value to be compensated is used in the formula.

6. A voltage offset of the sensor signal can be adjusted in the "Offset" field. The value entered here in [V] is subtracted from the sensor signal at the analog input.
7. In the "Dead zone" field, you can specify a bipolar voltage range around 0 V; the function will interpret the voltage range as the voltage value 0 V.
8. In a final step, you must check whether the mounting direction of the sensor matches the coordinate system of the drive. If they are opposed, the sensor signal can be negated via the "Negate signal" check box.

The orientation of the two systems can be identified by means of a simple measurement.

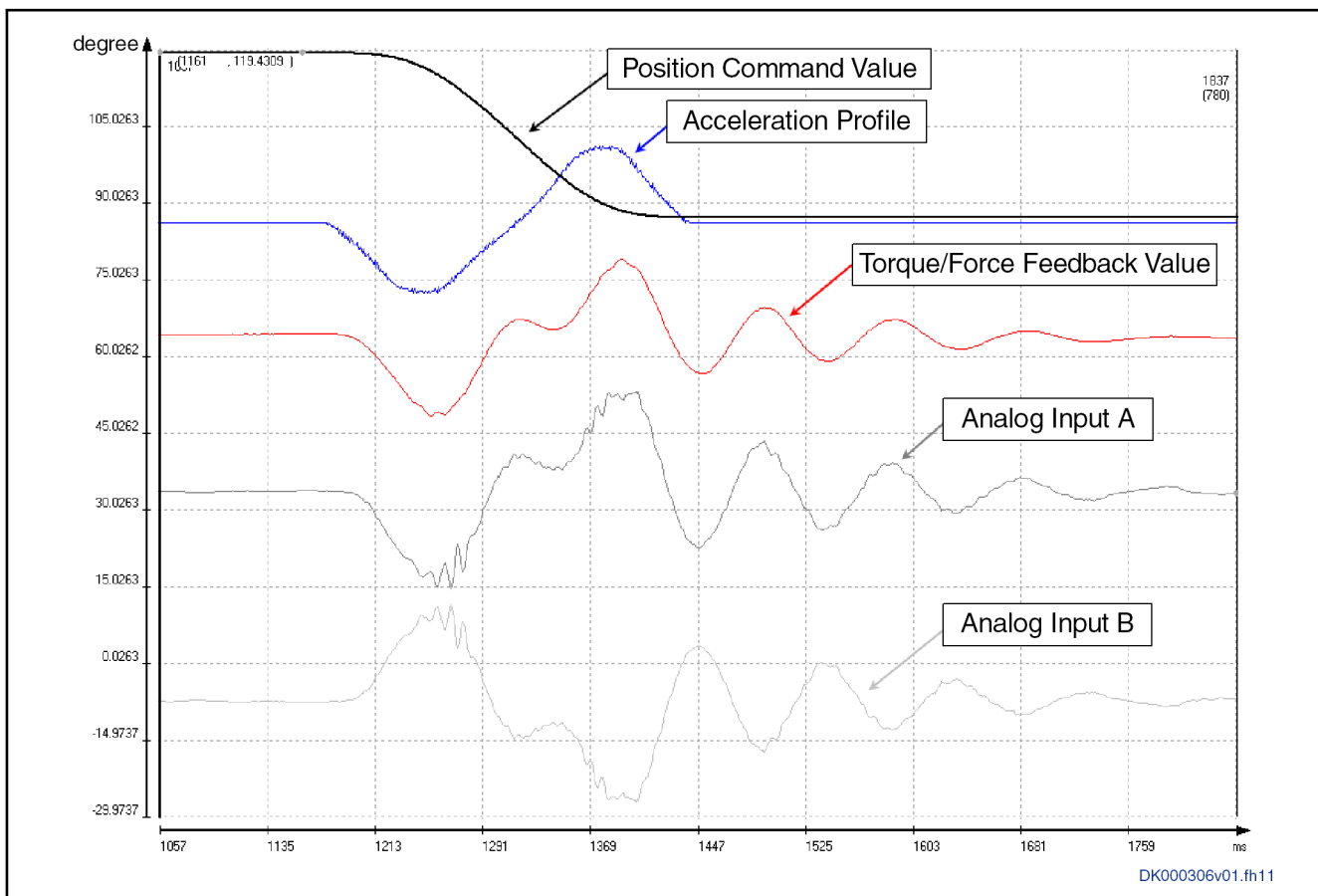


Fig. 11-8: Measurement to Identify the Orientation of the Sensor as Compared to the Coordinate System of the Drive

In the case of "analog input A", the mounting direction of the sensor complies with the orientation of the coordinate system of the axis: The measured acceleration curve matches the preset position command value and the torque /force feedback value. In the case of "analog input B", the two curves are opposed. This is due to the difference in orientation of the measuring system as compared to the coordinate system of the axis. In this case, you must tick the "Negate signal" check box.

#### Optional position encoder

## Vibration Damping and Avoiding (FWS\_MLDPaX\_VDA\_01Vxx\_D0\_MP0x)

1. When selecting the "optional position encoder", you can choose whether to have the feedback value signal generated from the velocity feedback value 2 or to directly use the acceleration feedback value 2 as the feedback value. On the firmware side, the acceleration feedback value 2 was already filtered by a low-pass filter for 4 ms.

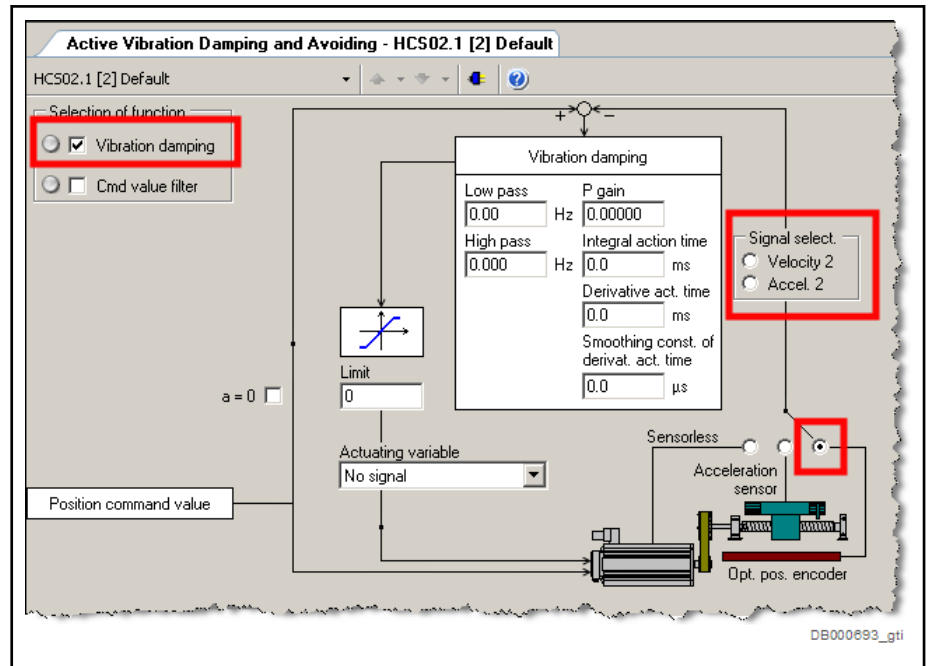


Fig. 11-9: Signal Selection of the Optional Position Encoder

2. For both sources, it is possible to additionally configure the "average value filter for display". This is a firmware function with an IndraWorks dialog:

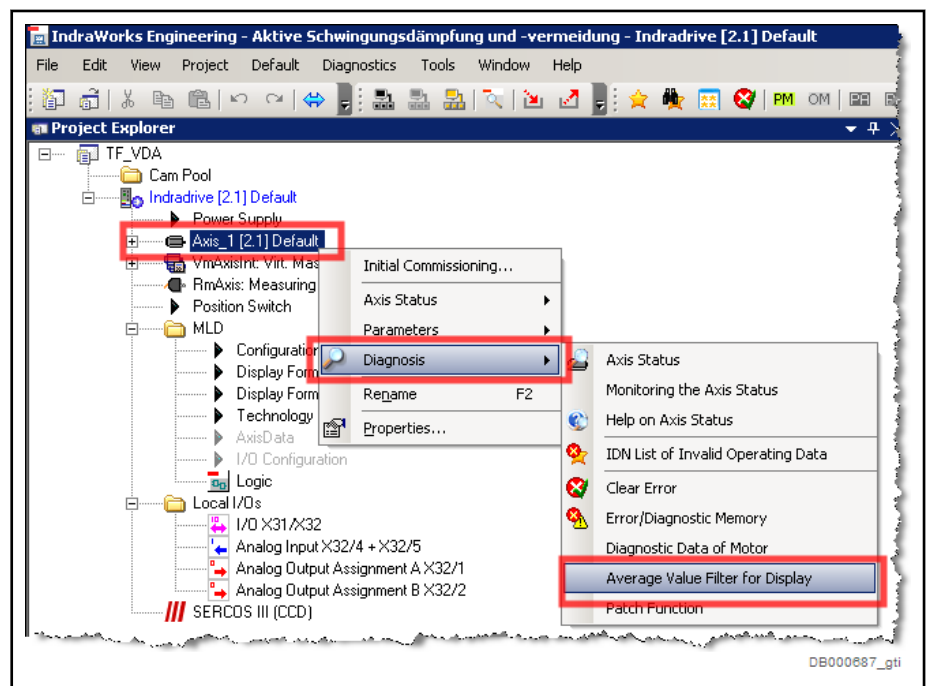


Fig. 11-10: Calling the "Average Value Filter for Display" Dialog

## Vibration Damping and Avoiding (FWS\_MLDPaX\_VDA\_01Vxx\_D0\_MP0x)

In the dialog it is possible to define up to 2 signals which can be filtered by a low-pass filter with a time constant to be set. In this case, you would enter the signal "S-0-0156, Velocity feedback value 2" or "S-0-0195, Acceleration feedback value 2". The filter time constant can be calculated as described for the acceleration sensor in the previous section.

**Torque/force feedback value**

1. When "Sensorless" is activated, i.e. "torque/force feedback value" is selected, an impact of the vibration of the mechanical system on the motor shaft must be noticeable, as shown in the figure below.

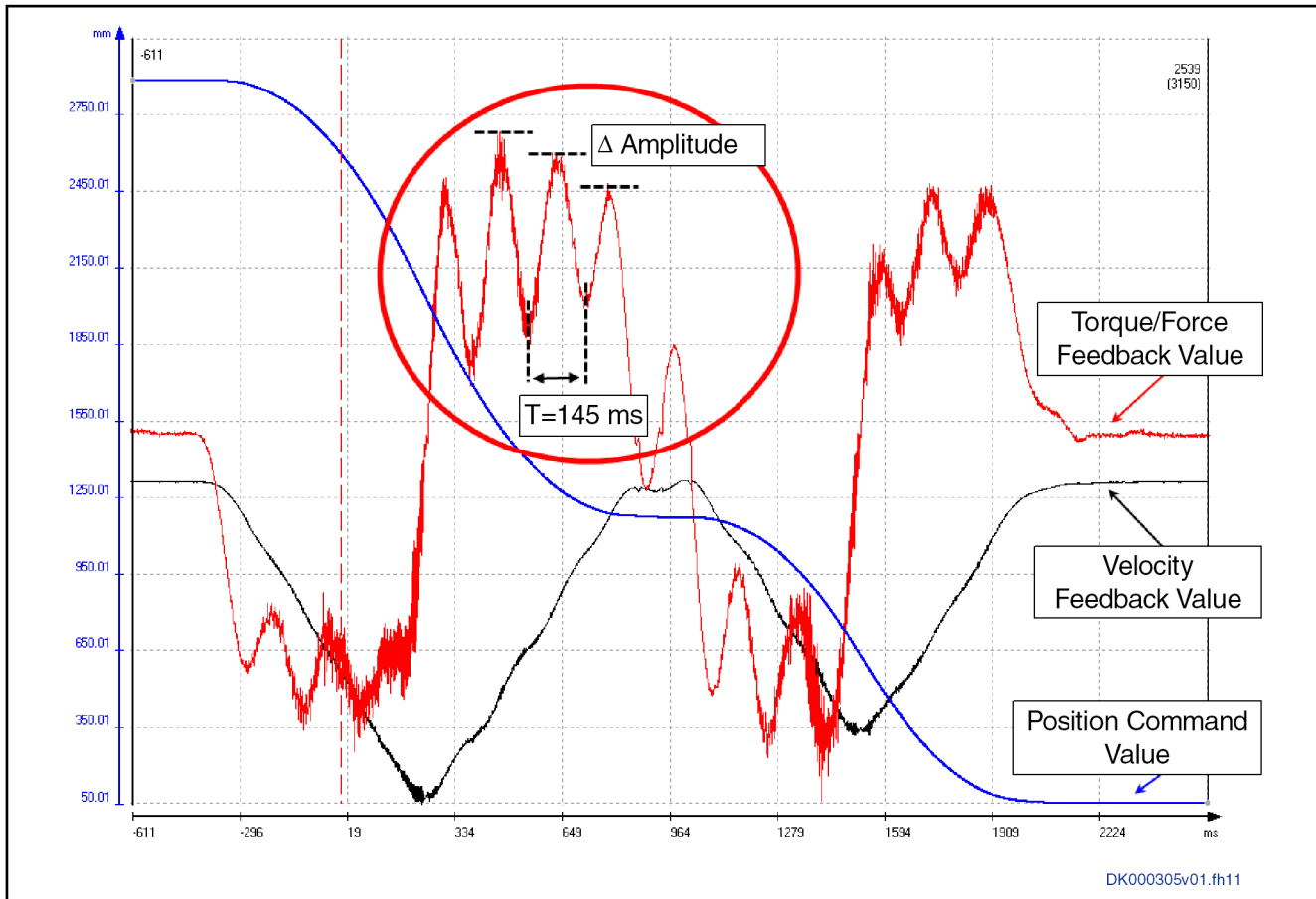


*Fig. 11-11: Impact of the Vibration of the Mechanical System on the Motor Shaft*

A 7 Hz vibration can be clearly seen in the torque/force feedback value. The velocity feedback value and the position feedback value, too, reflect this vibration.

As the dialog shows, a scaling factor is required when activating the sensorless solution; this factor is used to convert the torque (or force) to an acceleration. Enter the system inertia as the scaling factor.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

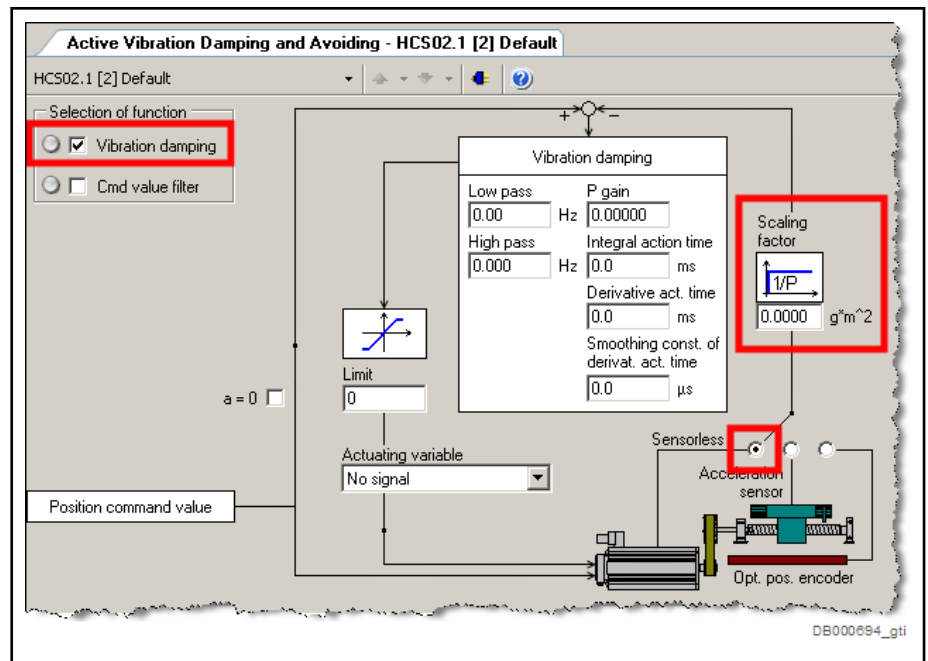


Fig. 11-12: Scaling Factor for Sensorless Vibration Damping

2.
  - Linear acceleration:  
The moved total mass in [kg] related to the motor must in this case be entered as the scaling factor.
  - Rotary acceleration:  
The total inertia in [gm<sup>2</sup>] related to the motor must in this case be entered as the scaling factor.



The total mass / total inertia consists of motor **and** load.

If the value is unknown, it can be determined by an experiment. For this purpose, the axis is accelerated and decelerated with reduced torque (or reduced force) and the torque/force curve, as well as the change of velocity, are evaluated. Here, it is necessary to examine a section of the recording with a constant acceleration curve.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

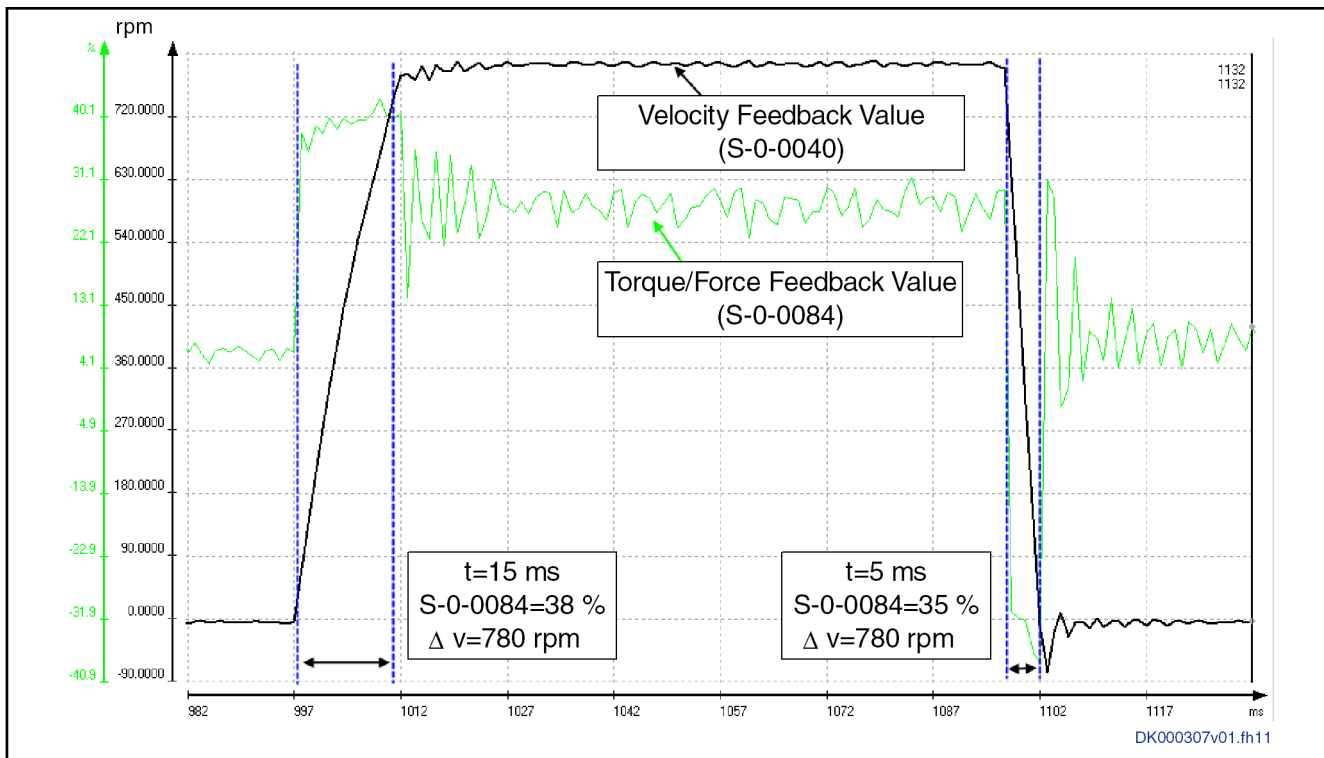


Fig.11-13: Measurement to Determine the Scaling Factor

Other parameters required for the calculation:

- S-0-0111, Motor current at standstill
- P-0-0051, Torque/force constant

The difference in the behavior for acceleration and deceleration is due to the friction in the system. The friction can be deducted when calculating the two curves.

$$J_B = T_B / \alpha_B = S-0-0084/100 * S-0-0111 * P-0-0051 / (\Delta S-0-0040 * 2 * \pi / 60 / \Delta t) = 38/100 * 1.5 A_{rms} * 0.29 Nm/A_{rms} / 81.68 rad/s / 0.015 s = 0.00003 Nms^2/rad = 0.00003 kgm^2 = 0.03 gm^2$$

$$J_V = T_V / \alpha_V = S-0-0084/100 * S-0-0111 * P-0-0051 / (\Delta S-0-0040 * 2 * \pi / 60 / \Delta t) \triangleq 0.00001 Nms^2/rad = 0.00001 kgm^2 = 0.01 gm^2$$

Thus, the total inertia of the system is  $J = J_B/2 + J_V/2 = 0.02 gm^2$

With variable inertia / mass, this value can be corrected to improve control or allow compensating the parasitic vibration. This is the case with kinematics such as robot arms. The control unit knows the angles of the different axes and can calculate a current inertia of the arm and cyclically transmit it to the function, i.e. to the "P-0-1321, Torque/force feedback value scaling factor".

3. For the torque/force feedback value, "average value filter for display" can be configured in addition. This is a firmware function with an IndraWorks dialog.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

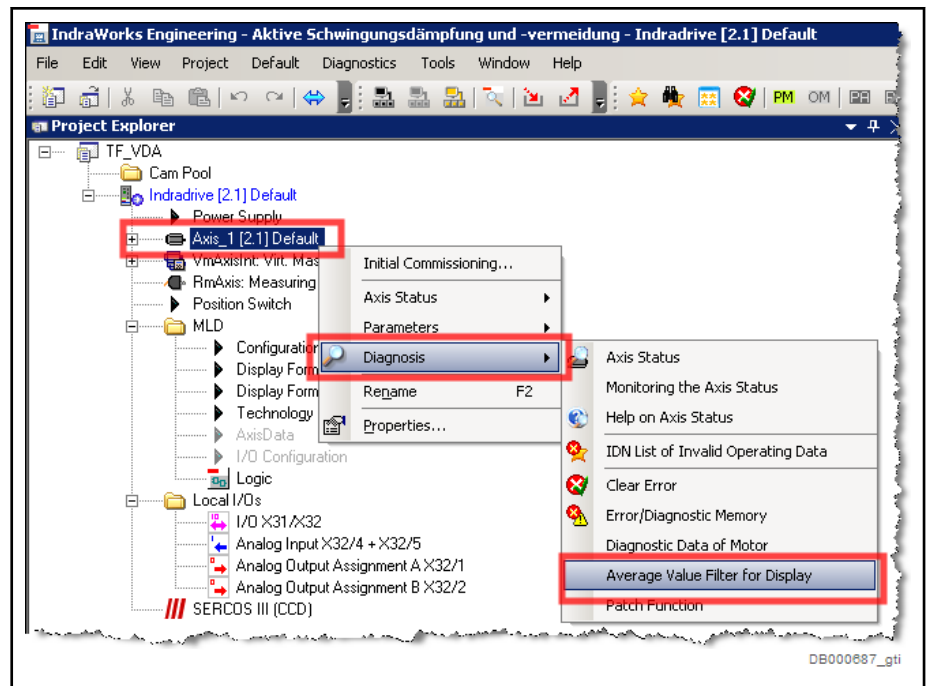


Fig. 11-14: Calling the "Average Value Filter for Display" Dialog

In the dialog it is possible to define up to 2 signals which can be filtered by a low-pass filter with a time constant to be set. In this case, you would enter the "S-0-0084, Torque/force feedback value" signal. The filter time constant can be calculated as described for the acceleration sensor in the previous section.

### Common part

Independent of the signal source, it is possible to suppress a fundamental vibration of the machine visible in the torque/force feedback value or in the sensor signal, but irrelevant to the compensation of the parasitic vibration. Via the parameters "P-0-1381, Acceleration feedback value band-stop filter, center frequency" and "P-0-1382, Acceleration feedback value band-stop filter, bandwidth", it is possible to parameterize a band-stop filter for the machine's fundamental vibration.



For instructions on how to parameterize the band-stop filter, see the chapter "Configuration and Operation of Vibration Avoiding by Means of IndraWorks", commissioning step 2 under "Calculating the Filter Parameters".

The parameter P-0-1272 displays the acceleration feedback value as it is used in the summation point for calculating the control difference, after it has been completely adjusted.

### Commissioning Step 2: Configuring and Adjusting the Command Value Signal

1.

## Vibration Damping and Avoiding (FWS\_MLDPaX\_VDA\_01Vxx\_D0\_MP0x)

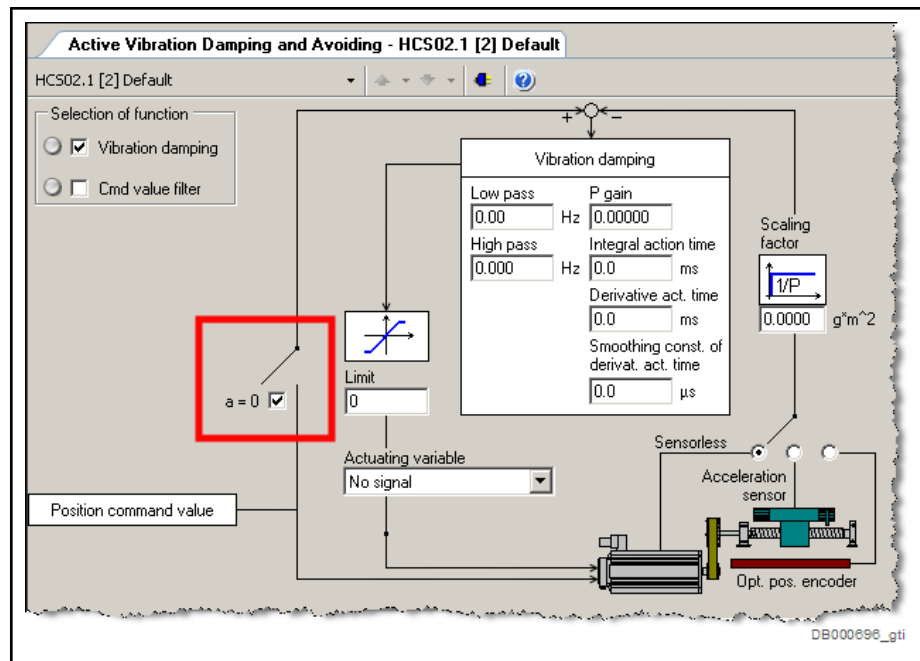


Fig. 11-15: Selecting the Command Signal of Control

Via the check box, select the command signal of control. The 2 recommended command signals are available in the dialog.

- Check box **not** selected: Command signal generated from "P-0-0434, Position command value of controller"
- Check box selected: Acceleration="0"

Select this setting, if the acceleration is to be set to ZERO, i.e. completely compensated. This setting can be helpful for dynamic axes with the corresponding filter settings.

Via the parameter "P-0-1370, Config word", you can select other signals which cannot be selected via the dialog (expert setting).

- Bit #6-4=100: P-0-0048, Effective velocity command value
- Bit #6-4=010: P-0-0454, Velocity feedforward actual value in the lagless position control mode  
Only makes sense with parameterized velocity feedforward (P-0-0040, Velocity feedforward evaluation)
- Bit #6-4=011: P-0-0455, Acceleration feedforward actual value in the position control mode  
Only makes sense with parameterized acceleration feedforward (S-0-0348, Acceleration feedforward gain)
- Bit #6-4=101: P-0-0455, Acceleration feedforward actual value in the velocity control mode  
Only makes sense with parameterized acceleration feedforward (P-0-1126, Velocity control loop: Acceleration feedforward)

2. If the acceleration command curve is to be delayed, the parameter "P-0-1383, Acceleration command value delay [ms]" provides the option to delay the command value, before it is used in the summation point for calculating the control difference. This is not displayed via the dialog and also is an expert setting.

## Vibration Damping and Avoiding (FWS\_MLDPaX\_VDA\_01Vxx\_D0\_MP0x)

The parameter P-0-1279 displays the acceleration command value as it is used in the summation point for calculating the control difference.

The parameter P-0-1273 displays the control difference directly after the summation point.

### Commissioning Step 3: Activation via the Config Word

### Commissioning Step 4: Parameterizing the Controller and the Required Filters

1. The vibration damping can be activated in the dialog under "Selection of function".

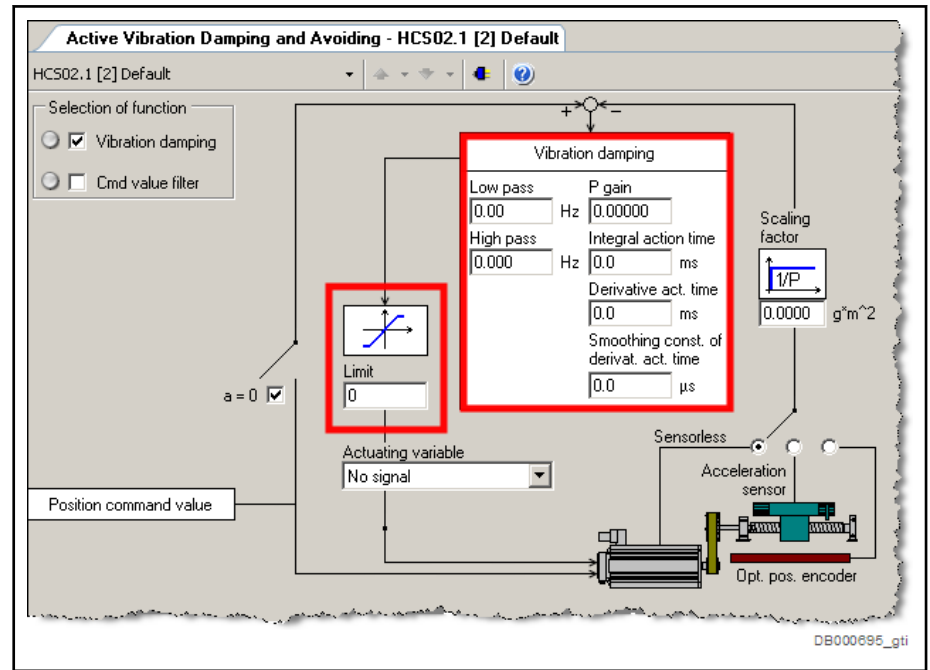


Fig. 11-16: Parameterizing the Controller and the Required Filters

#### 1. Filtering

The control difference is displayed in the parameter P-0-1273 and can be sufficiently filtered. For this purpose, a low-pass filter and a high-pass filter are available. If the values "0" are set here, the filters are inactive.



The corner frequencies in [Hz] are directly preset for these filters. In doing so, the following calculation formula should be complied with in order not to obtain any significant phase shift or amplitude change in the signal.

$$\text{Low pass: } f_{\text{Corner}} \geq 3 * f_{\text{Disturbance}}$$

$$\text{High pass: } f_{\text{Corner}} \leq 1/3 * f_{\text{Disturbance}}$$

In addition, a 2nd order low-pass filter (P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz]) and a band-stop filter (P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]; P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz]) are available, if further/stronger filtering should be necessary. This is not displayed in the dialog and is an expert setting.

The completely filtered control difference is displayed in the parameter P-0-1277.

#### 2. Acceleration controller

There is a PI(D-T1) controller structure available with the following parameters:

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

- P-0-1371, VD - PI(D-T1) controller proportional gain
- P-0-1372, VD - PI(D-T1) controller integral-action time [ms]
- P-0-1373, VD - PI(D-T1) controller derivative action time [ms]
- P-0-1374, VD - PI(D-T1) controller smoothing time constant, D-component [us]
- P-0-1375, VD - PI(D-T1) controller limitation

The calculated and limited controller output is displayed in the parameter P-0-1278.

Via the "Controller output" selection list, the point at which the controller output takes effect in the drive control loop is determined for acceleration control:

- P-0-0059, Additive position command value, controller
- S-0-0037, Additive velocity command value
- S-0-0081, Additive torque/force command value
- S-0-0000, Dummy parameter (empty)

When parameterizing the controller and the target parameter for the controller output, observe the following guidelines:

| Target parameter                    | Controller structure                                                |
|-------------------------------------|---------------------------------------------------------------------|
| Additive position command value     | P controller                                                        |
| Additive velocity command value     | P controller (recommended setting)                                  |
| Additive torque/force command value | PI controller, a D-T1 path might possibly allow further improvement |

Fig. 11-17: Relation between Controller Structure and Target Parameter



### Controller parameterization

It is recommended that you configure vibration damping with a mere P controller and the additive velocity command value as the target parameter, because this allows achieving the best results in a large part of the known applications.

The "velocity command value" (S-0-0037) is selected as the target parameter for the controller output, and the limitation of the controller output is set to a low value (a safe value for this application). It is now possible to parameterize the P-gain without risking an enormous axis motion. Starting with a small value for the P-gain and then increasing the P-gain, you will, by means of the drive-internal oscilloscope function, quickly get a picture of the range in which the value for the respective application is to be found by recording the calculated controller output (S-0-0037, Additive velocity command value, in this case). Increasing the P-gain requires adjusting the controller limitation, too.

The figure below again shows the controller structure with all possible display parameters available for easy and troublefree commissioning.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

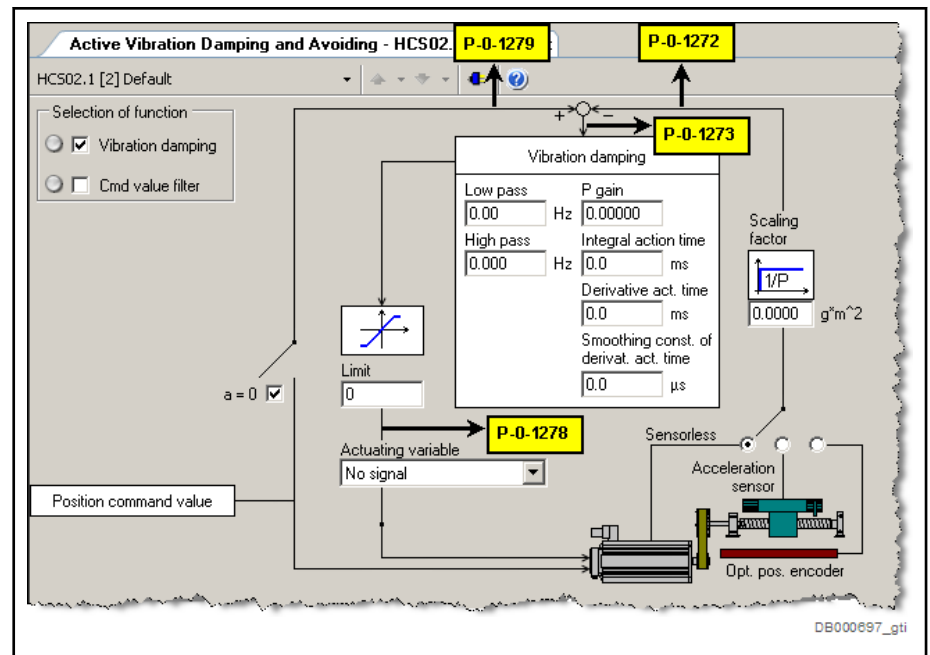


Fig.11-18: Controller Structure with Display Parameters

The control difference after high-pass and low-pass filtering can be read out in P-0-1277.

## Configuration and Operation of Vibration Damping via Parameters

### Commissioning Step 1: Configuring and Adjusting the Feedback Value Signal

According to the configuration of the feedback value, the signal source can or must be adjusted in different ways. The first part of the following description applies to the signal source for the feedback value.

#### Acceleration sensor

1. Structure of the sensor system, mounting and orientation of the acceleration sensor at a position in the vibrating mechanical system. Afterwards, the voltage output of the sensor system must be connected to one of the possible interfaces for the analog input.



The type of control section and the optional modules used determine which analog input interface (1-4) is available (see also Functional Description of firmware "Analog Inputs").



The allowed voltage range for the selected analog input must be complied with (see also Functional Description of firmware "Analog Inputs").

2. Via the parameter "P-0-1370, Config word", bits 11 to 8, set the analog input to which the sensor signal is connected. (Bit #11-8 : AnIn1 = 0000, AnIn2 = 0001, AnIn3 = 0010, AnIn4 = 0011)
3. In the parameter "P-0-1319, Sensor sensitivity [mV/g] / [mV/(rad/s²)]", enter the conversion factor for the voltage value at the analog input in accordance with the sensor system.



The chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" shows an exemplary determination of the conversion factor.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

4. Observe the relation between the measuring principle of the acceleration sensor and the occurring acceleration direction, or the acceleration direction you are interested in. For this purpose, set in "P-0-1370, Config word", bit 6, whether the relation is linear/linear or rotary/linear. In this context, the parameter "P-0-1320, Sensor distance to pivot [mm]" is additionally available; it must be determined, if P-0-1370, bit 6="1" is selected.



The chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" shows an exemplary relation between the measuring principle and the axis orientation.

5. The connected signal can be filtered with a digital low pass via "P-0-1316, Sensor input, input filter time constant [ms]". When the value "0" is set, the filter is inactive. Ideally, all frequencies above the interference frequency are filtered.



The chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" shows an exemplary determination of the time constant.

6. A voltage offset of the sensor signal can be adjusted via "P-0-1317, Sensor input, analog input offset [V]". The value entered here is subtracted from the sensor signal at the analog input.
7. In the parameter "P-0-1318, Analog input sensor dead zone (bipolar) [V]", you can specify a bipolar voltage range around 0 V; the function will interpret the voltage range as the voltage value 0 V.
8. In a final step, you must check whether the mounting direction of the sensor matches the coordinate system of the drive. If they are opposed, the sensor signal can be negated via the "P-0-1370, Config word", bit 3.



For instructions on how to determine the appropriate configuration by means of measurement, see the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks".

#### Optional position encoder

1. Via the parameter "P-0-1370, Config word", bits 11 to 8, configure one of the two following options:
  - Derivation of velocity feedback value 2:  $d(S-0-0156)/dt^2$  (P-0-1370, bits 11 to 8="0101")
  - Acceleration feedback value 2: S-0-0195 (P-0-1370, bits 11 to 8="0111")
2. By means of the drive functionality "average value filter for display", the selected signal can be filtered by a low-pass filter. In the parameter "P-0-0395, Average value filter for display: Signal selection", enter the selected signal (S-0-0156 or S-0-0195) for this purpose, and in "P-0-0397, Average value filter for display: Time constant", enter the filter time.

Observe that "S-0-0195, Acceleration feedback value 2" was already filtered for 4 ms.

#### Torque/force feedback value

1. In P-0-1370, Config word, bit #11-8 = 1000, the signal S-0-0084, Torque/force feedback value is selected as the source.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

2. Afterwards, P-0-1321, Torque/force feedback value scaling factor [gm<sup>2</sup>] / [kg] must be determined.



For instructions on how to determine the scaling factor, see the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks".

3. By means of the drive functionality "average value filter for display", the torque/force feedback value can be filtered by a low-pass filter. In the parameter "P-0-0395, Average value filter for display: Signal selection", enter the parameter S-0-0084 for this purpose, and in "P-0-0397, Average value filter for display: Time constant", enter the filter time. Ideally, select the filter time such that all frequencies above the interference frequency are filtered.



The chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" shows an exemplary determination of the time constant.

### Common part

Independent of the signal source, it is possible to suppress a fundamental vibration of the machine visible in the torque/force feedback value or in the sensor signal, but irrelevant to the compensation of the parasitic vibration. Via the parameters "P-0-1381, Acceleration feedback value band-stop filter, center frequency" and "P-0-1382, Acceleration feedback value band-stop filter, bandwidth", it is possible to parameterize a band-stop filter for the machine's fundamental vibration.



For instructions on how to parameterize the band-stop filter, see the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks".

The parameter P-0-1272 displays the acceleration feedback value as it is used in the summation point for calculating the control difference, after it has been completely adjusted.

### Commissioning Step 2: Configuring and Adjusting the Command Value Signal

1. In the P-0-1370, Config word, bit # 6-4, select one of the following sources for the generation of the command signal.
  - Bit 6-4="001": P-0-0434, Position command value of controller
  - Bit 6-4="000": S-0-0000, Dummy parameter  
Select this setting, if the acceleration is to be set to ZERO, i.e. completely compensated. This setting can be helpful for dynamic axes with the corresponding filter settings.
  - Bit 6-4="100": P-0-0048, Effective velocity command value
  - Bit 6-4="010": P-0-0454, Velocity feedforward actual value in the lagless position control mode  
Only makes sense with parameterized velocity feedforward (P-0-0040, Velocity feedforward evaluation)
  - Bit 6-4="011": P-0-0455, Acceleration feedforward actual value in the position control mode  
Only makes sense with parameterized acceleration feedforward (S-0-0348, Acceleration feedforward gain)
  - Bit 6-4="101": P-0-0455, Acceleration feedforward actual value in the velocity control mode

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

Only makes sense with parameterized acceleration feedforward (P-0-1126, Velocity control loop: Acceleration feedforward)

2. If the acceleration command curve is to be delayed, the parameter "P-0-1383, Acceleration command value delay [ms]" provides the option to delay the command value, before it is used in the summation point for calculating the control difference.
3. The parameter P-0-1279 displays the acceleration command value as it is used in the summation point for calculating the control difference.

### Commissioning Step 3: Activation via the Config Word

### Commissioning Step 4: Parameterizing the Controller and the Required Filters

Control is activated in the "P-0-1370, Config word", bit 0.

#### 1. Filtering

The control difference is displayed in the parameter P-0-1273 and can be sufficiently filtered. It is recommended that you parameterize "P-0-1377, VD - Control loop, low pass limit frequency [Hz]". The "P-0-1376, VD - Control loop, high pass limit frequency [Hz]" can be used to eliminate an offset in the control difference or an error in the actual acceleration feedback value calculation.



The chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks" shows an exemplary determination of the time constants for the low-pass and the high-pass filters.

In addition, a 2nd order low-pass filter (P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz]) and a band-stop filter (P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]; P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz]) are available, if further/stronger filtering should be necessary.

The completely filtered control difference is displayed in the parameter P-0-1277.

#### 2. Acceleration controller

There is a PI(D-T1) controller structure available with the following parameters:

- P-0-1371, VD - PI(D-T1) controller proportional gain
- P-0-1372, VD - PI(D-T1) controller integral-action time [ms]
- P-0-1373, VD - PI(D-T1) controller derivative action time [ms]
- P-0-1374, VD - PI(D-T1) controller smoothing time constant, D-component [us]
- P-0-1375, VD - PI(D-T1) controller limitation

The calculated and limited controller output is displayed in the parameter P-0-1278.

In addition, the point at which the controller output takes effect in the drive control loop must be determined for acceleration control in "P-0-1370, Config word":

- P-0-0059, Additive position command value, controller
- S-0-0037, Additive velocity command value
- S-0-0081, Additive torque/force command value
- S-0-0000, Dummy parameter (empty)

When parameterizing the controller and the target parameter for the controller output, observe the following guidelines:

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

| Target parameter | Recommended controller structure                                    |
|------------------|---------------------------------------------------------------------|
| P-0-0059         | P controller                                                        |
| S-0-0037         | P controller                                                        |
| S-0-0081         | PI controller, a D-T1 path might possibly allow further improvement |

Fig. 11-19: Relation between Controller Structure and Target Parameter



For a possible procedure used to parameterize and optimize the controller setting, see the chapter "Configuration and Operation of Vibration Damping by Means of IndraWorks".

## 11.4 Diagnostic and Status Messages

### Overview of Drive Warnings

- E2011 Changing the config word not allowed in AF
- E2012 Limitation of controller output is active (see P-0-1375)

### Error Output Overview

The pieces of information for Additional 1 and Additional 2 are output via the parameters P-0-1330 and P-0-1331:

| ErrorID | ErrorIdent |              |              | Explanation                                                                           |
|---------|------------|--------------|--------------|---------------------------------------------------------------------------------------|
|         | ErrorTable | Additional 1 | Additional 2 |                                                                                       |
| 16#0000 | 16#1000    | 16#0000      | 16#0000      | No error present                                                                      |
| 16#0007 | 16#1000    | 16#0001      | 16#0001      | Generation of command acceleration by P-0-0454 impossible, as P-0-0040 equals ZERO    |
| 16#0007 | 16#1000    | 16#0001      | 16#0002      | Generation of command acceleration by P-0-0455 impossible, as S-0-0348 equals ZERO    |
| 16#0007 | 16#1000    | 16#0001      | 16#0004      | Generation of command acceleration by P-0-0455 impossible, as P-0-1125 equals ZERO    |
| 16#0007 | 16#1000    | 16#0001      | 16#0005      | Generation of feedback acceleration impossible, as P-0-1319 equals ZERO               |
| 16#0001 | 16#1000    | 16#0001      | 16#0006      | Generation of feedback acceleration from S-0-0084 impossible, as P-0-1321 equals ZERO |
| 16#0001 | 16#1000    | 16#0001      | 16#0007      | Generation of feedback acceleration impossible, as P-0-1320 equals ZERO               |
| 16#0006 | 16#1000    | 16#0002      | 16#0001      | P-0-1376 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0003      | 16#0001      | P-0-1377 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0004      | 16#0001      | P-0-1378 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0005      | 16#0001      | P-0-1379 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0005      | 16#0002      | P-0-1380 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0006      | 16#0001      | P-0-1381 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0006      | 16#0002      | P-0-1382 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0007      | 16#0001      | P-0-1383 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0008      | 16#0001      | P-0-1371 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0008      | 16#0002      | P-0-1372 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0008      | 16#0003      | P-0-1373 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0008      | 16#0004      | P-0-1374 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0008      | 16#0005      | P-0-1375 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0010      | 16#0001      | P-0-1324 outside of input range                                                       |
| 16#0006 | 16#1000    | 16#0010      | 16#0002      | P-0-1325 outside of input range                                                       |

Vibration Damping and Avoiding (FWS\_MLDPa<sub>x</sub>\_VDA\_01Vxx\_D0\_MP0x)

| ErrorID | ErrorIdent |              |              | Explanation                                                                |
|---------|------------|--------------|--------------|----------------------------------------------------------------------------|
|         | ErrorTable | Additional 1 | Additional 2 |                                                                            |
| 16#0006 | 16#1000    | 16#0011      | 16#0001      | P-0-1326 outside of input range                                            |
| 16#0006 | 16#1000    | 16#0011      | 16#0002      | P-0-1327 outside of input range                                            |
| 16#0006 | 16#1000    | 16#0011      | 16#0003      | Anti-vibration filter cannot be calculated, as internal resolution too low |
| 16#0006 | 16#1000    | 16#0012      | 16#0001      | Command value filter type not defined (see P-0-1370, bit#19-18)            |
| 16#0006 | 16#1000    | 16#0012      | 16#0002      | Command value filter type not defined (see P-0-1370, bit#19-18)            |
| 16#0001 | 16#1000    | 16#1001      | 16#0001      | Changing the config word (P-0-1370) not allowed in "AF"                    |
| 16#0004 | 16#1000    | 16#1001      | 16#0002      | Target parameter of active vibration damping cyclically configured         |
| 16#0001 | 16#1000    | 16#1001      | 16#0005      | Analog input 2 does not exist at CSH control section                       |

ErrorID NONE\_ERROR

16#0000

ErrorID INPUT\_INVALID\_ERROR

16#0001

ErrorID ACCESS\_ERROR

16#0004

ErrorID ACCESS\_ERROR

16#0006

ErrorID CALCULATION\_ERROR

16#0007

ErrorTable NO\_TABLE\_USED

16#0000

ErrorTable USER1\_TABLE

16#1000

ErrorTable USER2\_TABLE

16#1001

Fig. 11-20: Overview of Error Messages

## 11.5 Description of the Parameters of Vibration Damping and Avoiding (FWS\_MLDPa<sub>x</sub>\_VDA\_01Vxx\_D0\_MP0x)

### 11.5.1 P-0-1272, Adjusted feedback signal before the summation point

When using vibration damping, the adjusted feedback signal can be read out, via P-0-1272, as it is used in the summation point of the controller.

### 11.5.2 P-0-1273, Control difference after the summation point

When using vibration damping, the generated control difference can be read out via P-0-1273; the control difference is generated from the command value (P-0-1279) less the des adjusted feedback value (P-0-1272).

### 11.5.3 P-0-1277, Control difference after high-pass and low-pass filtering

When using vibration damping, the filtered control difference can be read out via P-0-1277. This filtered value is the input value for control.

### 11.5.4 P-0-1278, Controller output after limitation

When using vibration damping, the controller output resulting at the output of the controller after limitation (P-0-1375) can be read out via P-0-1278.

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

## 11.5.5 P-0-1279, Adjusted command signal before the summation point

When using vibration damping, the generated command signal can be read out via P-0-1279. For generating the command signal, there are different sources available (see P-0-1370) which can in addition be delayed for a definable time (see P-0-1383).

## 11.5.6 P-0-1300, VA - NC position command value

When using vibration avoiding (command value pre-filter), P-0-1300 must be included in the cyclic data instead of the parameter "S-0-0047, Position command value". In the "cyclic position control" mode, the control unit transmits its cyclic command value input to the parameter P-0-1300.

|                                            |                          |
|--------------------------------------------|--------------------------|
| <b>Editability</b>                         |                          |
| <b>Min./max. value</b>                     | -2147483647 / 2147483647 |
| <b>Format</b>                              | DEC_MV                   |
| <b>Unit</b>                                | S-0-0076                 |
| <b>Type</b>                                | Input register           |
| <b>Decimal places</b>                      | S-0-0077 / S-0-0078      |
| <b>Buffered when control voltage fails</b> | -                        |

Fig. 11-21: Parameter Attributes

## 11.5.7 P-0-1301, VA - NC velocity command value

When using vibration avoiding (command value pre-filter), P-0-1301 must be included in the cyclic data instead of the parameter "S-0-0036, Velocity command value". In the "velocity control" mode, the control unit transmits its cyclic command value input to the parameter P-0-1301.

|                                            |                          |
|--------------------------------------------|--------------------------|
| <b>Editability</b>                         |                          |
| <b>Min./max. value</b>                     | -2147483647 / 2147483647 |
| <b>Format</b>                              | DEC_MV                   |
| <b>Unit</b>                                | S-0-0044                 |
| <b>Type</b>                                | Input register           |
| <b>Decimal places</b>                      | S-0-0045 / S-0-0046      |
| <b>Buffered when control voltage fails</b> | -                        |

Fig. 11-22: Parameter Attributes

## 11.5.8 P-0-1316, Sensor input, input filter time constant [ms]

The parameter P-0-1316 serves as a digital low-pass filter for the analog input that is used. In accordance with the connection configuration (P-0-1370), the value set in this parameter is copied to the corresponding parameter for the input filter of the analog input that is used.

|                        |        |
|------------------------|--------|
| <b>Editability</b>     |        |
| <b>Min./max. value</b> | 0/1000 |
| <b>Format</b>          | DEC_OV |
| <b>Unit</b>            | ms     |

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                     |                |
|-------------------------------------|----------------|
| Type                                | Input register |
| Decimal places                      | 3              |
| Buffered when control voltage fails | Yes            |

Fig. 11-23: Parameter Attributes

## 11.5.9 P-0-1317, Sensor input, analog input offset [V]

The parameter P-0-1317 can be used to eliminate an offset voltage [V] of the sensor at the analog input. The value entered here is subtracted from the measured voltage value.

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | -10/10         |
| Format                              | DEC_MV         |
| Unit                                | V              |
| Type                                | Input register |
| Decimal places                      | 3              |
| Buffered when control voltage fails | Yes            |

Fig. 11-24: Parameter Attributes

## 11.5.10 P-0-1318, Analog input, sensor dead zone (bipolar) [V]

By means of P-0-1318, it is possible to define a range of values for the analog input voltage which the controller interprets as the voltage value 0 V ("dead zone").

The "dead zone" is a symmetrical range of values around 0 V. The value entered in P-0-1318 is the positive and the negative limit value. All input voltage values the absolute value of which is smaller than the value in P-0-1318 are handled by the function like an input voltage of 0 V. This allows suppressing the noise level of the input voltage signal.

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | -10            |
| Format                              | DEC_OV         |
| Unit                                | V              |
| Type                                | Input register |
| Decimal places                      | 3              |
| Buffered when control voltage fails | Yes            |

Fig. 11-25: Parameter Attributes

## 11.5.11 P-0-1319, Sensor sensitivity (incl. amplifier) [mV/g] or [mV/(rad/s²)]

By means of P-0-1319, the analog input can be scaled for the acceleration value. In P-0-1319, enter the conversion factor resulting after the measuring amplifier in order to convert the voltage value that was read in to an acceleration (linear or rotary).

|                 |               |
|-----------------|---------------|
| Editability     |               |
| Min./max. value | -/4294967,295 |

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                            |                                  |
|--------------------------------------------|----------------------------------|
| <b>Format</b>                              | DEC_OV                           |
| <b>Unit</b>                                | mV/g or mV/(rad/s <sup>2</sup> ) |
| <b>Type</b>                                | Input register                   |
| <b>Decimal places</b>                      | 3                                |
| <b>Buffered when control voltage fails</b> | Yes                              |

Fig. 11-26: Parameter Attributes

## 11.5.12 P-0-1320, Sensor distance to pivot [mm]

When using a sensor measuring a linear acceleration that is to be converted to a rotary motion (rotary axis), the distance of the sensor to the pivot must be specified in P-0-1320.

|                                            |                     |
|--------------------------------------------|---------------------|
| <b>Editability</b>                         |                     |
| <b>Min./max. value</b>                     | 0 / 4294967295      |
| <b>Format</b>                              | DEC_OV              |
| <b>Unit</b>                                | mm                  |
| <b>Type</b>                                | Input register      |
| <b>Decimal places</b>                      | S-0-0077 / S-0-0078 |
| <b>Buffered when control voltage fails</b> | Yes                 |

Fig. 11-27: Parameter Attributes

## 11.5.13 P-0-1321, Torque/force feedback value scaling factor [gm<sup>2</sup>] or [kg]

The inertia of the system can be entered in P-0-1321. In the case of sensor-less compensation of the parasitic vibration, i.e. via the torque/force feedback value, this value is required to calculate the acceleration behavior of the mechanical system.

If the mechanical data are known, the inertia value can be directly entered. With variable inertia, this value can be corrected to improve control or allow compensating the parasitic vibration.

If the value is unknown, it can be determined by a simple experiment (see chapter "Notes on Commissioning and Operation").

|                                            |                       |
|--------------------------------------------|-----------------------|
| <b>Editability</b>                         |                       |
| <b>Min./max. value</b>                     | 0/214748,3647         |
| <b>Format</b>                              | DEC_OV                |
| <b>Unit</b>                                | gm <sup>2</sup> or kg |
| <b>Type</b>                                | Input register        |
| <b>Decimal places</b>                      | 4                     |
| <b>Buffered when control voltage fails</b> | Yes                   |

Fig. 11-28: Parameter Attributes

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

**11.5.14 P-0-1324, VA - Position command value band-stop filter, center frequency [Hz]**

For command value filtering, the center frequency of the filter can be set in P-0-1324 when the notch filter is used. When the value "0" is set, the filter is inactive.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/1000,00      |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-29: Parameter Attributes

**11.5.15 P-0-1325, VA - Position command value band-stop filter, bandwidth [Hz]**

For command value filtering, the bandwidth of the filter can be set in P-0-1325 when the notch filter is used.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/1000,00      |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-30: Parameter Attributes

**11.5.16 P-0-1326, VA - Position command value anti-vibration, characteristic frequency [Hz]**

For command value filtering, the characteristic frequency of the filter can be set in P-0-1326 when the anti-vibration filter is used. When the value "0" is set, the filter is inactive.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/1000,00      |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-31: Parameter Attributes

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

## 11.5.17 P-0-1327, VA - Position command value anti-vibration, damping degree [-]

For command value filtering, the damping degree of the system can be set in P-0-1327 when the anti-vibration filter is used.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/1000,00      |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-32: Parameter Attributes

## 11.5.18 P-0-1328, Error diagnosis Error ID

The current Error ID is displayed in P-0-1328. There are the following IDs:

- 16#0000: NONE\_ERROR
- 16#0001: INPUT\_INVALID\_ERROR
- 16#0004: ACCESS\_ERROR
- 16#0006: ACCESS\_ERROR
- 16#0007: CALCULATION\_ERROR

|                                            |                 |
|--------------------------------------------|-----------------|
| <b>Min./max. value</b>                     | 0/0xFFFFFFFF    |
| <b>Format</b>                              | HEX             |
| <b>Unit</b>                                | -               |
| <b>Type</b>                                | Output register |
| <b>Decimal places</b>                      | None            |
| <b>Buffered when control voltage fails</b> | No              |

Fig. 11-33: Parameter Attributes

## 11.5.19 P-0-1329, Error diagnosis ErrorIdent: Table

The current error table is displayed in P-0-1329. There are the following error tables:

- 16#0000: NO\_TABLE\_USED
- 16#1000: USER1\_TABLE
- 16#1001: USER2\_TABLE

|                        |                 |
|------------------------|-----------------|
| <b>Min./max. value</b> | 0/0xFFFFFFFF    |
| <b>Format</b>          | HEX             |
| <b>Unit</b>            | -               |
| <b>Type</b>            | Output register |

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                     |      |
|-------------------------------------|------|
| Decimal places                      | None |
| Buffered when control voltage fails | No   |

Fig.11-34: Parameter Attributes

## 11.5.20 P-0-1330, Error diagnosis ErrorIdent: Additional 1

P-0-1330 contains the value "Additional 1" used to classify the cause of the error.

For an overview of all errors, see the chapter "Diagnostic and Status Messages".

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/0xFFFFFFFF    |
| Format                              | HEX             |
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig.11-35: Parameter Attributes

## 11.5.21 P-0-1331, Error diagnosis ErrorIdent: Additional 2

P-0-1331 contains the value "Additional 2" used to classify the cause of the error.

For an overview of all errors, see the chapter "Diagnostic and Status Messages".

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | 0/0xFFFFFFFF    |
| Format                              | HEX             |
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig.11-36: Parameter Attributes

## 11.5.22 P-0-1370, Config word

By means of P-0-1370, the frequency response measurement can be configured.

| Bit | Designation/function                                                                               | Comment                                                                |
|-----|----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 0   | <b>VD activation</b><br>0: Inactive<br>1: Active                                                   | Vibration damping                                                      |
| 2-1 | <b>VD target parameter</b><br>00: Empty (S-0-0000)<br>01: P-0-0059<br>10: S-0-0037<br>11: S-0-0081 | Specifies the target parameter on which vibration damping takes effect |

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

| Bit   | Designation/function                                                                                                                                                                                                                                                                                                                                                                                                                                 | Comment                                                                                                                                                                                                                                                          |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3     | <b>VD negation of acceleration sensor signal</b><br>0: Inactive<br>1: Active                                                                                                                                                                                                                                                                                                                                                                         | Negation of the acceleration sensor signal                                                                                                                                                                                                                       |
| 6-4   | <b>VD acceleration command value</b><br>000: 0<br>001: $d^2(P-0-0434, \text{Position command value of controller})/dt^2$<br>010: $d(P-0-0454, \text{Velocity feedforward actual value})/dt$<br>011: P-0-0455 (Acceleration feedforward actual value) operation mode position control<br>100: P-0-0048 (Effective velocity command value)<br>101: P-0-0455 (Acceleration feedforward actual value) operation mode velocity control                    | Specifies the acceleration command value that is to be used (see Overview of Drive Control)<br>001: In position control only<br>010: In position control only<br>011: In position control only<br>100: In velocity control only<br>101: In velocity control only |
| 7     | <b>VD performance level</b><br>0: Standard (1ms)<br>1: Advanced (position loop clock)                                                                                                                                                                                                                                                                                                                                                                | Performance of the control loop of active vibration damping (sampling time)                                                                                                                                                                                      |
| 11-8  | <b>VD acceleration feedback value</b><br>0000: Sensor on analog input 1<br>0001: Sensor on analog input 2<br>0010: Sensor on analog input 3<br>0011: Sensor on analog input 4<br>0100: $d(S-0-0040, \text{Velocity feedback value})/dt$<br>0101: $d(S-0-0156, \text{Velocity feedback value 2})/dt$<br>0110: S-0-0164, Acceleration feedback value 1<br>0111: S-0-0195, Acceleration feedback value 2<br>1000: S-0-0084, Torque/force feedback value | Specifies the acceleration feedback value that is to be used<br><br>With S-0-0040, observe the velocity mix factor P-0-1119<br><br>The acceleration feedback values are filtered with 4 ms                                                                       |
| 12    | <b>VD sensor mounting / type</b><br>0: Linear / linear or<br>Rotary / rotary<br>1: Rotary / linear                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                  |
| 15-13 | No function                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                  |
| 17-16 | <b>VA target parameter of NC command value</b><br>00: Neither P-0-1300 nor P-0-1301 have been included in the cyclic protocol<br>01: The cyclic command values are transmitted to the parameter "P-0-1300, NC position command value"<br>10: The cyclic command values are transmitted to the parameter "P-0-1301, NC velocity command value"<br>11: Not used                                                                                        | To use command value filtering, the NC must assign its command value in an appropriate way<br>01: In cyclic position control<br>10: In "velocity control" mode                                                                                                   |

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

| Bit   | Designation/function                                                                                                                                                     | Comment                                                                    |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| 19-18 | <b>VA command value filtering activation</b><br>00: No filter is active<br>01: The rejection filter is active<br>10: The anti-vibration filter is active<br>11: Not used | Command value filtering can only be used if bit 16 or bit 17 has been set. |
| 29-20 | No function                                                                                                                                                              |                                                                            |
| 30    | Setting default values without config word<br>0-1 change: Default values are set                                                                                         |                                                                            |
| 31    | Setting default values with config word<br>0-1 change: Default values are set                                                                                            |                                                                            |

Fig. 11-37: Bit Assignment

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | -/-            |
| <b>Format</b>                              | BIN            |
| <b>Unit</b>                                | None           |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | None           |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-38: Parameter Attributes

## 11.5.23 P-0-1371, VD - PI(D-T1) controller proportional gain

The difference of the configured command value and feedback value is multiplied with the value parameterized in P-0-1371 and therefore is the proportional component of the controller output. When the value "0" is set, the P-component and thus the controller are inactive.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/42949,67295  |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | -              |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 5              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-39: Parameter Attributes

## 11.5.24 P-0-1372, VD - PI(D-T1) controller integral-action time [ms]

The integral-action time of the controller can be set in P-0-1372. The integral component of the controller is calculated by means of the integral-action time. When the value "0" is set, the I-component is inactive.

|                        |          |
|------------------------|----------|
| <b>Editability</b>     |          |
| <b>Min./max. value</b> | 0/6553,5 |

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                     |                |
|-------------------------------------|----------------|
| Format                              | DEC_OV         |
| Unit                                | ms             |
| Type                                | Input register |
| Decimal places                      | 1              |
| Buffered when control voltage fails | Yes            |

Fig. 11-40: Parameter Attributes

## 11.5.25 P-0-1373, VD - PI(D-T1) controller derivative action time [ms]

The derivative action time of the controller can be set in P-0-1373. The differential component of the controller is calculated by means of the derivative action time. This D-component can be filtered via a T1 element (P-0-1374). When the value "0" is set, the D-component is inactive.

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | 0/6553,5       |
| Format                              | DEC_OV         |
| Unit                                | ms             |
| Type                                | Input register |
| Decimal places                      | 1              |
| Buffered when control voltage fails | Yes            |

Fig. 11-41: Parameter Attributes

## 11.5.26 P-0-1374, VD - PI(D-T1) controller smoothing time constant, D-component [us]

The filter time of the T1 filter of the D-component is set via P-0-1374. This time must be parameterized considerably smaller than the derivative action time (P-0-1373). When the value "0" is set, the filter is inactive.

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | 0/429496729,5  |
| Format                              | DEC_OV         |
| Unit                                | us             |
| Type                                | Input register |
| Decimal places                      | 1              |
| Buffered when control voltage fails | Yes            |

Fig. 11-42: Parameter Attributes

## 11.5.27 P-0-1375, VD - PI(D-T1) controller limitation

The limitation of the controller output can be set in P-0-1375. The limitation acts in a bipolar way and is the positive and the negative limitation. If the output of the controller is limited later on in operation, the integral component is limited at the same time to avoid the anti-windup effect of the I-component.

|                 |               |
|-----------------|---------------|
| Editability     |               |
| Min./max. value | 0/429496729,5 |

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                            |                |
|--------------------------------------------|----------------|
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | -              |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 1              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-43: Parameter Attributes

**11.5.28 P-0-1376, VD - Control loop, high pass limit frequency [Hz]**

For active vibration damping, the limit frequency for 1st order high-pass filtering can be parameterized via P-0-1376. The filter takes effect after the control difference has been generated. When the value "0" is set, the filter is inactive.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/10000,000    |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 3              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-44: Parameter Attributes

**11.5.29 P-0-1377, VD - Control loop, low pass limit frequency [Hz]**

For active vibration damping, the limit frequency for 1st order low-pass filtering can be parameterized via P-0-1377. The filter takes effect after the control difference has been generated. When the value "0" is set, the filter is inactive.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/10000,00     |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-45: Parameter Attributes

**11.5.30 P-0-1378, VD - Control loop, 2nd order low pass limit frequency [Hz]**

For active vibration damping, the limit frequency for 2nd order low-pass filtering can be parameterized via P-0-1378. The filter takes effect after the control difference has been generated. When the value "0" is set, the filter is inactive.

|                        |            |
|------------------------|------------|
| <b>Editability</b>     |            |
| <b>Min./max. value</b> | 0/10000,00 |
| <b>Format</b>          | DEC_OV     |
| <b>Unit</b>            | Hz         |

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                     |                |
|-------------------------------------|----------------|
| Type                                | Input register |
| Decimal places                      | 2              |
| Buffered when control voltage fails | Yes            |

Fig. 11-46: Parameter Attributes

### 11.5.31 P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]

For active vibration damping, a band-stop filter can be parameterized. The center frequency for the band-stop filter is preset by means of P-0-1379. The filter takes effect after the control difference has been generated. When the value "0" is set, the filter is inactive.

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | 0/10000,00     |
| Format                              | DEC_OV         |
| Unit                                | Hz             |
| Type                                | Input register |
| Decimal places                      | 2              |
| Buffered when control voltage fails | Yes            |

Fig. 11-47: Parameter Attributes

### 11.5.32 P-0-1380, VD - Control loop, band-stop filter bandwidth [Hz]

For active vibration damping, a band-stop filter can be parameterized. The bandwidth around the center frequency is preset for the band-stop filter by means of P-0-1380. P-0-1380 takes effect in conjunction with "P-0-1379, VD - Control loop, band-stop filter center frequency [Hz]".

|                                     |                |
|-------------------------------------|----------------|
| Editability                         |                |
| Min./max. value                     | 0/10000,00     |
| Format                              | DEC_OV         |
| Unit                                | Hz             |
| Type                                | Input register |
| Decimal places                      | 2              |
| Buffered when control voltage fails | Yes            |

Fig. 11-48: Parameter Attributes

### 11.5.33 P-0-1381, Acceleration feedback value band-stop filter, center frequency [Hz]

Due to the machine's fundamental vibrations, this fundamental vibration sometimes is measured, too, when the acceleration feedback value is generated by means of a mounted acceleration sensor, although the fundamental vibration does not have any influence on the process quality. Therefore, a band-stop filter can be parameterized only the acceleration feedback value. For this purpose, P-0-1381 is used as the center frequency. When the value "0" is set, the filter is inactive.

## Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/10000,00     |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-49: Parameter Attributes

**11.5.34 P-0-1382, Acceleration feedback value band-stop filter, bandwidth [Hz]**

P-0-1382 is used as the bandwidth for the band-stop filter for the acceleration feedback value. P-0-1382 takes effect in conjunction with "P-0-1381, Acceleration feedback value band-stop filter, center frequency [Hz]".

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/10000,00     |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | Hz             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 2              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-50: Parameter Attributes

**11.5.35 P-0-1383, Acceleration command value delay [ms]**

By means of P-0-1383, it is possible to parameterize a delay [ms] by which the calculated acceleration command value is delayed before it is used in the summation point of command value and feedback value.

|                                            |                |
|--------------------------------------------|----------------|
| <b>Editability</b>                         |                |
| <b>Min./max. value</b>                     | 0/100,000      |
| <b>Format</b>                              | DEC_OV         |
| <b>Unit</b>                                | ms             |
| <b>Type</b>                                | Input register |
| <b>Decimal places</b>                      | 3              |
| <b>Buffered when control voltage fails</b> | Yes            |

Fig. 11-51: Parameter Attributes

**11.5.36 P-0-1387, Error text display**

The PLC's status text / diagnostic message text is output via P-0-1387.

|                        |       |
|------------------------|-------|
| <b>Min./max. value</b> | -/-   |
| <b>Format</b>          | ASCII |

Vibration Damping and Avoiding (FWS\_MLDPAx\_VDA\_01Vxx\_D0\_MP0x)

|                                     |                 |
|-------------------------------------|-----------------|
| Unit                                | -               |
| Type                                | Output register |
| Decimal places                      | -               |
| Buffered when control voltage fails | No              |

Fig. 11-52: Parameter Attributes

## 11.5.37 P-0-1410, Status word

The current status of the MLD functionality can be read out via P-0-1410.

- The bits #0-2 are relevant for active vibration damping.
- The bits #4-6 are relevant for command value filtering (vibration avoiding).

| Bit  | Designation/function                                                                                                                 | Comment |
|------|--------------------------------------------------------------------------------------------------------------------------------------|---------|
| 0    | <b>Vibration damping, status</b><br>0: Inactive<br>1: Active                                                                         |         |
| 1    | <b>Vibration damping, limitation</b><br>0: Inactive<br>1: Active                                                                     |         |
| 2    | <b>Vibration damping, parameterization status</b><br>0: No error<br>1: Error                                                         |         |
| 3    | No function                                                                                                                          |         |
| 5-4  | <b>Vibration avoiding, position command value</b><br>00: Inactive<br>01: Rejection filter active<br>10: Anti-vibration filter active |         |
| 6    | <b>Vibration avoiding, parameterization status</b><br>0: No error<br>1: Error                                                        |         |
| 15-7 | No function                                                                                                                          |         |

Fig. 11-53: Bit Assignment

|                                     |                 |
|-------------------------------------|-----------------|
| Min./max. value                     | -/-             |
| Format                              | DEC_MV          |
| Unit                                | None            |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig. 11-54: Parameter Attributes



## Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

# 12 Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

## 12.1 Brief Description

|                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fields of Application</b>         | The "analysis of characteristic curve S1" function can be used to assess whether the motor in use can permanently run a defined machine cycle without being thermally overloaded.                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Features</b>                      | <ul style="list-style-type: none"> <li>• Cyclic calculation of the average working point of the motor (absolute value of average speed, rms value of motor current)</li> <li>• Calculation period can be freely defined via control bit</li> <li>• Calculation of the power dissipation in the average working point</li> <li>• Characteristic curve S1 check to assess whether the motor can be permanently operated in the average working point</li> <li>• Configurable reaction (warning) when thermal overload of the motor is expected</li> </ul> |
| <b>Requirements of Use</b>           | To use the extended diagnostic function, the software, firmware and hardware requirements must have been fulfilled and the PLC project "FWS_MLDPAx_MCG_01V02_D0_MPxx" must have been loaded and activated in the drive.                                                                                                                                                                                                                                                                                                                                 |
| <b>Limitation of the Function</b>    | Only use the analysis function in combination with synchronous motors. Using the function with other motor types provides incorrect results and has not been authorized.                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Pertinent Parameters</b>          | <ul style="list-style-type: none"> <li>• P-0-1270, Status word</li> <li>• P-0-1272, Absolute value of average speed</li> <li>• P-0-1273, RMS value of motor current</li> <li>• P-0-1274, Characteristic curve S1 power dissipation</li> <li>• P-0-1275, Working point power dissipation</li> <li>• P-0-1370, Control word</li> <li>• P-0-1371, Config word</li> <li>• P-0-1372, Nominal speed</li> </ul>                                                                                                                                                |
| <b>Pertinent Diagnostic Messages</b> | <ul style="list-style-type: none"> <li>• E2011 PLC - Warning no. 1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## 12.2 Functional Description

The block diagram below shows the calculation procedure of the MLD technology function.

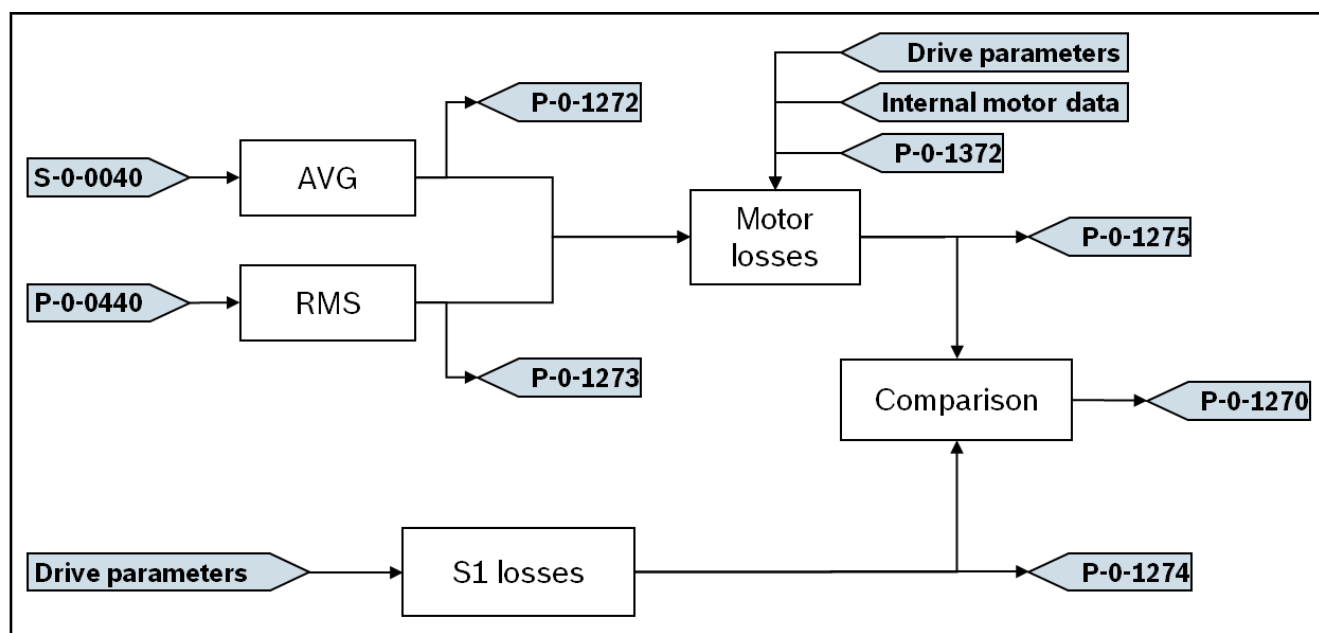
Analysis of Characteristic Curve S1 (FWS\_MLDPa<sub>x</sub>\_MCG\_01V02\_D0\_MPxx)

Fig.12-1: Calculation Procedure Block Diagram

Two models have been implemented to calculate the motor power dissipation; these models differ in the precision and data source. Select the model via P-0-1372.

Analysis of Characteristic Curve S1 (FWS\_MLDPaX\_MCG\_01V02\_D0\_MPxx)

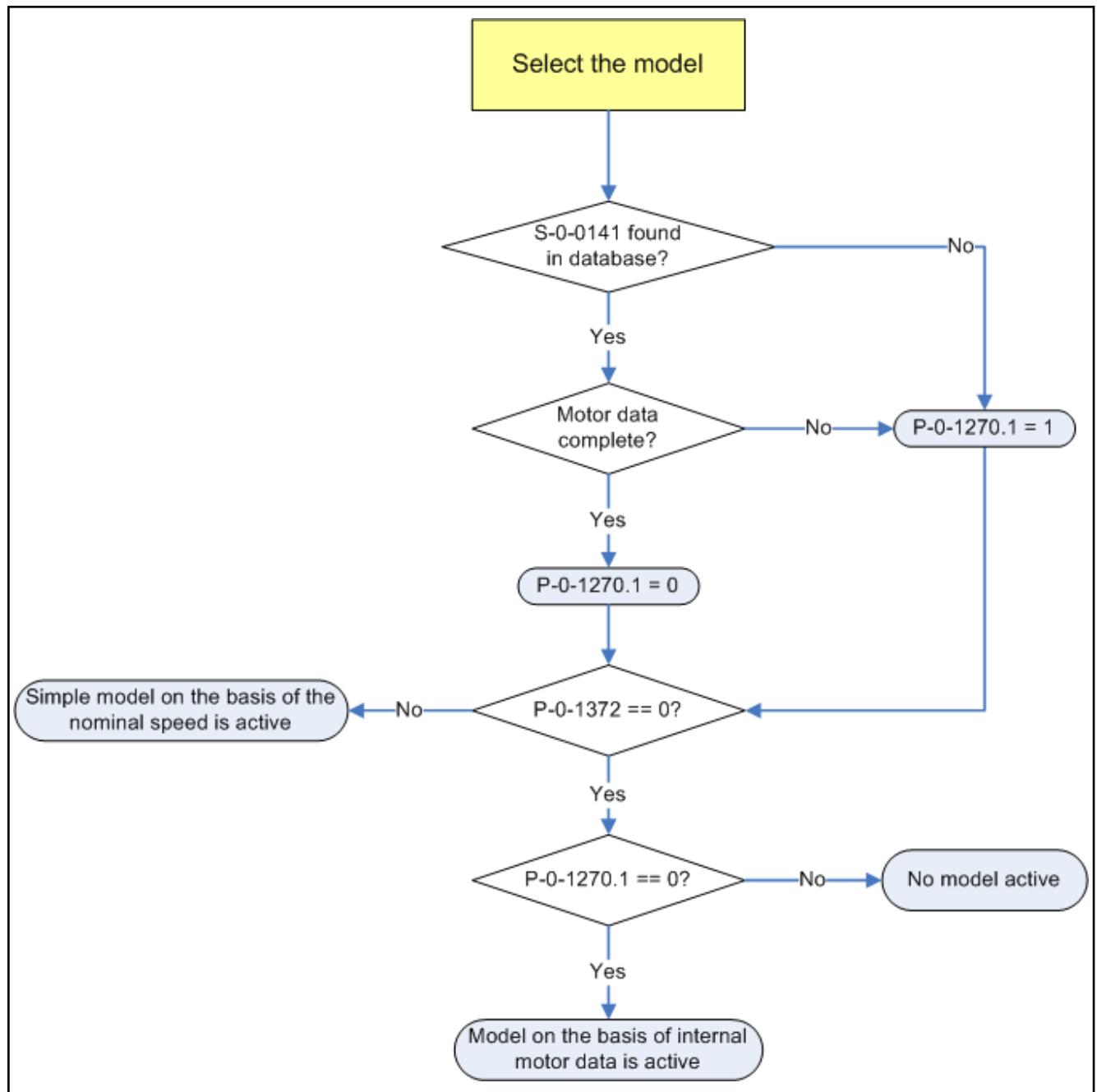


Fig. 12-2: Selecting the Model via P-0-1372

**Calculation on the Basis of the Nominal Speed**

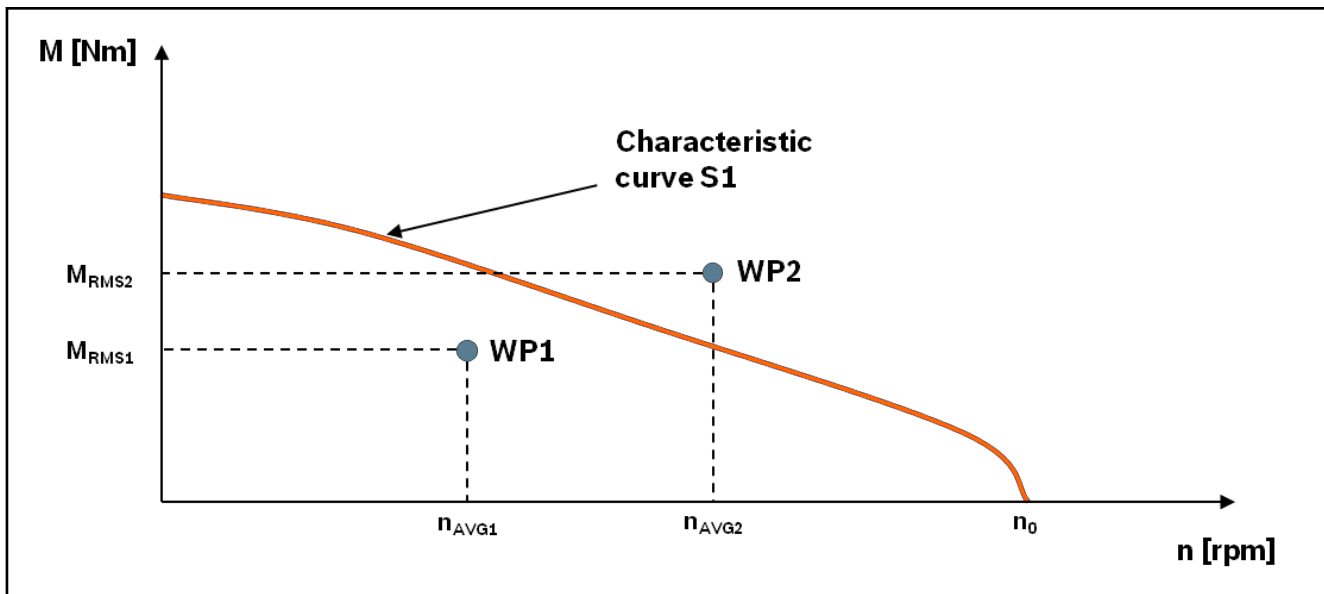
The simple model for calculating the motor power dissipation is based on the use of drive parameters and nominal speed (P-0-1372) that has to be input by the user. The advantage of this model is that it can be used for all synchronous motors; however, it requires that the nominal speed be known.

**Calculation on the Basis of Internal Motor Data**

The more precise model for calculating the motor power dissipation is based on internal characteristic motor values of the "DriveBase" database. The model is easy to handle, because it does not require any additional motor data. Currently, the model can only be used in combination with MSK motors.

In both models, the position of the average working point of the motor is determined with reference to the characteristic curve S1; this shows whether the motor can be used or not.

## Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)



|       |                                                                                                    |
|-------|----------------------------------------------------------------------------------------------------|
| WP1   | Working point below the characteristic curve S1: Motor can be used (P-0-1270, bit 0="0")           |
| WP2   | Working point above the characteristic curve S1: Motor <b>cannot</b> be used (P-0-1270, bit 0="1") |
| $n_0$ | Nominal motor speed (see P-0-1372)                                                                 |

Fig. 12-3: Characteristic Curve S1 Check

When the average working point is above the characteristic curve S1, the bit 0 of the parameter P-0-1270 is set and a drive warning is output if P-0-1371 has been parameterized accordingly.

## 12.3 Notes on Commissioning and Operation

### 12.3.1 Configuration and Operation via Parameters

There are two methods to determine the average working point and its position with reference to the characteristic curve S1. The method based on the internal motor data provides more precise values which is why it should be used where possible.

#### Analysis of characteristic curve S1 on the basis of the nominal motor speed

*Nominal speed or (virtual) intersection of the characteristic curve S1 and the speed axis is known and has been entered in P-0-1372.*

1. Set P-0-1370, bit 0, with the beginning of the machine cycle.
2. Clear P-0-1370, bit 0, with the end of the machine cycle.

In P-0-1270, bit 0, you can see whether the motor used can permanently run the machine cycle (0: yes, 1: no).

For an extended diagnosis, the average working point (absolute value of average speed, rms value of motor current) and the motor power dissipation can be taken from the corresponding parameters.

#### Analysis of characteristic curve S1 on the basis of internal motor data

*Motor data are complete (P-0-1270, bit 1="0") and the method on the basis of internal motor data has been activated (P-0-1372="0").*

1. Set P-0-1370, bit 0, with the beginning of the machine cycle.
2. Clear P-0-1370, bit 0, with the end of the machine cycle.

## Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

In P-0-1270, bit 0, you can see whether the motor used can permanently run the machine cycle (0: yes, 1: no).

For an extended diagnosis, the average working point (absolute value of average speed, rms value of motor current) and the motor power dissipation can be taken from the corresponding parameters.

### 12.3.2 Configuration and Operation by Means of IndraWorks

Presently, the possibility of configuring and operating the "analysis of characteristic curve S1" by means of IndraWorks is not provided.

## 12.4 Description of the Parameters of the Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

### 12.4.1 P-0-1270, Status word

| Bit   | Designation/function                                                                             | Comment                                                 |
|-------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 0     | 0: Working point below characteristic curve S1<br>1: Working point above characteristic curve S1 | Comparison of working point and characteristic curve S1 |
| 1     | 0: Motor data complete<br>1: Motor data incomplete                                               | Availability of the internal motor data (DriveBase)     |
| 31..2 | No function                                                                                      |                                                         |

Fig. 12-4: Parameter Structure P-0-1270, Status Word

|                                     |                 |
|-------------------------------------|-----------------|
| Data length                         | 4 bytes         |
| Min. value /max. value              | -- / --         |
| Format                              | BIN             |
| Default unit                        | --              |
| Type                                | Output register |
| Decimal places                      | None            |
| Buffered when control voltage fails | No              |

Fig. 12-5: Parameter Attributes P-0-1270, Status Word

### 12.4.2 P-0-1272, Absolute value of average speed

Current value of the average motor speed. The control bit (P-0-1370, Bit 0) starts and stops the calculation of the value. When the calculation is stopped, the last calculated value is frozen.

|                        |                 |
|------------------------|-----------------|
| Data length            | 4 bytes         |
| Min. value /max. value | -- / --         |
| Format                 | DEC_OV          |
| Default unit           | rpm             |
| Type                   | Output register |

## Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

|                                     |    |
|-------------------------------------|----|
| Decimal places                      | 2  |
| Buffered when control voltage fails | No |

Fig. 12-6: Parameter Attributes P-0-1272, Absolute Value of Average Speed

## 12.4.3 P-0-1273, RMS value of motor current

Current rms value of the motor current. The control bit (P-0-1370, Bit 0) starts and stops the calculation of the value. When the calculation is stopped, the last calculated value is frozen.

|                                     |                 |
|-------------------------------------|-----------------|
| Data length                         | 4 bytes         |
| Min. value /max. value              | -- / --         |
| Format                              | DEC_OV          |
| Default unit                        | A               |
| Type                                | Output register |
| Decimal places                      | 3               |
| Buffered when control voltage fails | No              |

Fig. 12-7: Parameter Attributes P-0-1273, RMS Value of Motor Current

## 12.4.4 P-0-1274, Characteristic curve S1 power dissipation

Constant power dissipation along the characteristic curve S1. The value depends on the motor and cooling type that are used.

|                                     |                 |
|-------------------------------------|-----------------|
| Data length                         | 4 bytes         |
| Min. value /max. value              | -- / --         |
| Format                              | DEC_OV          |
| Default unit                        | W               |
| Type                                | Output register |
| Decimal places                      | 2               |
| Buffered when control voltage fails | No              |

Fig. 12-8: Parameter Attributes P-0-1274, Characteristic Curve S1 Power Dissipation

## 12.4.5 P-0-1275, Working point power dissipation

Current motor power dissipation in the average working point. Copper losses and iron losses are taken into account. The control bit (P-0-1370, Bit 0) starts and stops the calculation of the value. When the calculation is stopped, the last calculated value is frozen.

|                        |                 |
|------------------------|-----------------|
| Data length            | 4 bytes         |
| Min. value /max. value | -- / --         |
| Format                 | DEC_OV          |
| Default unit           | W               |
| Type                   | Output register |

### Analysis of Characteristic Curve S1 (FWS\_MLDPa<sub>x</sub>\_MCG\_01V02\_D0\_MPxx)

|                                     |    |
|-------------------------------------|----|
| Decimal places                      | 2  |
| Buffered when control voltage fails | No |

Fig. 12-9: Parameter Attributes P-0-1275, Working Point Power Dissipation

## 12.4.6 P-0-1370, Control word

| Bit   | Designation/function                                             | Comment                                      |
|-------|------------------------------------------------------------------|----------------------------------------------|
| 0     | 0: Cyclic calculation not active<br>1: Cyclic calculation active | Control bit to define the calculation period |
| 31..1 | No function                                                      |                                              |

Fig. 12-10: Parameter Structure P-0-1370, Control Word

|                                     |                |
|-------------------------------------|----------------|
| Data length                         | 4 bytes        |
| Min. value /max. value              | -- / --        |
| Format                              | BIN            |
| Default unit                        | --             |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 12-11: Parameter Attributes P-0-1370, Control Word

## 12.4.7 P-0-1371, Config word

| Bit   | Designation/function                     | Comment                                        |
|-------|------------------------------------------|------------------------------------------------|
| 0     | 0: Warning inactive<br>1: Warning active | PLC warning when S1 power dissipation exceeded |
| 3..1  | No function                              |                                                |
| 4     | Reserved                                 |                                                |
| 31..5 | No function                              |                                                |

Fig. 12-12: Parameter Structure P-0-1371, Config Word

|                                     |                |
|-------------------------------------|----------------|
| Data length                         | 4 bytes        |
| Min. value /max. value              | -- / --        |
| Format                              | BIN            |
| Default unit                        | --             |
| Type                                | Input register |
| Decimal places                      | None           |
| Buffered when control voltage fails | Yes            |

Fig. 12-13: Parameter Attributes P-0-1371, Config Word

Analysis of Characteristic Curve S1 (FWS\_MLDPAx\_MCG\_01V02\_D0\_MPxx)

### 12.4.8 P-0-1372, Nominal speed

Nominal speed of the motor. Corresponds to the (virtual) intersection of the characteristic curve S1 and the speed axis. With P-0-1372="0", the use of the nominal speed for calculation is deactivated and the calculation based on the internal motor data is active.

 If the internal motor data are incomplete (P-0-1270, bit 1="1"), this value is absolutely required to calculate the motor losses.

|                                     |                |
|-------------------------------------|----------------|
| Data length                         | 4 bytes        |
| Min. value /max. value              | -- / --        |
| Format                              | DEC_OV         |
| Default unit                        | rpm            |
| Type                                | Input register |
| Decimal places                      | 0              |
| Buffered when control voltage fails | Yes            |

Fig. 12-14: Parameter Attributes P-0-1372, Nominal Speed

# 13 Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

## 13.1 Brief Description

**General Information** The "process controller" function allows controlling with regard to an external value, in addition to the operation and control modes already existing in the drive. Thus, the drive can be used for direct, rapid process control. The possible options are force, pressure or distance control and many more, the feedback value being compensated by IndraMotion MLD directly in the drive. The command value can be preset by an external control unit, for example.

After control has been activated, the controller output is given and causes the process feedback value that was returned to reach the preset command value.

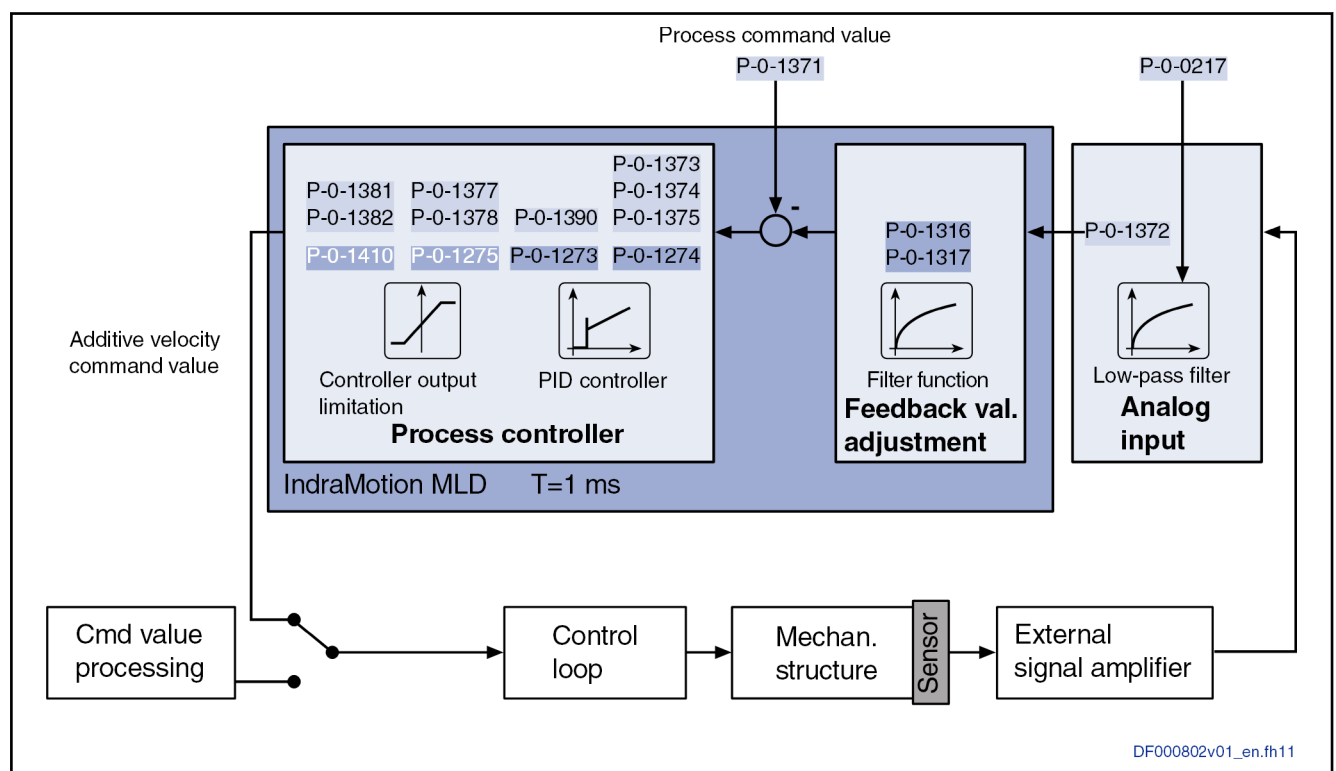


Fig. 13-1: Structural Overview of Process Controller

- Features** The "process controller" function has the following features:
- High quality of control by 1 ms controller clock
  - Operated and parameterized via single parameters
  - Process controller can be switched on and off at any time
  - Cyclic command value input is possible
  - Feedback values can be filtered by means of band-stop filter
  - Controller output can be limited
  - Switch cam depending on the velocity can be parameterized
  - Torque feedforward is possible
  - Position limitation is possible
  - Command value feedforward is possible

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

- Controller switching, depending on the feedback value or velocity
- Ramp for changes in controller output
- Ramp for changes in command value
- PT1 command value filter

**System Requirements**

The following requirements must be met when using process control:

**Drive controller**

Each power section of the "Rexroth IndraDrive" product range is suited to use the "process controller" (inverters: HMS01.1N-Wxxx, HMS02.1N-Wxxx; converters: HCS02.1N-Wxxx, HCS03.1N-Wxxx).

For control sections, there is the following restriction: The "process controller" currently can only be used with single-axis control sections [BASIC (CSB01.1) or ADVANCED (CSH01.xC)].

With IndraDrive Cs, the "process controller" can only be used for BASIC and ADVANCED devices.



For BASIC double-axis control sections and IndraDrive Cs ECONOMY devices, the "process controller" is not available, as the required integrated PLC/MLD (optional firmware expansion package "TF") is not available for these devices.



For BASIC devices (CSB01.1), the minimum cycle time of the process controller is 2 ms.

**Drive firmware**

The function of the "process controller" can be used for the firmware version MPH05VRS or MPB05VRS and above, and for MPB17VRS or MPH17VRS and above.

As the function of the "process controller" has been realized on the basis of the integrated PLC (IndraMotion MLD), the optional functional package "ML" or "TF" (depending on the drive firmware) is required in addition to the drive firmware.

**Commissioning software**

The process controller function can be configured and operated via parameters (see "Pertinent Parameters"); it is therefore possible to use the same software that is used to commission the drive controller. With the software version IndraWorks MLD 12V04 and higher versions, the function is supported by individual operation and commissioning dialogs in IndraWorks. In older versions, there aren't any dialogs available; with these versions operation can only take place via the parameter editor or the predefined parameter group.

**Pertinent Parameters**

- P-0-1390, Control word
- P-0-1410, Status word
- P-0-1411, Switch cam status word
- P-0-1270, Effective control difference
- P-0-1271, Active command value
- P-0-1272, Torque feedforward, feedforward value
- P-0-1273, Effective process feedback value
- P-0-1274, Controller output
- P-0-1275, Controller output, limited
- P-0-1276, Controller cycle time

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

- P-0-1370, Configuration
- P-0-1371, Process command value
- P-0-1372, Process feedback value, analog
- P-0-1373, P-gain of controller
- P-0-1374, I-component of controller
- P-0-1375, D-component of controller
- P-0-1377, Controller output limitation, upper
- P-0-1378, Controller output limitation, lower
- P-0-1380, Tolerance window
- P-0-1381, Position limitation, upper
- P-0-1382, Position limitation, lower
- P-0-1384, Command value feedforward factor
- P-0-1385, Command value feedforward filter time constant
- P-0-1316, Band-stop filter, center frequency
- P-0-1317, Band-stop filter, bandwidth
- P-0-1318, Switch cam, switch-on threshold
- P-0-1319, Switch cam, switch-off threshold
- P-0-1320, P-gain 2 of controller
- P-0-1321, I-component 2 of controller
- P-0-1322, Switch point of controller setting 2
- P-0-1323, Switch point of controller setting 1
- P-0-1325, Torque feedforward factor
- P-0-1326, PT1 command value filter, filter time constant
- P-0-1327, Maximum command value increase
- P-0-1328, Maximum command value decrease
- P-0-1329, Maximum controller output increase
- P-0-1330, Maximum controller output decrease

## 13.2 Functional Description

### Activating the Process Control

Starting MLD (start behavior parameterized with P-0-1367 or manual start with P-0-1350; see also MLD Application Manual) initializes the function including the concerned parameters. The actual process control is activated/enabled via P-0-1390, bit 0.



To successfully activate process control, the drive must be in drive enable (AF). Otherwise, bit 10 is set in the status word P-0-1410 if process control was activated via P-0-1390, bit 0, and control does not take place. In the case of successful activation, control over the drive is given to IndraMotion MLD and the drive is switched to the "velocity control" mode.

### Structural Overview of Process Controller

The overview below outlines the basic functional principle and structure of the process controller (input values highlighted in light gray, display values highlighted in dark gray):

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

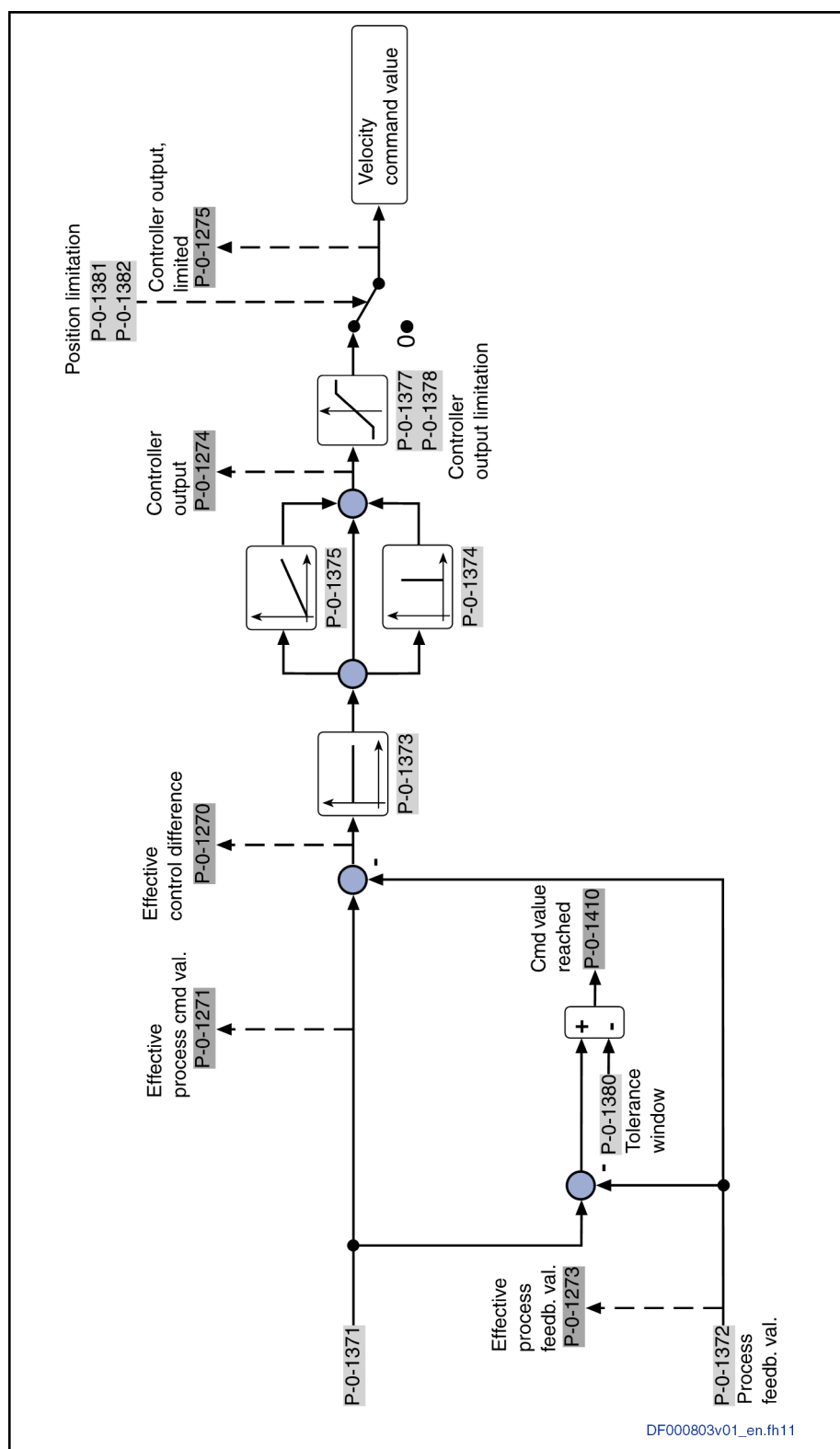


Fig. 13-2: Structural Overview of Process Controller

## Functionality of Process Control

Immediately after the initialization phase, the process controller starts compensating the difference between command value and process feedback value via the controller output S-0-0037. This state is signaled back in the status word P-0-1410, bit 0.

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

As long as the process controller is active, i.e. bit 0 is set in P-0-1390, bit 0 remains set in the status word P-0-1410.

The command value is directly preset for the process controller via P-0-1371.

If necessary, the process feedback value supplied via P-0-1372 can be filtered with P-0-1316 and P-0-1317 with a band-stop filter.

### Optional Band-Stop Filter

The figure below shows the effect and parameter assignment of the band-stop filter:

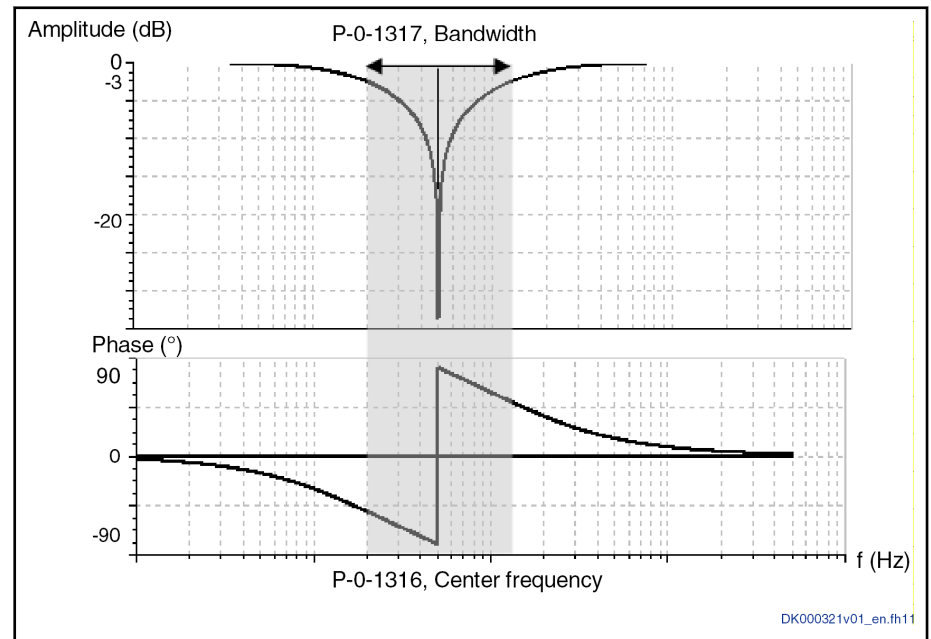


Fig. 13-3: Effect and Parameter Assignment of the Band-Stop Filter

The feedback value that takes effect for the PID controller after filtering is displayed in "P-0-1273, Effective process feedback value".

The PID controller is parameterized with the following parameters

- P-0-1373, P-gain of controller
- P-0-1374, I-component of controller
- P-0-1375, D-component of controller



If necessary, the process command value (P-0-1371) can be changed at any time. The changes take immediate effect (possibly via a ramp or PT1 filter), the command value can therefore be permanently corrected.

When the effective process feedback value (P-0-1273) reaches the command value preset in P-0-1371, or when the difference between these feedback and command values is within the tolerance window (P-0-1380) that can be set, the drive signals this in the control word P-0-1410, bit 1.

The **control difference** (process command value - process feedback value) can be inverted with P-0-1370, bit 6. For this purpose, both the process command value and the process feedback value are inverted.

The effective and possibly inverted **process command value** is displayed in P-0-1271.

The effective and possibly inverted and filtered **process feedback value** is displayed in P-0-1273.

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | <p>The effective (possibly inverted) <b>control difference</b> (P-0-1271 – P-0-1273) is displayed in P-0-1270. The inversion is required according to the process feedback value, in order to achieve correct control behavior. [Example of application for the inversion of the control difference: distance control (control difference decreases as the controller output increases)].</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Controller Switching</b>      | <p>Depending on the effective process feedback value (P-0-1273) or the effective command velocity (P-0-0048), it is possible to switch the controller settings automatically:</p> <p>When the absolute value of the effective process feedback value or the effective command velocity (to be selected in P-0-1370, bit 7) exceeds the value from "P-0-1322, Switch point of controller setting 2", the controller settings from P-0-1320 and P-0-1321 take effect. When the absolute value of the effective process feedback value or the effective command velocity falls below the value from "P-0-1323, Switch point of controller setting 1", the controller settings from P-0-1373 and P-0-1374 take effect again.</p> <hr/> <p> The D-component is not switched, the value from P-0-1375 always takes effect in unchanged form.</p> <hr/> <p>P-0-1410, bit 12, displays which controller settings is currently active and whether the controller settings are continuously adjusted. When both switch points (P-0-1322, P-0-1323) are "0" and switching has been set as hysteresis (P-0-1370, bit 8="0"), switching does not take place and the settings from P-0-1373 and P-0-1374 always take effect.</p> <p>If required, the ramp for controller output limitation (P-0-1329, P-0-1330) can be used so that controller switching does not take effect abruptly. Otherwise, controller switching can cause jumps in the controller output.</p> |
| <b>Torque Feedforward</b>        | <p>With the factor for torque feedforward (P-0-1325), it is possible to implement feedforward in addition to the PID controller. Thereby, the value from "P-0-1325, Torque feedforward factor" is multiplied with the effective process command value. The process command value possibly was already inverted and/or filtered via a ramp. The torque value to be currently fed forward is displayed in "P-0-1272, Torque feedforward, feedforward value" and preset via "S-0-0081, Additive torque/force command value".</p> <hr/> <p> Using torque feedforward (P-0-1325 unequal "0") can deactivate the controller output limitation!</p> <hr/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Command Value Feedforward</b> | <p>The effective command value (P-0-1271) can be additionally fed forward in parallel with the actual PID controller. Thereby, a value calculated by means of the effective command value (P-0-1271) is added to the controller output calculated by the PID controller. The effective command value (P-0-1271) is multiplied with the factor for command value feedforward from P-0-1384 and subsequently filtered with the filter time constant from P-0-1385. The filtered value then is added to the controller output calculated in the PID controller.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Command Value Ramp</b>        | <p>To limit the maximum change of the command value, the preset command value can be changed by means of a command value ramp, if the command value change preset in P-0-1371 should be greater than set by the ramp. The maximum increase and decrease of the command value can be set independently of each other via P-0-1327 and P-0-1328. What must be set is the maximum command value change per process controller cycle, e.g. a maximum of 10 N/ms. The possibly limited and filtered command value is displayed in P-0-1271.</p> <p>Bit 7 in P-0-1410 shows whether the possibly limited and filtered active command value (P-0-1271) corresponds to the original command value from</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

P-0-1371. If bit 7="0", the command value change is limited by the ramp and/or the filter: P-0-1271 <> P-0-1371.



This is a mere limitation, not general filtering or interpolation! The command value is not changed when the command value change does not exceed the specified limits!



With P-0-1327 or P-0-1328="0", the respective ramp limitation is deactivated.

**Command Value Filter**

Another possibility of changing the command value is the (PT1) command value filter; its filter time constant can be entered in P-0-1326. For this purpose, the command value, preset in P-0-1371 and possibly limited by the command value ramp with P-0-1327 and P-0-1328, is filtered. The effective process command value is displayed in P-0-1271.

Bit 7 in P-0-1410 shows whether the possibly limited and filtered active command value (P-0-1271) corresponds to the original command value from P-0-1371. If bit 7="0", the command value change is limited by the ramp and/or the filter: P-0-1271 <> P-0-1371.



When a filter time constant of 0 ms is entered in P-0-1326, the command value is not filtered.

**Controller Output Ramp**

To limit the maximum change in the controller output, the preset controller output can be changed by means of a controller output ramp, if the controller output change to be output (calculated from PID controller, controller output feedforward and command value feedforward) should be greater than set by the ramp. The maximum increase and decrease of the controller output can be set independently of each other via P-0-1329 and P-0-1330. What must be set is the maximum controller output change per process controller cycle, e.g. a maximum of 10 N/ms.



This is a mere limitation, not general filtering or interpolation! The controller output is not changed when the controller output change does not exceed the specified limits!

**Controller Output Limitation**

With the parameters P-0-1377 and P-0-1378, an upper and a lower limit can be set for the controller output (→velocity), i.e. the process controller output. The status word P-0-1410, bit 2 and bit 3, shows whether the limitation is active or not.



This is a mere limitation, not general filtering or interpolation! The controller output is not changed when the controller output change does not exceed the specified limits! In order not to limit the controller output, enter accordingly high values in P-0-1377 or P-0-1378.

**Position Limitation**

Furthermore, it is possible to limit the absolute position of the drive. This is done via "P-0-1381, Position limitation, upper" and "P-0-1382, Position limitation, lower". The value in "S-0-0386, Active position feedback value" is monitored to find out whether it exceeds the preset position limits (P-0-1381/P-0-1382). When the process controller detects that the value has exceeded the limit (S-0-0386 <= P-0-1382 or P-0-1381 <= S-0-0386), the controller output is set to "0". The exceeded limit is displayed in the status word P-0-1410 in bit 5 or bit 6. As long as the controller calculates and outputs a controller output (P-0-1274, Controller output) that does not cause the axis to move between the two limits again, the effective controller output is set to "0". Only

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

when the controller output causes a motion that moves the axis out of the limits is the controller output really transmitted to the drive. The actually effective and possibly limited controller output is displayed in "P-0-1275, Controller output, limited". The position limitation can be activated via P-0-1370, bit 2.



As the drive cannot stop abruptly, it might still move a little into the limitation; how far it moves depends on the initial velocity immediately before the limit, as well as on the delay that takes effect for velocity control.

### Using a Switch Cam

Besides the actual control function, the process controller makes available a switch cam depending on the velocity. Depending on the absolute value of the current command velocity (absolute value of P-0-0040), the bit 0 is set in the P-0-1411, Switch cam status word. When the velocity exceeds the velocity value set in P-0-1318, the bit is set; when the absolute value of the feedback velocity falls below the value in P-0-1319, the bit is reset to 0. If both velocity thresholds (P-0-1318, P-0-1319) are "0", the generation of the switch cam depending on the velocity is deactivated and the bit 0 in P-0-1411, Switch cam status word is always "0". The switch-on threshold must be greater than the switch-off threshold so that the function of a hysteresis is given. When the value in "P-0-1318, Switch cam, switch-on threshold" is smaller than the value in "P-0-1319, Switch cam, switch-off threshold", this is displayed in the status word P-0-1410 in bit 11.

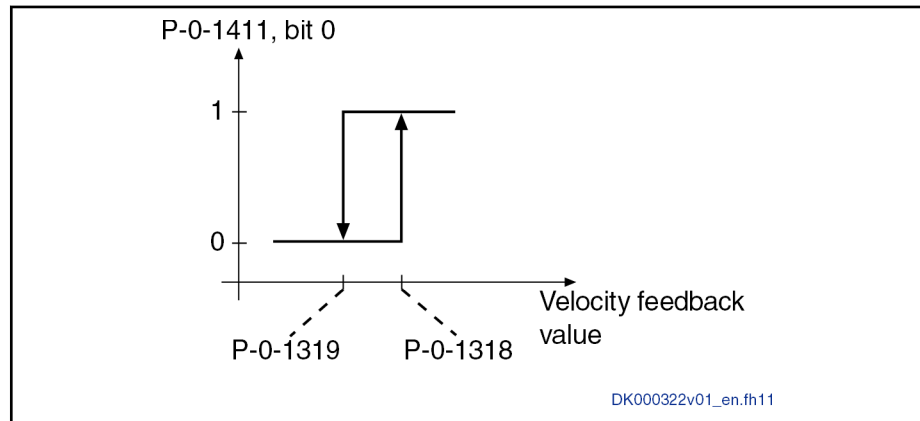


Fig. 13-4: Hysteresis Function of the Parameterizable Switch Cam



The velocity feedback value can be filtered by means of the average value filter for display in the drive firmware (see Functional Description).

The switch cam status word (P-0-1411) is updated/generated every 10 ms. It is also generated if the process controller is not active.

### Switching the Process Controller Off

The process controller is switched off with P-0-1390, bit 0 = 0, and the drive is stopped. The control is ceded to the master communication again and the drive is switched back to the preset operation mode.



By removing drive enable, the process controller is also switched off and the control is returned to the master communication.

## 13.3 Commissioning and Use

### 13.3.1 General Information

#### Using the Process Controller as a Library

The function of the process controller is based on the MLD function in the drive. To use the process controller, MLD must therefore have been enabled as a functional package (see "Enabling Functional Packages").

If other functionalities besides the process controller are required in MLD, the process controller cannot be used as a self-contained, loadable parameter file. The process controller in this case must be included as a library in the MLD program. The respective functions then must be called in the corresponding tasks:

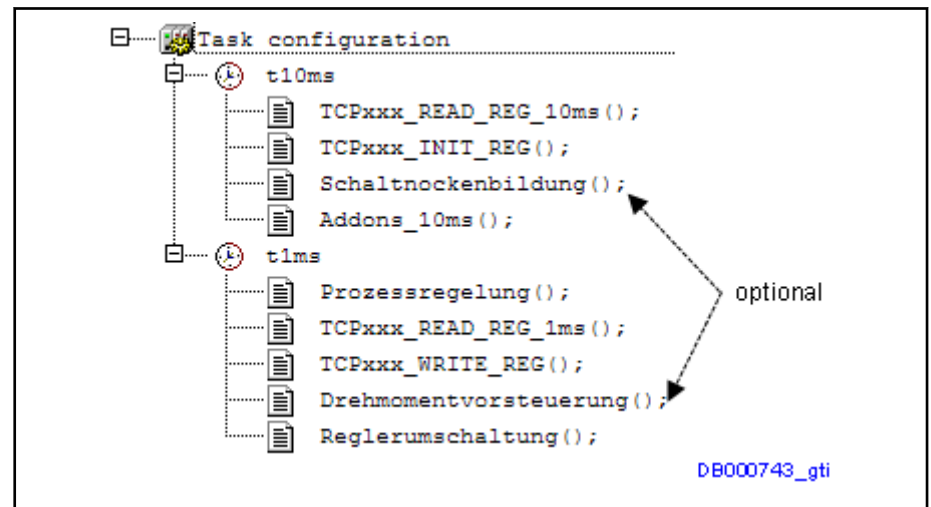


Fig. 13-5: Program Calls Required when Using the Library



To use the IndraWorks dialogs for operating and diagnosing the process controller when employing the library, the file name of the pro file must begin with the following characters: FWS\_MLDPCx\_PRE\_01.

#### Using the Process Controller as a Self-Contained Function

If other functionalities besides the process controller function must be implemented in MLD, it is recommended that you use the exemplary project "FWS\_MLDPCx\_PRE\_01Vxx\_MPxx.pro" as a template or basis. This ensures that the IndraWorks dialogs can be operated and the correct task configuration is available, and that the correct programs are included at the right places.

If the process controller function is exclusively used and required, no additional programming effort is necessary and the functionality can always be accessed via the dialogs in IndraWorks. In this case, the ready-made and self-contained function must be loaded to the drive in the form of a parameter file "FWS\_MLDPCx\_PRE\_01Vxx\_MPxx.par". Among other things, this can be done via the "Project Info" dialog in IndraWorks:

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

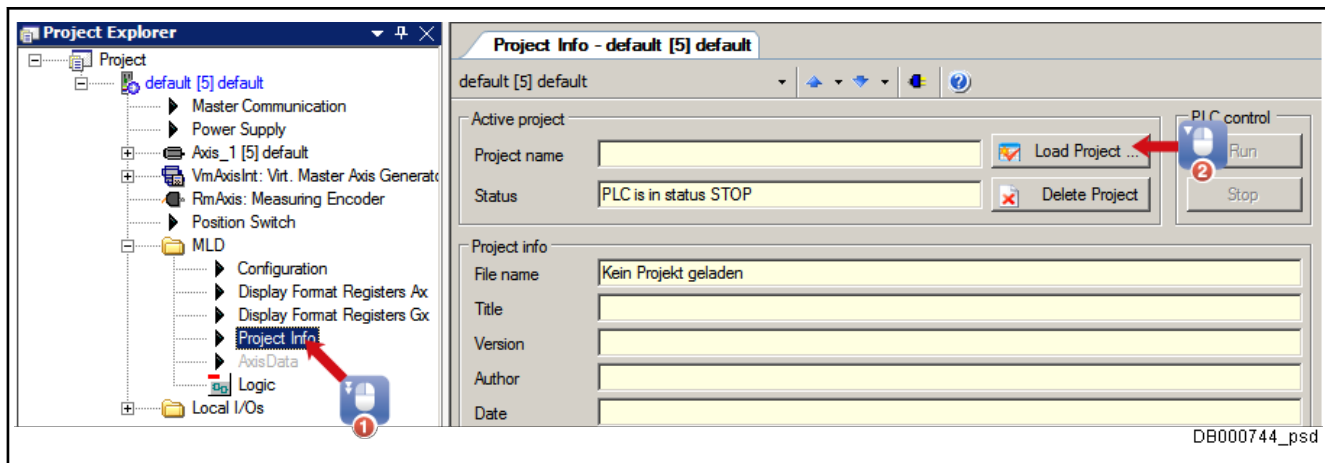


Fig. 13-6: Loading the Self-Contained Function as a Parameter File with IndraWorks

### 13.3.2 Operating the Process Controller by External Control Unit / Master Communication

#### Signals for Cyclic Operation

To control the process controller in the drive in a useful way, certain data/parameters must be exchanged between the drive and the external control unit (see [fig. 13-7 "Communication Channels to Control and Diagnose the Process Controller"](#) on page 207). The data are automatically exchanged within the drive between the drive control (firmware) and the process controller (MLD). The data between the external control unit and the drive via the master communication must be configured accordingly.

The following parameters **must** be transmitted/written by the control unit to the drive:

- Drive control word (e.g. P-0-4077 with Profibus master communication)
- Process controller control word (P-0-1390)
- Process command value (P-0-1371)

The following parameters **should** be transmitted by the drive to the control unit (and be evaluated):

- Drive status word (e.g. P-0-4078 with Profibus master communication)
- Process controller status word (P-0-1410)
- Effective process feedback value (P-0-1273)
- Diagnostic message (S-0-0390)



Depending on the application, it might be useful to transmit more parameters!

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

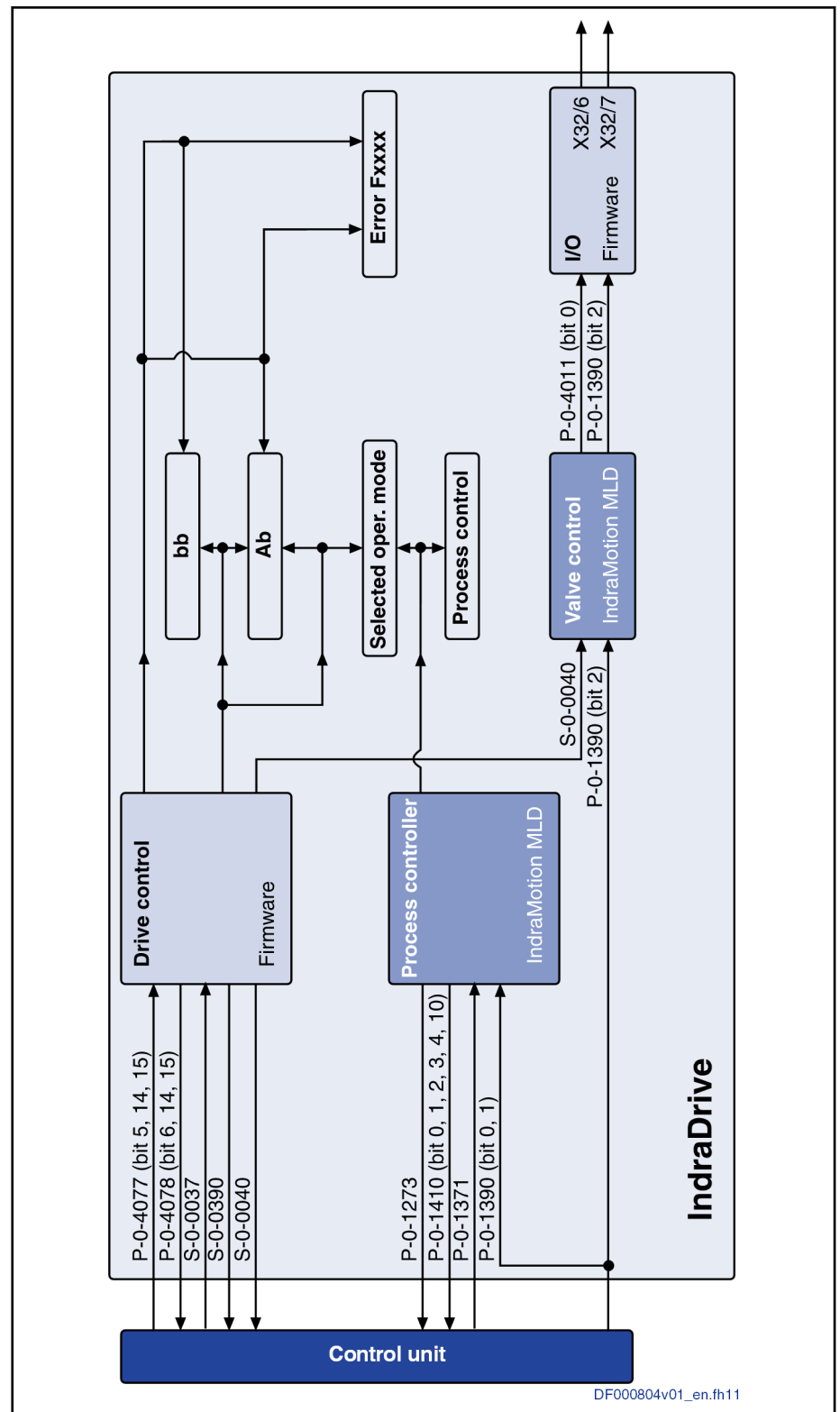


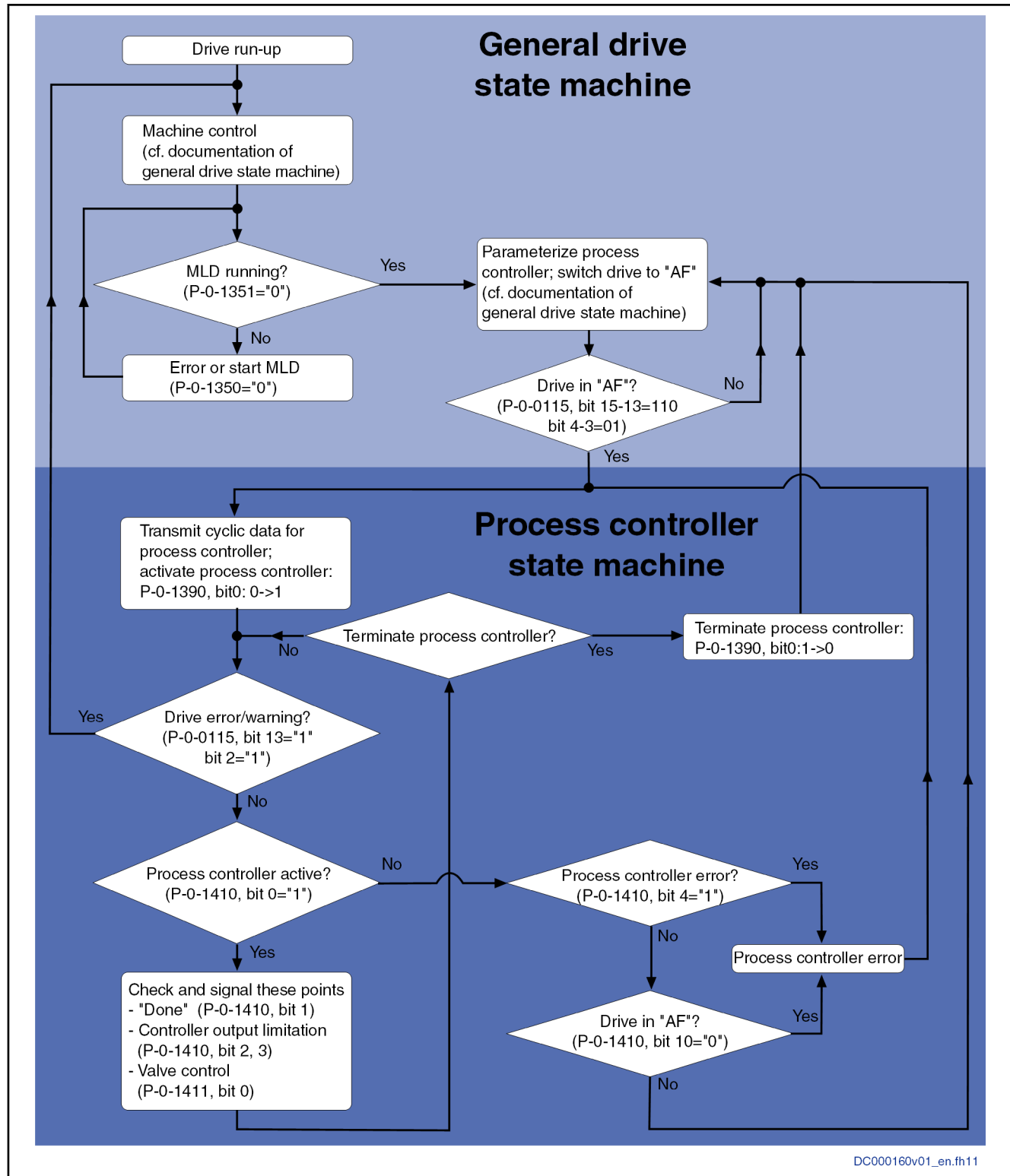
Fig. 13-7: Communication Channels to Control and Diagnose the Process Controller

Control Signals to Operate the Process Controller

To operate the process controller, the drive must be brought to the "drive enable" state (by external control unit, digital input, "easy startup" mode,...). As soon as the drive has reached this state, the process controller can be ac-

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

tivated/started via P-0-1390, bit 0. When the process controller has been deactivated (P-0-1390, bit 0="0"), the axis is operated in the selected operation mode and can be used like a normal servo axis (e.g., in velocity control, drive-internal interpolation, ...). In this case, the process controller does not preset any axis motion.



DC000160v01\_en.fh11

Fig.13-8: Sequence and State Diagram for Operating the Process Controller

### 13.3.3 Operating and Setting the Process Controller by Dialogs in IndraWorks

#### Requirement for Operating the Process Controller

To operate the process controller, the drive must be brought to the "drive enable" state (by external control unit, digital input, "easy startup" mode,...).

The dialog for operating and parameterizing the process controller with IndraWorks can be accessed via the project tree under MLD. Double-clicking "Process Loop" opens the main dialog of the process controller function:

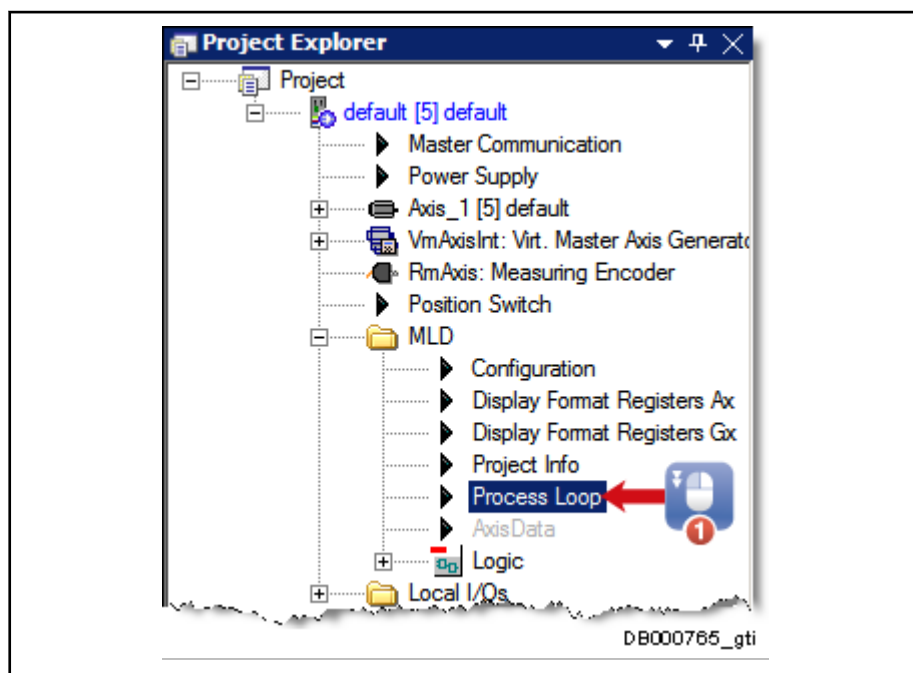


Fig. 13-9: Dialog for Opening the Process Controller Function  
Main/operation dialog

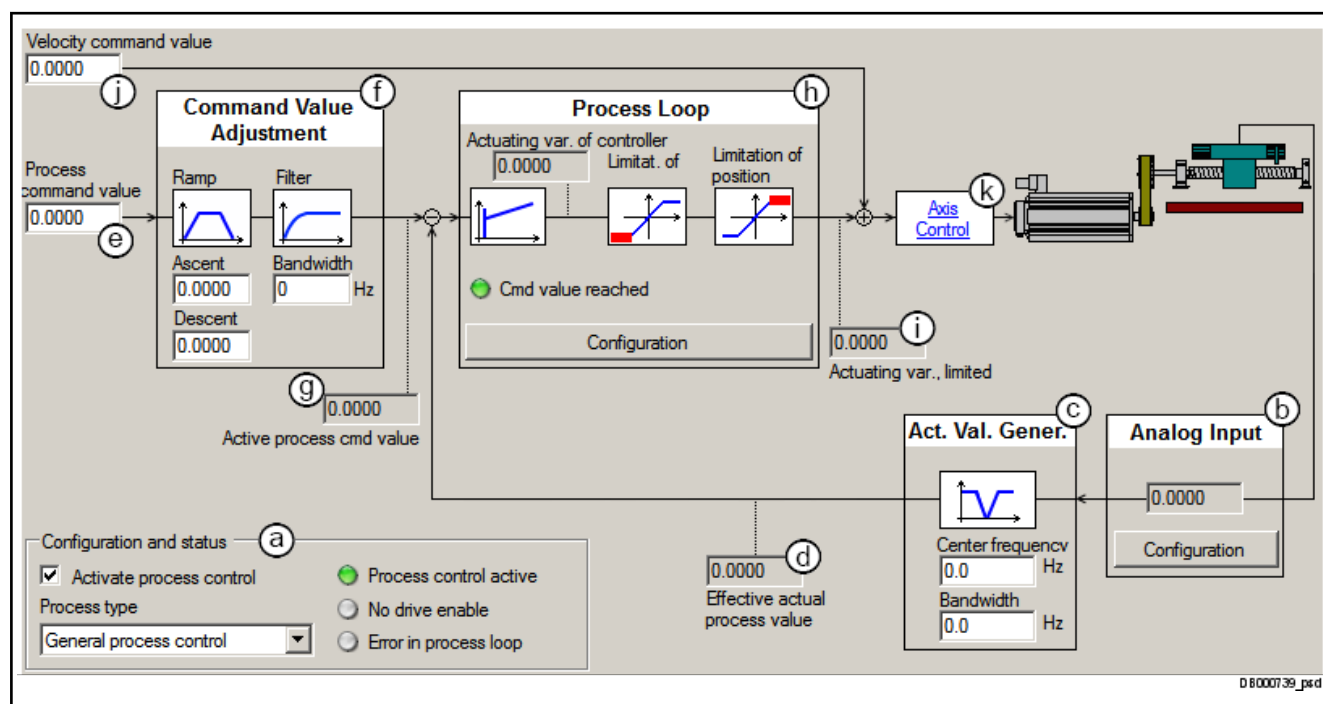


Fig. 13-10: Main Dialog in IndraWorks for Operating the Process Controller

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Configuration and Status ③</b>                       | Under "Configuration and status" ③, the displays and input options required for operating the process controller are provided. As soon as the drive is in the "drive enable" state (NO red dot next to "No drive enable"), the process controller can be activated/started via the "Activate process control" check box. Thereupon, the dot next to "Process control active" turns green which indicates that the process controller is working and moving the axis in such a way that feedback value reaches the command value. When the process controller has been deactivated, i.e. the "Activate process control" check box has NOT been selected, the axis is operated in the selected operation mode and can be used like a normal servo axis (e.g., in velocity control, drive-internal interpolation, ...). In this case, the dot next to "Process control active" is no longer green. The process controller then does not preset any axis motion. If an error occurs within the process controller, the dot next to "Error in process controller" turns red (Fxxxx drive errors are NOT displayed here!). |
| <b>Analog Input ⑥</b>                                   | The feedback value written to P-0-1372 by the analog input of the drive or a control unit is displayed under Analog Input ⑥. Clicking the "Configuration" button opens the dialog for setting the analog input for the connected sensor (see also „configuration dialog of analog input“).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Feedback Value Generation ③ ④</b>                    | <p>The process feedback value read in before can be additionally adjusted under "Feedb. Val. Gener." ③. A band-stop filter available as a feedback value filter can be set and activated at this point.</p> <p>The possibly adjusted/filtered feedback value is displayed in the field as the "Effective process feedback value" ④. The value is directly used to generate the control difference for the controller.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Command Value and Command Value Adjustment ③ ⑦ ⑨</b> | <p>The "Process command value" ③ can be preset directly in the dialog, or the process command value preset via the master communication is displayed at this point.</p> <p>Under "Command Value Adjustment" ⑦, it is possible to limit the increase and decrease per process controller clock (e.g. 1ms) of the process command value preset in this way. Here, it is also possible to activate and set a subsequently effective PT1 command value filter in order to additionally filter the (possibly limited) process command value.</p> <p>This adjusted process command value is displayed as the "Active process cmd value" ⑨ which then is directly used to generated the control difference for the controller.</p>                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Process Controller ⑩</b>                             | <p>In the "Process Controller" ⑩ area, the dot next to "Cmd value reached" signals whether the process feedback value corresponds to the preset active process command value. When the dot is green, the control difference is within the tolerance range, the feedback value so to speak has reached the command value.</p> <p>The controller output that was given by the PID controller due to the calculated control difference, is displayed in the "Controller output" field.</p> <p>In the diagrams "Limitat. of controller output" and "Limitation of position", a red dot at the corresponding point in the respective diagram signals that one of these limits has been reached.</p> <p>Clicking the "Configuration" button opens the configuration dialog in which you can make the settings of the process controller and of the limitations (see „configuration dialog of process controller“).</p>                                                                                                                                                                                                     |
| <b>Controller Output, Limited ①</b>                     | The "Controller output, limited" ① field displays the velocity actually preset by the process controller for the drive; the velocity is required to compensate the control difference.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

### Velocity Command Value, Additive ①

Under "Velocity command value, additive" ①, an additional velocity command value can be preset for the drive, in addition to the controller output of the process controller.

### Axis Control ⑫

The "Axis Control" ⑫ link leads to the dialogs required for setting the fundamental drive control of IndraDrive (speed loop, feedforwards, etc.).

### Configuration dialog of process controller

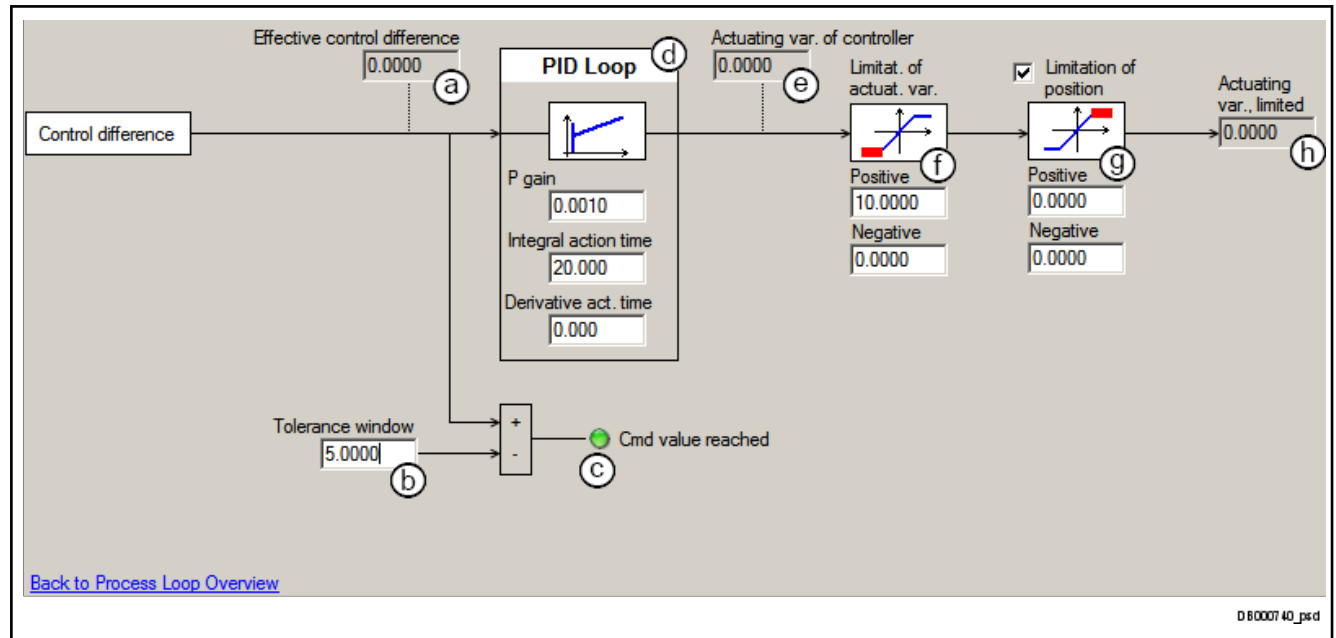


Fig. 13-11: IndraWorks Configuration Dialog for Setting the Properties of the Process Controller

### Effective Control Difference ②

The field under "Effective control difference" ② displays the difference between the effective command value and feedback value. This value is the input value for the PID controller.

### Tolerance Window ③ and Command Value Reached ⑨

If the absolute value is smaller than the entered "Tolerance window" ③, this is signaled by a green dot next to "Cmd value reached" ⑨.

### PID Controller ④

The actual PID process controller can be set under "PID Controller" ④.

### Controller Output ⑤

The "Controller output" ⑤ field displays the controller output calculated by the PID controller due to the effective control difference and required to adjust the feedback value to the command value.

### Limitation of Controller Output ⑥

It might be necessary to limit the controller output given by the PID controller; for example, when the velocity mustn't exceed a certain value. For this purpose, the upper and lower controller output limitation can be set independently of each other under "Limitat. of controller output" ⑥.

### Limitation of Position ⑦

If position limitation is additionally required for the process controller, e.g. for force control, this can be activated with "Limitation of position" ⑦. Here, the upper and lower position limit must be separately entered.

### Controller Output, Limited ⑧

The controller output (velocity) actually preset, after all possible limitations, by the process controller for the drive to compensate the control difference is displayed under "Controller output, limited" ⑧.

### Configuring the Analog Input for the Process Feedback Value



Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

| Bit   | Designation/function                                                      | Comment                                                                  |
|-------|---------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 0     | Activating/enabling process control<br>0: Not active<br>1: Active/enabled |                                                                          |
| 1     | Freeze controller output                                                  |                                                                          |
| 2     | Control valve                                                             |                                                                          |
| 3     | Reserved                                                                  |                                                                          |
| 4     | Reserved                                                                  |                                                                          |
| 5     | Reserved                                                                  |                                                                          |
| 6     | 0→1: Load default values                                                  | The parameters of the process controller are set to their default values |
| 7..15 | Reserved                                                                  |                                                                          |

Fig. 13-13: Parameter Structure

|                    |                |
|--------------------|----------------|
| Min./max. value    | -/-            |
| Format             | BIN            |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | None           |
| Buffered parameter | No             |
| Default value      | -              |

Fig. 13-14: Parameter Attributes

## 13.5.2 P-0-1410, Status word

The parameter P-0-1410 is used as the status word of process control.

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

| Bit   | Designation/function                                                                                                                                                                                                               | Comment                                                                                                                                                                                                                                      |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | Process control active                                                                                                                                                                                                             | Process control was activated (P-0-1390, bit 0) and initialization has been completed                                                                                                                                                        |
| 1     | <b>Control difference within tolerance window?</b><br>0: Control difference > tolerance window<br>1: Control difference <= tolerance window                                                                                        |                                                                                                                                                                                                                                              |
| 2     | Upper controller output limitation active                                                                                                                                                                                          | Controller output is limited by P-0-1377                                                                                                                                                                                                     |
| 3     | Lower controller output limitation active                                                                                                                                                                                          | Controller output is limited by P-0-1378                                                                                                                                                                                                     |
| 4     | Error                                                                                                                                                                                                                              | An error in process control has occurred                                                                                                                                                                                                     |
| 5     | Upper position limit exceeded                                                                                                                                                                                                      | Upper position limit P-0-1381 exceeded                                                                                                                                                                                                       |
| 6     | Lower position limit exceeded                                                                                                                                                                                                      | Lower position limit P-0-1382 exceeded                                                                                                                                                                                                       |
| 7     | <b>Limitation of command value change NOT active</b><br>0: Command value change is limited/filtered (P-0-1371 <> P-0-1271)<br>1: Command value corresponds to possibly limited/filtered active command value (P-0-1371 = P-0-1271) | Displays whether P-0-1371 = P-0-1271<br>If bit 7 = 0, the command value change is limited by the ramp and/or the filter                                                                                                                      |
| 8     | Reserved                                                                                                                                                                                                                           |                                                                                                                                                                                                                                              |
| 10    | No AF                                                                                                                                                                                                                              | The drive is not in drive enable when process control is activated                                                                                                                                                                           |
| 11    | <b>Switch cam velocity</b><br>1:<br>Switch-on threshold (P-0-1318) smaller than switch-off threshold (P-0-1319)                                                                                                                    |                                                                                                                                                                                                                                              |
| 12    | <b>Active controller setting</b><br>0: Controller setting 1 takes effect (P-0-1373, P-0-1374)<br>1: Controller setting 2 takes effect (P-0-1320, P-0-1321)                                                                         | Displays which controller settings are currently active, depending on the effective process feedback value (P-0-1273) or on the effective velocity command value (P-0-0048) and on the switch points (P-0-1322, P-0-1323) that have been set |
| 13-15 | Reserved                                                                                                                                                                                                                           |                                                                                                                                                                                                                                              |

Fig. 13-15: Parameter Structure

|                    |                 |
|--------------------|-----------------|
| Min./max. value    | -/-             |
| Format             | BIN             |
| Unit               | -               |
| Type               | Output register |
| Decimal places     | None            |
| Buffered parameter | No              |
| Default value      | -               |

Fig. 13-16: Parameter Attributes

## 13.5.3 P-0-1411, Switch cam status word

The parameter P-0-1411 is used as the status word of the generated switch cams. When the generation of a switch cam or bit has been activated via the

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

corresponding configuration, the respective bit in P-0-1411 is written depending on the configuration.

| Bit  | Designation/function                                                                                                                                                                                        | Comment                                                                                              |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| 0    | <b>Switch cam velocity</b><br>0: Switch-on velocity not reached or velocity value fallen below switch-off velocity<br>1: Switch-on velocity exceeded or velocity value not fallen below switch-off velocity | The bit is set depending on P-0-1318 and P-0-1319, taking the command velocity P-0-0040 into account |
| 1-15 | Reserved                                                                                                                                                                                                    |                                                                                                      |

Fig. 13-17: Parameter Structure

|                    |                 |
|--------------------|-----------------|
| Min./max. value    | 0/-             |
| Format             | BIN             |
| Unit               | -               |
| Type               | Output register |
| Decimal places     | None            |
| Buffered parameter | No              |
| Default value      | -               |

Fig. 13-18: Parameter Attributes

## 13.5.4 P-0-1270, Effective control difference

P-0-1270 displays the control difference that actually takes effect for the PID controller. For this purpose, the effective process feedback value (P-0-1273) (possibly inverted and filtered) is subtracted from the effective process command value (P-0-1271) (possibly inverted and filtered). The value is used, among other things, to generate P-0-1410, bit 1.

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | -/-                   |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Output register       |
| Decimal places     | 4                     |
| Buffered parameter | No                    |
| Default value      | -                     |

Fig. 13-19: Parameter Attributes

## 13.5.5 P-0-1271, Effective command value

P-0-1271 displays the command value that actually takes effect for the generation of the control difference. The value might be filtered (P-0-1326). If the control difference has been inverted (P-0-1370, bit 6), the value is displayed in inverted form.

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | -/-                   |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Output register       |
| Decimal places     | 4                     |
| Buffered parameter | No                    |
| Default value      | -                     |

Fig. 13-20: Parameter Attributes

## 13.5.6 P-0-1272, Torque feedforward, feedforward value

With active torque feedforward (P-0-1325  $\neq$  0), P-0-1272 displays the value preset by torque feedforward. The value is calculated from the effective process command value (P-0-1271) and is preset in addition to the controller output of the process controller via the additive torque/force command value. With active controller output / position limitation, the value of torque feedforward is "0".

|                    |                 |
|--------------------|-----------------|
| Min./max. value    | -/-             |
| Format             | DEC_MV          |
| Unit               | As S81          |
| Type               | Output register |
| Decimal places     | 4               |
| Buffered parameter | No              |
| Default value      | -               |

Fig. 13-21: Parameter Attributes

## 13.5.7 P-0-1273, Effective process feedback value

For diagnostic purposes, P-0-1273 displays the feedback value for the process controller that actually takes effect. It is the value after feedback value adjustment, i.e. after all filter functions (e.g. band-stop filter). If the control difference has been inverted (P-0-1370, bit 6), the value is displayed in inverted form.

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | -/-                   |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Output register       |
| Decimal places     | 4                     |
| Buffered parameter | No                    |
| Default value      | -                     |

Fig. 13-22: Parameter Attributes

## 13.5.8 P-0-1274, Controller output

P-0-1274 displays the controller output calculated in the PID controller. The position and controller output limitation is not taken into account for the dis-

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

played value. A possible limitation by the controller output ramp, as well as the controller output feedforward are used for calculating the value (only if the functions are really used!).

|                    |                 |
|--------------------|-----------------|
| Min./max. value    | -/-             |
| Format             | DEC_MV          |
| Unit               | As P-0-0690     |
| Type               | Output register |
| Decimal places     | 4               |
| Buffered parameter | No              |
| Default value      | -               |

Fig. 13-23: Parameter Attributes

### 13.5.9 P-0-1275, Controller output, limited

P-0-1275 displays the controller output which is limited by P-0-1377 and P-0-1378 (controller output limitation) and thereby takes effect for the drive. This value is preset for the drive via P-0-0690. If a position limitation exists, the value is "0".

|                    |                   |
|--------------------|-------------------|
| Min./max. value    | P-0-1377/P-0-1378 |
| Format             | DEC_MV            |
| Unit               | As P-0-0690       |
| Type               | Output register   |
| Decimal places     | 4                 |
| Buffered parameter | No                |
| Default value      | -                 |

Fig. 13-24: Parameter Attributes

### 13.5.10 P-0-1276, Controller cycle time

P-0-1276 indicates the actual and current cycle time in which the process controller is calculated in the drive. The cycle time depends on the control section used and on the device design, and besides can depend on the current device load.

|                    |                 |
|--------------------|-----------------|
| Min./max. value    | 1/-             |
| Format             | DEC_OV          |
| Unit               | µs              |
| Type               | Output register |
| Decimal places     | 0               |
| Buffered parameter | No              |
| Default value      | -               |

Fig. 13-25: Parameter Attributes

### 13.5.11 P-0-1316, Band-stop filter, center frequency

In P-0-1316, set the center frequency of the band-stop filter (rejection filter). Entering the minimum input value (zero) switches the filter off.

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0/-          |
| Format             | DEC_OV         |
| Unit               | Hz             |
| Type               | Input register |
| Decimal places     | 1              |
| Buffered parameter | Yes            |
| Default value      | 0,0            |

Fig. 13-26: Parameter Attributes

### 13.5.12 P-0-1317, Band-stop filter, bandwidth

In P-0-1317, you can enter the value for the bandwidth of the band-stop filter (rejection filter). Entering the minimum input value (zero) switches the filter off.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0/-          |
| Format             | DEC_OV         |
| Unit               | Hz             |
| Type               | Input register |
| Decimal places     | 1              |
| Buffered parameter | Yes            |
| Default value      | 0,0            |

Fig. 13-27: Parameter Attributes

### 13.5.13 P-0-1318, Switch cam, switch-on threshold

When the **absolute value** of the effective velocity command value (P-0-0040) exceeds the value entered in P-0-1318, the bit 0 is set in "P-0-1411, Switch cam status word". If P-0-1318 and P-0-1319 are simultaneously "0", the switch cam depending on the velocity is deactivated, i.e. the bit 0 in P-0-1411 is always "0".

When the value in P-0-1318 is smaller than the value in P-0-1319, this is displayed in the status word P-0-1410 in bit 11.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,000/-        |
| Format             | DEC_MV         |
| Unit               | As S-0-0040    |
| Type               | Input register |
| Decimal places     | 3              |
| Buffered parameter | Yes            |
| Default value      | 0,000          |

Fig. 13-28: Parameter Attributes

### 13.5.14 P-0-1319, Switch cam, switch-off threshold

When the **absolute value** of the effective velocity command value (P-0-0040) falls below the value entered in P-0-1319, the bit 0 in "P-0-1411, Switch cam status word" is set to "0". If P-0-1318 and P-0-1319 are simultaneously "0",

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

the switch cam depending on the velocity is deactivated, i.e. the bit 0 in P-0-1411 is always "0".

When the value in P-0-1318 is smaller than the value in P-0-1319, this is displayed in the status word P-0-1410 in bit 11.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,000/-        |
| Format             | DEC_MV         |
| Unit               | As S-0-0040    |
| Type               | Input register |
| Decimal places     | 3              |
| Buffered parameter | Yes            |
| Default value      | 0,000          |

Fig. 13-29: Parameter Attributes

### 13.5.15 P-0-1320, P-gain 2 of controller

The parameter P-0-1320 is used to preset the optional P-component of the PID controller for switching the controller setting. If the switching of the controller setting has not been set with P-0-1322/P-0-1323, then P-0-1320 has no function.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0000/-       |
| Format             | DEC_OV         |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0010         |

Fig. 13-30: Parameter Attributes

### 13.5.16 P-0-1321, I-component 2 of controller

The parameter P-0-1321 is used to preset the optional I-component (integral-action time) of the PID controller for switching the controller setting. If the switching of the controller setting has not been set with P-0-1322/P-0-1323, then P-0-1321 has no function.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,000/-        |
| Format             | DEC_OV         |
| Unit               | ms             |
| Type               | Input register |
| Decimal places     | 3              |
| Buffered parameter | Yes            |
| Default value      | 20,000         |

Fig. 13-31: Parameter Attributes

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

### 13.5.17 P-0-1322, Switch point of controller setting 2

When the absolute value of the effective process feedback value (P-0-1273) or the effective command velocity (P-0-0048) (can be set via P-0-1370, bit 7) is greater than the value entered in P-0-1322, other values (P-0-1320/ P-0-1321) become valid for P- and I-component of the PID controller. If P-0-1323="0" and P-0-1322="0", the controller setting is not switched.

The active controller setting is displayed in P-0-1410, bit 12.

|                    |                                         |
|--------------------|-----------------------------------------|
| Min./max. value    | 0,0000/-                                |
| Format             | DEC_OV                                  |
| Unit               | N or Nm; bar; mm; ...<br>or as P-0-0048 |
| Type               | Input register                          |
| Decimal places     | 4                                       |
| Buffered parameter | Yes                                     |
| Default value      | 0,0000                                  |

Fig. 13-32: Parameter Attributes

### 13.5.18 P-0-1323, Switch point of controller setting 1

When the absolute value of the effective control difference (P-0-1270) or the effective command velocity (P-0-0048) (can be set via P-0-1370, bit 7) is smaller than the value entered in P-0-1323, the original values (P-0-1373/ P-0-1374) become valid again for P- and I-component of the PID controller. If P-0-1323="0" and P-0-1322="0", the controller setting is not switched.

The active controller setting is displayed in P-0-1410, bit 12.

|                    |                                         |
|--------------------|-----------------------------------------|
| Min./max. value    | 0,0000/-                                |
| Format             | DEC_OV                                  |
| Unit               | N or Nm; bar; mm; ...<br>or as P-0-0048 |
| Type               | Input register                          |
| Decimal places     | 4                                       |
| Buffered parameter | Yes                                     |
| Default value      | 0,0000                                  |

Fig. 13-33: Parameter Attributes

### 13.5.19 P-0-1325, Torque feedforward factor

With P-0-1325, you can set the torque feedforward. For this purpose, the effective process command value (P-0-1271) is multiplied with the value from P-0-1325 and then preset for the drive as the additive torque/force command value via S-0-0081.

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0.0000/-       |
| Format             | DEC_OV         |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0000         |

Fig. 13-34: Parameter Attributes

## 13.5.20 P-0-1326, PT1 command value filter, filter time constant [ms]

In P-0-1326, you can enter the filter time constant of the command value filter. In this case, the possibly inverted (P-0-1370, bit 6) command value is filtered. The filtered command value is displayed in P-0-1271. P-0-1326="0,0" deactivates the command value filter. P-0-1271 then corresponds to the unfiltered, possibly inverted command value P-0-1371.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0/-          |
| Format             | DEC_OV         |
| Unit               | ms             |
| Type               | Input register |
| Decimal places     | 1              |
| Buffered parameter | Yes            |
| Default value      | 0,0            |

Fig. 13-35: Parameter Attributes

## 13.5.21 P-0-1327, Maximum command value increase

With P-0-1327, a maximum possible increase of the command value can be set. If the preset command value increases by more than the value set in this parameter within one process controller clock (corresponds to minimum MLD cycle time; for example, 1 ms with MPH firmware), the increase of the command value is limited to the maximum allowed value set here. The command value with a possibly limited increase is displayed in P-0-1271.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0000/-       |
| Format             | DEC_OV         |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0000         |

Fig. 13-36: Parameter Attributes

## 13.5.22 P-0-1328, Maximum command value decrease

With P-0-1328, a maximum possible decrease of the command value can be set. If the preset command value decreases by more than the value set in

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

this parameter within one process controller clock (corresponds to minimum MLD cycle time; for example, 1 ms with MPH firmware), the decrease of the command value is limited to the maximum allowed value set here. The command value with a possibly limited decrease is displayed in P-0-1271.

|                           |                |
|---------------------------|----------------|
| <b>Min./max. value</b>    | 0,0000/-       |
| <b>Format</b>             | DEC_OV         |
| <b>Unit</b>               | -              |
| <b>Type</b>               | Input register |
| <b>Decimal places</b>     | 4              |
| <b>Buffered parameter</b> | Yes            |
| <b>Default value</b>      | 0,0000         |

Fig. 13-37: Parameter Attributes

## 13.5.23 P-0-1329, Maximum controller output increase

With P-0-1329, a maximum possible increase of the controller output is set. If the calculated controller output increases by more than the value set in this parameter within one process controller clock (corresponds to minimum MLD cycle time; for example, 1 ms with MPH firmware), the increase of the controller output is limited to the maximum allowed value set here. The controller output with a possibly limited increase is displayed in P-0-1274.

|                           |                |
|---------------------------|----------------|
| <b>Min./max. value</b>    | 0,0000/-       |
| <b>Format</b>             | DEC_OV         |
| <b>Unit</b>               | As S-0-0036    |
| <b>Type</b>               | Input register |
| <b>Decimal places</b>     | 4              |
| <b>Buffered parameter</b> | Yes            |
| <b>Default value</b>      | 0,0000         |

Fig. 13-38: Parameter Attributes

## 13.5.24 P-0-1330, Maximum controller output decrease

With P-0-1330, a maximum possible decrease of the controller output is set. If the calculated controller output decreases by more than the value set in this parameter within one process controller clock (corresponds to minimum MLD cycle time; for example, 1 ms with MPH firmware), the decrease of the controller output is limited to the maximum allowed value set here. The controller output with a possibly limited decrease is displayed in P-0-1274.

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0000/-       |
| Format             | DEC_OV         |
| Unit               | As S-0-0036    |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0000         |

Fig. 13-39: Parameter Attributes

## 13.5.25 P-0-1370, Configuration

The parameter P-0-1370 is used to configure process control.

| Bit    | Designation/function                                                                                                                          | Comment                                                                                                          |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| 1/0    | <b>Controller output</b><br>00: Velocity command value (P-0-0690)                                                                             | Set with regard to which variable in the drive the process controller takes effect.                              |
| 2      | <b>Position limit value monitoring</b><br>0: Not active<br>1: Active                                                                          | With this bit, position limit value monitoring can be activated. The limits are set in P-0-1381 and P-0-1382.    |
| 4/3    | <b>Source of process feedback value</b><br>00: Analog input / external sensor (P-0-1372)                                                      | Set wherefrom the process feedback value comes.                                                                  |
| 5      | <b>Switch-off behavior</b><br>0: Controller output = 0                                                                                        | Set how the drive is to behave when the process controller is switched off.                                      |
| 6      | <b>Control difference</b><br>0: Not inverted<br>1: Inverted                                                                                   | With this bit it is possible to invert the control difference, if necessary                                      |
| 7      | <b>Signal source for controller switching</b><br>0: Effective process feedback value P-0-1273<br>1: Effective velocity command value P-0-0048 | With this bit, select the signal to which the switch points for controller switching (P-0-1322, P-0-1323) relate |
| 8...31 | Not used                                                                                                                                      |                                                                                                                  |

Fig. 13-40: Parameter Structure

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0/-            |
| Format             | BIN            |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | None           |
| Buffered parameter | Yes            |
| Default value      | -              |

Fig. 13-41: Parameter Attributes

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

### 13.5.26 P-0-1371, Process command value

The command value for the process controller is preset via P-0-1371. The command value can be preset by a control unit via the master communication or an analog input.

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | -/-                   |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Input register        |
| Decimal places     | 4                     |
| Buffered parameter | Yes                   |
| Default value      | -                     |

*Fig. 13-42: Parameter Attributes*

### 13.5.27 P-0-1372, Process feedback value, analog

The feedback value for the process controller is read in via P-0-1372. Ideally, this parameter is assigned to an analog input of the drive controller.

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | -/-                   |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Input register        |
| Decimal places     | 4                     |
| Buffered parameter | No                    |
| Default value      | -                     |

*Fig. 13-43: Parameter Attributes*

### 13.5.28 P-0-1373, P-gain of controller

The parameter P-0-1373 is used to preset the P-component of the process controller.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0000/-       |
| Format             | DEC_OV         |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0010         |

*Fig. 13-44: Parameter Attributes*

### 13.5.29 P-0-1374, I-component of controller

The parameter P-0-1374 is used to preset the I-component (integral-action time) of the process controller.

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,000/-        |
| Format             | DEC_OV         |
| Unit               | ms             |
| Type               | Input register |
| Decimal places     | 3              |
| Buffered parameter | Yes            |
| Default value      | 20,000         |

Fig. 13-45: Parameter Attributes

### 13.5.30 P-0-1375, D-component of controller

The parameter P-0-1375 is used to preset the D-component (derivative action time) of the process controller.

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,000/-        |
| Format             | DEC_OV         |
| Unit               | ms             |
| Type               | Input register |
| Decimal places     | 3              |
| Buffered parameter | Yes            |
| Default value      | 0,000          |

Fig. 13-46: Parameter Attributes

### 13.5.31 P-0-1377, Controller output limitation, upper

Via this parameter, it is possible to set an upper limit for the process controller output. The status word P-0-1410, bit 2, shows whether the limitation is active. In order not to limit the controller output, enter accordingly high values in P-0-1377 (e.g. P-0-1377 > S-0-0091).

The entered value must be signed!

|                    |                |
|--------------------|----------------|
| Min./max. value    | -/-            |
| Format             | DEZ            |
| Unit               | As S-0-0091    |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 10,0000        |

Fig. 13-47: Parameter Attributes

### 13.5.32 P-0-1378, Controller output limitation, lower

Via this parameter, it is possible to set a lower limit for the process controller output. The status word P-0-1410, bit 3, shows whether the limitation is active. In order not to limit the controller output, enter accordingly high values in P-0-1378 (e.g. P-0-1378 < S-0-0091).

The entered value must be signed!

## Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                    |                |
|--------------------|----------------|
| Min./max. value    | -/-            |
| Format             | DEZ            |
| Unit               | As S-0-0091    |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | -10,0000       |

Fig. 13-48: Parameter Attributes

## 13.5.33 P-0-1380, Tolerance window

The tolerance window defines a range around the preset command value (P-0-1371). When the feedback value (P-0-1372) is within this range, the process controller signals back "Done" in the status word (P-0-1410, bit 1), i.e. the effective control difference (P-0-1270) is smaller than the tolerance window.

|                    |                       |
|--------------------|-----------------------|
| Min./max. value    | 0,0000/-              |
| Format             | DEC_MV                |
| Unit               | N or Nm; bar; mm; ... |
| Type               | Input register        |
| Decimal places     | 4                     |
| Buffered parameter | Yes                   |
| Default value      | 5,0000                |

Fig. 13-49: Parameter Attributes

## 13.5.34 P-0-1381, Position limitation, upper

The parameter P-0-1381 is used to preset the upper (→ more positive) position limit value which the axis is not allowed to pass. When the position feedback value S-0-0051 reaches/exceeds the position limit that was set, the drive decelerates until standstill has been reached (command velocity = 0), as long as the process controller gives controller output values (P-0-1385) which would not cause the drive to leave the limit. The entered value must be signed! The position limitation is activated via P-0-1370, bit 2.

|                    |                    |
|--------------------|--------------------|
| Min./max. value    | -/-                |
| Format             | DEC_MV             |
| Unit               | Like position data |
| Type               | Input register     |
| Decimal places     | Like position data |
| Buffered parameter | Yes                |
| Default value      | 0                  |

Fig. 13-50: Parameter Attributes

### 13.5.35 P-0-1382, Position limitation, lower

The parameter P-0-1382 is used to preset the lower (→ more negative) position limit value which the axis is not allowed to pass. When the effective position feedback value S-0-0386 reaches/exceeds the position limit that was set, the drive decelerates until standstill has been reached (command velocity = 0), as long as the process controller gives controller output values (P-0-1385) which would not cause the drive to leave the limit. The entered value must be signed! The position limitation is activated via P-0-1370, bit 2.

|                    |                    |
|--------------------|--------------------|
| Min./max. value    | -/-                |
| Format             | DEC_MV             |
| Unit               | Like position data |
| Type               | Input register     |
| Decimal places     | Like position data |
| Buffered parameter | Yes                |
| Default value      | 0                  |

Fig. 13-51: Parameter Attributes

### 13.5.36 P-0-1384, Command value feedforward factor

For command value feedforward, the effective process command value (P-0-1271) is multiplied with the value entered in P-0-1384 and subsequently filtered (see P-0-1385).

|                    |                |
|--------------------|----------------|
| Min./max. value    | 0,0000/-       |
| Format             | DEC_OV         |
| Unit               | -              |
| Type               | Input register |
| Decimal places     | 4              |
| Buffered parameter | Yes            |
| Default value      | 0,0000         |

Fig. 13-52: Parameter Attributes

### 13.5.37 P-0-1385, Command value feedforward filter time constant

The effective process command value previously multiplied with P-0-1384 can be additionally filtered. In P-0-1385, the time constant in [ms] is set for this filter. The value filtered in such a way is then added to the controller output calculated in parallel in the PID controller. With P-0-1385="0", the filter is deactivated and the process command value is not filtered. In this case, feedforward of the effective process command value (P-0-1271), multiplied with P-0-1384, takes place directly, i.e. the effective process command value is added to the controller output of the PID controller.

Process Controller (FWS\_MLDPCx\_PRE\_01Vxx\_MPxx)

|                           |                |
|---------------------------|----------------|
| <b>Min./max. value</b>    | 0/-            |
| <b>Format</b>             | DEC_OV         |
| <b>Unit</b>               | ms             |
| <b>Type</b>               | Input register |
| <b>Decimal places</b>     | 0              |
| <b>Buffered parameter</b> | Yes            |
| <b>Default value</b>      | 0              |

*Fig. 13-53: Parameter Attributes*

## 14 Service and Support

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# Index

## A

|                                                             |     |
|-------------------------------------------------------------|-----|
| Analysis of characteristic curve S1.....                    | 189 |
| Configuration and operation by means of<br>IndraWorks ..... | 193 |
| Configuration and operation via parameters .....            | 192 |
| P-0-1270 .....                                              | 193 |
| P-0-1272 .....                                              | 193 |
| P-0-1273 .....                                              | 194 |
| P-0-1274 .....                                              | 194 |
| P-0-1275 .....                                              | 194 |
| P-0-1370 .....                                              | 195 |
| P-0-1371 .....                                              | 195 |
| P-0-1372 .....                                              | 196 |
| Appropriate use.....                                        | 31  |
| Applications .....                                          | 31  |

## C

|                                                             |     |
|-------------------------------------------------------------|-----|
| Collision monitoring.....                                   | 131 |
| Configuration and operation by means of<br>IndraWorks ..... | 140 |
| Configuration and operation via parameters .....            | 135 |
| P-0-1311 .....                                              | 141 |
| P-0-1312 .....                                              | 142 |
| P-0-1370 .....                                              | 142 |
| P-0-1375 .....                                              | 143 |
| P-0-1378 .....                                              | 143 |
| P-0-1387 .....                                              | 144 |
| P-0-1410 .....                                              | 144 |

## D

|                                                      |     |
|------------------------------------------------------|-----|
| Diagnostic and status messages                       |     |
| Frequency response measurement and<br>analysis ..... | 88  |
| Mechanical analysis .....                            | 52  |
| Vibration damping and avoiding .....                 | 173 |
| Drive system.....                                    | 21  |

## E

|                                                             |     |
|-------------------------------------------------------------|-----|
| Electric drive system.....                                  | 21  |
| Enabling functional packages.....                           | 33  |
| Envelope curve monitoring.....                              | 103 |
| Configuration and operation by means of<br>IndraWorks ..... | 116 |
| Configuration and operation via parameters .....            | 109 |
| P-0-1368 .....                                              | 123 |
| P-0-1370 .....                                              | 123 |
| P-0-1371 .....                                              | 124 |
| P-0-1372 .....                                              | 124 |
| P-0-1373 .....                                              | 125 |
| P-0-1374 .....                                              | 125 |
| P-0-1375 .....                                              | 125 |

## E

|                              |     |
|------------------------------|-----|
| ...Envelope curve monitoring |     |
| P-0-1376 .....               | 126 |
| P-0-1377 .....               | 126 |
| P-0-1378 .....               | 126 |
| P-0-1384 .....               | 127 |
| P-0-1385 .....               | 127 |
| P-0-1387 .....               | 127 |
| P-0-1389 .....               | 128 |
| P-0-1390 .....               | 129 |
| P-0-1410 .....               | 129 |

## F

|                                                             |        |
|-------------------------------------------------------------|--------|
| Frequency response measurement and analysis                 |        |
| Configuration and operation by means of<br>IndraWorks ..... | 81     |
| Configuration and operation via parameters .....            | 76     |
| Diagnostic and status messages .....                        | 88     |
| Load reference measurement .....                            | 79, 84 |
| P-0-1155 .....                                              | 89     |
| P-0-1316 .....                                              | 89     |
| P-0-1317 .....                                              | 89     |
| P-0-1318 .....                                              | 89     |
| P-0-1319 .....                                              | 90     |
| P-0-1320 .....                                              | 90     |
| P-0-1321 .....                                              | 90     |
| P-0-1322 .....                                              | 90     |
| P-0-1323 .....                                              | 90     |
| P-0-1368 .....                                              | 90     |
| P-0-1370 .....                                              | 92     |
| P-0-1371 .....                                              | 93     |
| P-0-1372 .....                                              | 94     |
| P-0-1373 .....                                              | 94     |
| P-0-1374 .....                                              | 94     |
| P-0-1375 .....                                              | 94     |
| P-0-1376 .....                                              | 94     |
| P-0-1377 .....                                              | 94     |
| P-0-1378 .....                                              | 95     |
| P-0-1379 .....                                              | 95     |
| P-0-1380 .....                                              | 95     |
| P-0-1381 .....                                              | 95     |
| P-0-1382 .....                                              | 95     |
| P-0-1383 .....                                              | 95     |
| P-0-1384 .....                                              | 96     |
| P-0-1385 .....                                              | 96     |
| P-0-1387 .....                                              | 96     |
| P-0-1389 .....                                              | 97     |
| P-0-1390 .....                                              | 99     |
| P-0-1410 .....                                              | 99     |
| P-0-1412 .....                                              | 101    |
| P-0-1413 .....                                              | 102    |
| P-0-1414 .....                                              | 102    |
| Reference data, several .....                               | 78, 84 |
| Save reference measurement .....                            | 78, 84 |
| FWS_MLDPAx_MCG_01V02_D0_MPxx.....                           | 189    |

## Index

**F**

|                                                                          |     |
|--------------------------------------------------------------------------|-----|
| FWS_MLDPa <sub>x</sub> _SAM_02V <sub>xx</sub> _D0_MP0 <sub>x</sub> ..... | 37  |
| FWS_MLDPa <sub>x</sub> _SCH_02V <sub>xx</sub> _D0_MP0 <sub>x</sub> ..... | 103 |
| FWS_MLDTFx_SCM_01V <sub>xx</sub> _D0_MP07.....                           | 131 |

**H**

|                                                   |    |
|---------------------------------------------------|----|
| How to load technology functions to the drive.... | 35 |
|---------------------------------------------------|----|

**I**

|                                            |    |
|--------------------------------------------|----|
| Inappropriate use.....                     | 32 |
| Consequences, exclusion of liability ..... | 31 |

**M**

|                                            |        |
|--------------------------------------------|--------|
| Means of representation                    |        |
| Conventions of notation .....              | 9      |
| Notations .....                            | 9      |
| Mechanical analysis.....                   | 37     |
| Configuration and operation by means of    |        |
| IndraWorks .....                           | 48     |
| Configuration and operation via parameters | 43     |
| Diagnostic and status messages .....       | 52     |
| Load reference measurement .....           | 45, 51 |
| P-0-1370 .....                             | 54     |
| P-0-1371 .....                             | 55     |
| P-0-1372 .....                             | 55     |
| P-0-1373 .....                             | 56     |
| P-0-1374 .....                             | 56     |
| P-0-1375 .....                             | 56     |
| P-0-1376 .....                             | 57     |
| P-0-1377 .....                             | 57     |
| P-0-1378 .....                             | 57     |
| P-0-1379 .....                             | 58     |
| P-0-1380 .....                             | 58     |
| P-0-1381 .....                             | 59     |
| P-0-1382 .....                             | 59     |
| P-0-1383 .....                             | 59     |
| P-0-1384 .....                             | 60     |
| P-0-1385 .....                             | 60     |
| P-0-1387 .....                             | 60     |
| P-0-1389 .....                             | 60     |
| P-0-1390 .....                             | 63     |
| P-0-1410 .....                             | 63     |
| Reference data, several .....              | 45, 51 |
| Save reference measurement .....           | 45, 51 |
| Start reference measurement .....          | 44     |

**O**

|                            |    |
|----------------------------|----|
| Overview of functions..... | 18 |
|----------------------------|----|

**P**

|                    |     |
|--------------------|-----|
| PELV.....          | 25  |
| Process controller |     |
| P-0-1270 .....     | 215 |
| P-0-1271 .....     | 215 |
| P-0-1272 .....     | 216 |

**P**

|                                   |     |
|-----------------------------------|-----|
| ...Process controller             |     |
| P-0-1273 .....                    | 216 |
| P-0-1274 .....                    | 216 |
| P-0-1275 .....                    | 217 |
| P-0-1276 .....                    | 217 |
| P-0-1316 .....                    | 217 |
| P-0-1317 .....                    | 218 |
| P-0-1318 .....                    | 218 |
| P-0-1319 .....                    | 218 |
| P-0-1320 .....                    | 219 |
| P-0-1321 .....                    | 219 |
| P-0-1322 .....                    | 220 |
| P-0-1323 .....                    | 220 |
| P-0-1325 .....                    | 220 |
| P-0-1326 .....                    | 221 |
| P-0-1327 .....                    | 221 |
| P-0-1328 .....                    | 221 |
| P-0-1329 .....                    | 222 |
| P-0-1330 .....                    | 222 |
| P-0-1370 .....                    | 223 |
| P-0-1371 .....                    | 224 |
| P-0-1372 .....                    | 224 |
| P-0-1373 .....                    | 224 |
| P-0-1374 .....                    | 224 |
| P-0-1375 .....                    | 225 |
| P-0-1377 .....                    | 225 |
| P-0-1378 .....                    | 225 |
| P-0-1380 .....                    | 226 |
| P-0-1381 .....                    | 226 |
| P-0-1382 .....                    | 227 |
| P-0-1384 .....                    | 227 |
| P-0-1385 .....                    | 227 |
| P-0-1390 .....                    | 212 |
| P-0-1410 .....                    | 213 |
| P-0-1411 .....                    | 214 |
| Protective extra-low voltage..... | 25  |

**R**

|                                          |    |
|------------------------------------------|----|
| Reference curve recording: See Reference |    |
| measurement.....                         | 44 |
| Required components.....                 | 12 |

**S**

|                                             |     |
|---------------------------------------------|-----|
| Safety instructions for electric drives and |     |
| controls.....                               | 21  |
| State-of-the-art.....                       | 31  |
| Support                                     |     |
| See service hotline .....                   | 229 |

**T**

|                                           |    |
|-------------------------------------------|----|
| Type codes.....                           | 18 |
| Type codes and overview of functions..... | 18 |

## U

### Use

|                         |    |
|-------------------------|----|
| Appropriate use .....   | 31 |
| Inappropriate use ..... | 32 |

## V

### Vibration avoiding

|                                                             |     |
|-------------------------------------------------------------|-----|
| Configuration and operation by means of<br>IndraWorks ..... | 151 |
|-------------------------------------------------------------|-----|

### Vibration damping

|                                                             |     |
|-------------------------------------------------------------|-----|
| Configuration and operation by means of<br>IndraWorks ..... | 158 |
|-------------------------------------------------------------|-----|

### Vibration damping and avoiding

|                                                  |          |
|--------------------------------------------------|----------|
| Configuration and operation via parameters ..... | 154, 169 |
| Diagnostic and status messages .....             | 173      |
| P-0-1272 .....                                   | 174      |
| P-0-1273 .....                                   | 174      |
| P-0-1277 .....                                   | 174      |
| P-0-1278 .....                                   | 174      |
| P-0-1279 .....                                   | 175      |
| P-0-1300 .....                                   | 175      |
| P-0-1301 .....                                   | 175      |
| P-0-1316 .....                                   | 175      |
| P-0-1317 .....                                   | 176      |
| P-0-1318 .....                                   | 176      |
| P-0-1319 .....                                   | 176      |

## V

### ...Vibration damping and avoiding

|                |     |
|----------------|-----|
| P-0-1320 ..... | 177 |
| P-0-1321 ..... | 177 |
| P-0-1324 ..... | 178 |
| P-0-1325 ..... | 178 |
| P-0-1326 ..... | 178 |
| P-0-1327 ..... | 179 |
| P-0-1328 ..... | 179 |
| P-0-1329 ..... | 179 |
| P-0-1330 ..... | 180 |
| P-0-1331 ..... | 180 |
| P-0-1370 ..... | 180 |
| P-0-1371 ..... | 182 |
| P-0-1372 ..... | 182 |
| P-0-1373 ..... | 183 |
| P-0-1374 ..... | 183 |
| P-0-1375 ..... | 183 |
| P-0-1376 ..... | 184 |
| P-0-1377 ..... | 184 |
| P-0-1378 ..... | 184 |
| P-0-1379 ..... | 185 |
| P-0-1380 ..... | 185 |
| P-0-1381 ..... | 185 |
| P-0-1382 ..... | 186 |
| P-0-1383 ..... | 186 |
| P-0-1387 ..... | 186 |
| P-0-1410 ..... | 187 |



## Notes

Bosch Rexroth AG  
Electric Drives and Controls  
P.O. Box 13 57  
97803 Lohr, Germany  
Bgm.-Dr.-Nebel-Str. 2  
97816 Lohr, Germany  
Tel. +49 9352 18 0  
Fax +49 9352 18 8400  
[www.boschrexroth.com/electrics](http://www.boschrexroth.com/electrics)



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