Application Manual
AC Servo Controller YukonDrive®

Harmonic Drive AG

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Content

The modularity of the YukonDrive® family ensures optimum integration of the servo axis into the machine process. Whether in high speed field bus communication with a central machine controller or with distributed motion control intelligence in the servo controller – the YukonDrive® is a master of both.

We reserve the right to make technical changes.

The content of our Operation Manual was compiled with the greatest care and attention, and based on the latest information available to us.

We should nevertheless point out that this document cannot always be updated in line with ongoing technical developments in our products.

Information and specifications may be subject to change at any time. Please visit www.harmonicdrive.de for details of the latest versions.

1. Power stage

1.1 Setting the power stage parameters

The YukonDrive® can be operated with different voltages and switching frequencies for the power stage. To operate the controller generally, the power stage must be adapted to the local voltage conditions. It must be ensured that the switching frequencies and voltage match.

DM5 setup screen

Illustration 5.1 Power stage screen

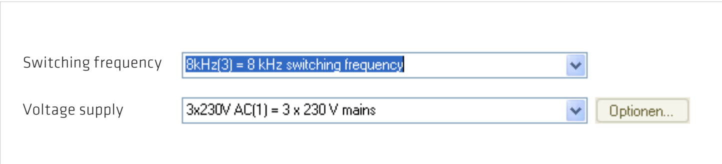


Table 5.2 Parameter table

P. no.	Parameter name/ settings	Designation in DM5	Description
P 0302	CON_SwitchFreq	Switching frequency	Power stage switching frequency setting..
	2 kHz - 16 kHz (dependent on device)	Switching frequency	It is advisable to operate the drive controller with the default setting. Increasing the switching frequency can be useful to improve the control dynamism. Temperature-related derating may occur. Switching frequency noise decreases as the switching frequency rises (audible range < 12 kHz)..
P 0307	CON_ VoltageSupply	Voltage supply mode	Adaptation to the voltage conditions
	1x 230 V(0)	Votage supply mode	Adjustable voltage range
	3x 230 V(1)		
	3x 400 V(2)		
	3x 460 V(3)		
	3x480 V(4)		
	Safety low voltage(5)		

Mains supply
During initial commissioning the mains voltage setting must first be checked and adjusted as necessary via parameter **P 0307 CON_VoltageSupply**. The combination of voltage value and switching frequency corresponds to a stored power stage data set.

⚠

Attention!
Any changes to parameters must be saved in the device. The setting is only applied on the device after a power off/on cycle.
If the power stage parameters are changed, the rated currents, overload values and braking chopper thresholds may also change.

Switching frequency
As another power stage parameter, the switching frequency can also be set via **P 0302 CON_SwitchFreq**. It is advisable to operate the drive controller with the default setting.
Increasing the switching frequency can be useful to improve the control dynamism. Temperature-related derating may occur. Switching frequency noise decreases as the switching frequency rises (audible range < 12 kHz). For an overview of the currents dependent on the switching frequency refer to the Operation Manual.

2. Motor
In general, permanently excited synchronous motors can be driven as well as asynchronous motors. In the case of motors from third-party manufacturers, basic suitability for operation with Harmonic Drive® controllers must be verified on the basis of the motor data and the data of any installed encoder. The values of the parameters for adaptation of the control device must be determined specifically for each motor by Calculation or Identification. The difference between the two methods is that when calculating a motor data set the impedances must be taken from the data sheet. The electrical data is determined automatically during identification.

Designs:

- Rotary motors
- Linear motors

To start up a system quickly and easily and attain good overall performance, we recommend using Harmonic Drive® standard motors and encoders from the catalogue.

Note:
In order to simplify the commissioning, the controllers YukonDrive® are already set up for the specific actuator ordered prior to delivery. There is no necessity to change any parameters in the subject fields of motor and encoder.

Note:
Each motor can only be operated if its field model and the control parameters are correctly set.

Note:
Appendix B "Quick Commissioning" at the end of the Application Manual presents a short commissioning guide for rotary and linear drive systems respectively.

2.1 Loading motor data

You can obtain the data sets of all Harmonic Drive® standard motors from the website. Using the right motor data set ensures that

- the electrical data of the motor is known;
- the motor protection is correctly set;
- the control circuits of the drive are preset;
- the torque controller is optimally set, so no further adaptations are required for test running of the motor.

2.1.1 Motor selection

- Selection of the desired motor data set via Motor selection (possibly Harmonic Drive AG website). All necessary parameters (e.g motor protection, control parameters) are read-in.
- With the motor selection, the complete motor data set (name, parameter, motion mode) is loaded. Preset parameters are overwritten.
- Motor data must be saved in the device.

Note:
Note that the encoder data must be set manually or loaded as an encoder data set (see sections 3 and 4).

2.2 Data sets for third-party motors

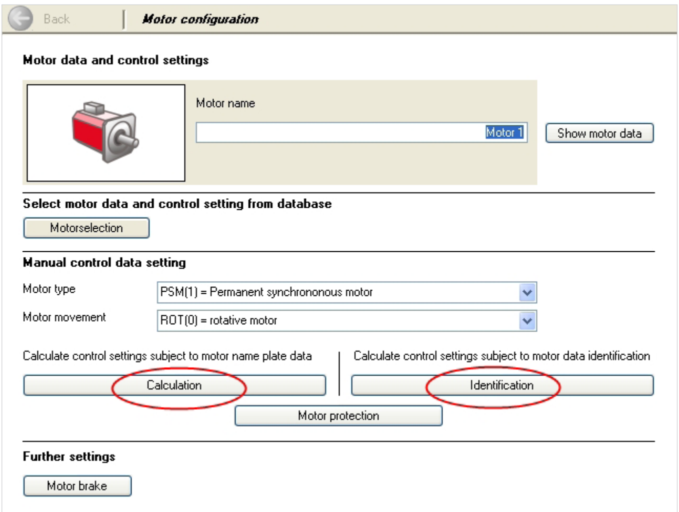
In the case of motors from third-party manufacturers, basic suitability for operation with Harmonic Drive AG controllers must first be verified on the basis of the motor data and the data of any installed encoder. The values of the parameters for adaptation of the control device must be determined specifically for each motor by Calculation or Identification. Each motor can only be operated if its field model and the control parameters are correctly set.

2.2.1 Determining the data set for a rotary synchronous machine

There are two methods of determining the motor data set for a rotary synchronous motor. The first method is identification; the second is calculation. The differences are explained in the following section.

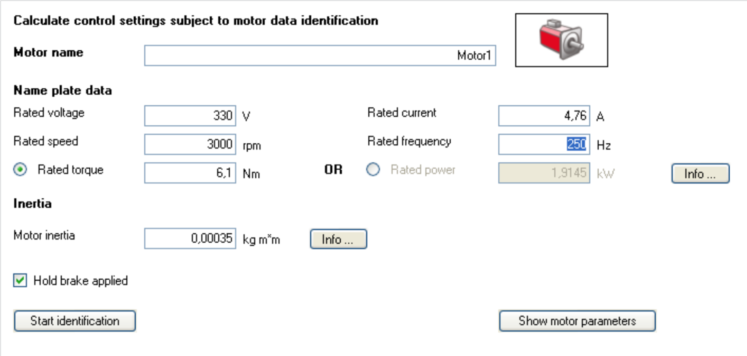
Motor Data Set

Illustration 7.1 Motor data, rotary system



Identification

Illustration 8.1   Indetification of Motor data



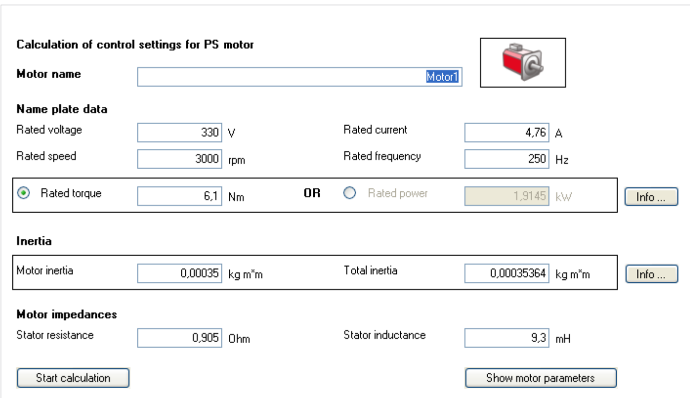
- Enter motor data
- Click the “Start identification” button

This initiates:

- Current controller tuning: The current controller is automatically optimized.
- The motor impedances are automatically measured.
- Calculation of operating point
- Calculation of: current, speed and position control parameters
- V/F characteristic (boost voltage, rated voltage, rated frequency)

Note:
To start identification, the hardware enables “ENPO”, “ISDSH” must be switched and the DC link voltage must be present. The identification may take a few minutes.

Illustration 8.2   Calculation of Motor data



- Click the “Calculation” button. The motor data relevant to the calculation must be entered manually from the data sheet.
- Click the “Start calculation” button.

This initiates:

- Current controller tuning: The current controller is automatically optimized.
- Calculation of operating point
- Calculation of: current, speed and position control parameters
- V/F characteristic (boost voltage, rated voltage, rated frequency)

Attention!
All previous speed and position control parameters are overwritten.

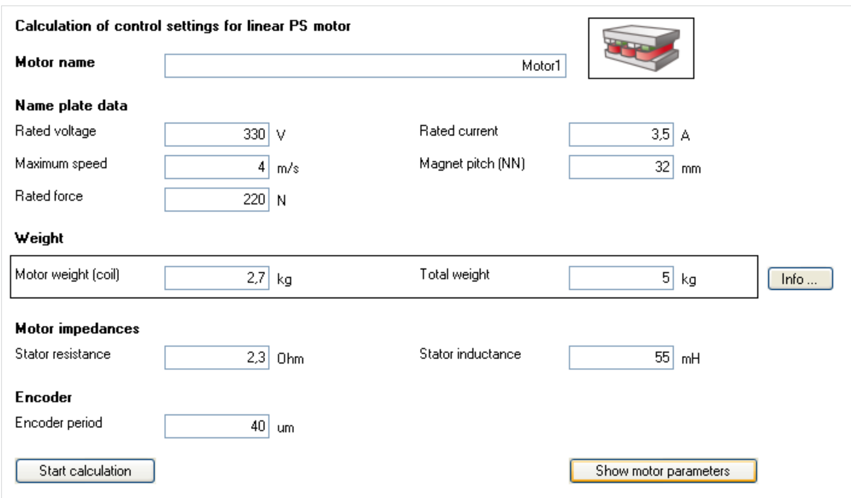
Recommended:
It is advisable to use **motor identification** to determine the motor data. The motor impedances do not need to be known for this, as they are measured in this procedure. If motor identification fails, or if the motor is physically not present, motor calculation provides an additional method of determining the motor data set.

2.3 Linearmotor

The motor data of a PS linear motor is always determined by calculation. To make the calculations based on the characteristic quantities for a linear motor, **P 0490 = LIN(1)** the parameter automatically sets the number of pole pairs for the motor to **P 0463 = 1**. As a result, a North to North pole pitch corresponds to one virtual revolution **P 0492**.

PS Linear motor

Illustration 9.1 PS Linear motor screen



The following values are calculated:

- Translation of the linear nominal quantities into virtual rotary nominal quantities
- Default values for autocommutation
- Encoder lines per virtual revolution
- Calculation of: current, speed and position control parameters
- The default value for speed tracking error monitoring corresponds to 50 % of the nominal speed.
- V/F characteristic (boost voltage, rated voltage, rated frequency

Table 10.1 Parameters linear motor

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0490	MOT_IsLinMot -> LIN (1)	Selection if linear or rotatory motor data are valid	Selection for rotary or linear motor
P 0450	MOT_Type -> PSM	Motortype	Motor typ
P 0451	MOT_Name [1)]	Motorname	Motor name
P 0457	MOT_CNom [2)]	Motor rated current	Rated current
P 0492	MOT_MagnetPitch [2)]	Width of one motor pole (NN)	Pole pitch (NN)
P 0493	MOT_SpeedMax [2)]	Maximum (nominal) motor speed	Maximum speed
P 0494	MOT_ForceNom [2)]	Nominal force of motor	Rated force
P 0496	MOT_MassMotor [2)]	Mass of motor slide	Mass of motor carriages
P 0497	MOT_MassSum [2)]	Mass of total mass, moved by the motor	Total mass to be moved
P 0498	MOT_EncoderPeriod [2])	Period of line signals	Encoder signal period
P 0470	MOT_Lsig [2)]	Motor stray/stator inductance	Primary section inductance
P 0471	MOT_Rstat [2]	Motor stator resistance	Stator resistance

[1)] The parameters are only of informative nature, but should be set for a complete motor data set.

[2)] The parameters are used for calculation of controller settings, and have a direct effect on the response of the servocontroller..

Attention!
The parameters of the encoder used must be set manually as per the “Encoder” section or be read from the encoder database.

2.4 Asynchronous motor

2.4.1 Electrical Data

For commissioning of third-party motors, the rated data and characteristic variables of the motor must be known and be entered manually in the relevant screen. Click the Identification button to calculate the basic setting for the control based on those values. The impedances (stator and stray impedances) are obtained by measurement.
If the identification is successful, the torque control is adequately configured. An adjustment to the machine mechanism and to the motion profile is also required.

- Enter motor data
- Click the „Start identification" button

Illustration 11.1 Motor identification

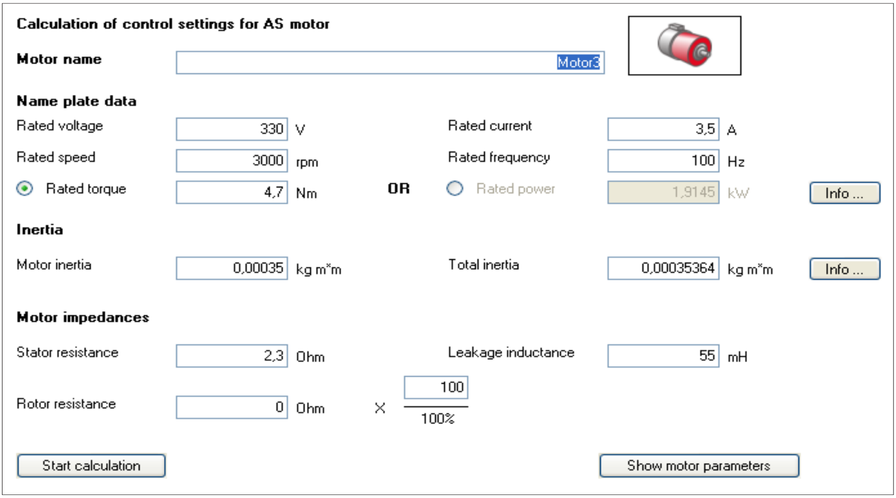


Illustration 11.2 Electrical data of the asynchronous machine

Table 12.1

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0490	MOT_IsLinMot -> ROT (0)	Motor selection	Selection for rotary or linear motor
P 0451	MOT_Type	Motor type	Motor type
P 0451	MOT_Name [1)]	Motor name	Motor name
P 0452	MOT_CosPhi [2)]	Cos phi	
P 0455	MOT_FNom [2)]	Motor nominal frequency	
P 0456	MOT_VNom [2)]	Motor rated voltage	
P 0457	MOT_CNom [2)]	Motor rated current	Rated current
P 0458	MOT_SNom [2)]	Motor rated speed	
P 0459	MOT_PNomv [2)]	Rated motor power	
P 0460	MOT_TNom [2)]	Motor rated torque	
P 0461	MOT_J [2)]	Motor mass inertia	
P 0470	MOT_Rstat [2)]	Stator resistance	Primary section inductance
P 0471	MOT_Lsig [2]	Stator resistance	Secondary section inductance
P 0478	MOT_LmagNom	Nominal inductance	Display of actual nominal inductance. This value is taken from table P 0473, and relates to the preset magnetizing current P 0340.
P 0492	MOT_MagnetPitch [2])	Pole pitch (NN)	
P 0493	MOT_SpeedMax [2)]	Maximum speed	
P 0494	MOT_ForceNom [2)]	Rated force	
P 0496	MOT_MassMotor [2)]	Mass of motor carriage	
P 0497	MOT_MassSum [2)]	Total mass to be moved	
P 0498	MOT_EncoderPeriod [2])	Encoder signal period	

[1)] The parameters are only of informative nature, but should be set for a complete motor data set.

[2)] The parameters are used for calculation of controller settings, and have a direct effect on the response of the servocontroller.

This initiates:

- Current controller tuning: The current controller is automatically optimized.
- The motor impedances are automatically measured.
- Calculation of operating point
- Calculation of: current, speed and position control parameters
- V/F characteristic (boost voltage, rated voltage, rated frequency)

Note:
To start identification, the hardware enables “ENPO”, “ISDSH” must be switched and the DC link voltage must be present. The identification may take a few minutes.

Attention!
All existing motor parameters are overwritten.

2.4.2 Saturation characteristic for main inductance

The main inductance is frequently determined inaccurately, in particular for higher-powered motors. An improvement of this value can be achieved at high speed, with no load on the machine if possible, by way of a measurement process.

Procedure:

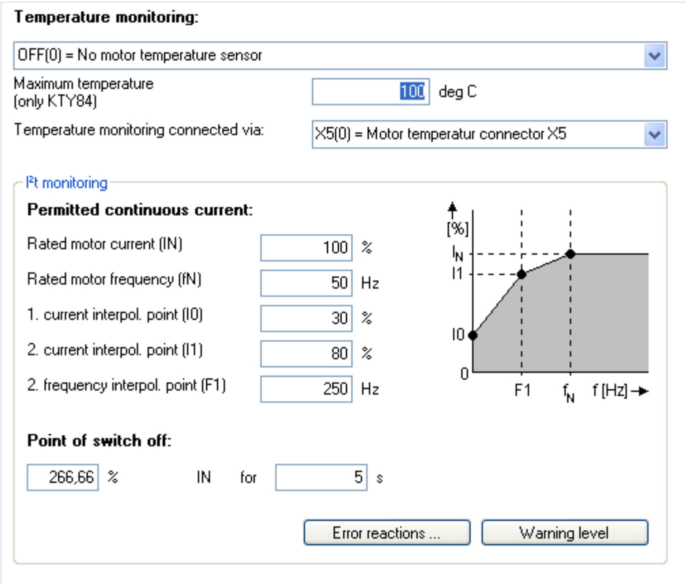
- Run motor at 50 - 90 % nominal speed (e.g. via “Manual Mode“)
- Tuning is started when **P 1531 Tune Lmag chracteristics = 4**
- Sequence: **The main inductance is determined with varying magnetization.**
- The results are written to parameters **P 0473 MOT_LmagTab, P 0474 MOT_LmagIdMax**.

The operating point is recalculated.

Temperature monitor setting

The device can evaluate different temperature sensors. With **P 0732** the sensor fitted in the motor and the wiring variant are set (sensor cable routed in resolver or separate). In an evaluation via KTY, the shut-off threshold of the motor temperature can additionally be set.

Illustration 14.1 Temperature monitor setting



Parameters for temperature monitor setting:

- P 0732(0) selects the matching motor temperature sensor
- P 0732(1) selects the matching wiring variant
- P 0731(0) If thermal protection is implemented by way of a KTY, the trigger temperature is set via this parameter.
- P 0734(0) is the actual value parameter for the momentary motor temperature. The readout is only active when a KTY is used. When using a PTC, PTC1 or TSS, monitoring is active, but the momentary temperature value is not displayed. The actual value is displayed as 0.

Illustration 15.1 Temperature monitor setting

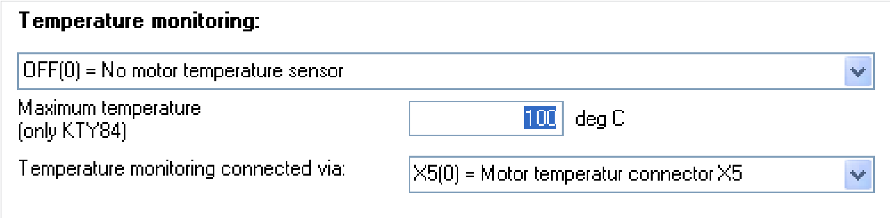


Table 15.2

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0731	MON_MotorTemMax_	max. motor temperature, switch off value	Shut-off threshold for KTY
0	0-1000	-	Default setting: 100 °C
P 0732	MON_MotorPTC	Select motor temperature sensor	Selection of sensor type
(0)	OFF(0)	No sensor	No evaluation
	KTY(1)	KTY84-130 sensor	KTY84-130[1]
	PTC(2)	PTC with short circuit proof	PTC as per DIN 44081 with short-circuit monitoring
	TSS(3)	Switch (Klixon)	Klixon switch
	PTC1(4)	PTC1 without short circuit proof	PTC as per DIN 44081 without short-circuit monitoring
	Not used(5)		
	Not used (6)		
	Not used (7)		
	Not used (8)		
(1)	contact	Sensor connection	Connection variant
	X5(0)	Motortemperatur connector X5	Connection of the sensor to terminal X5
	X6/X7(1)	Via Resolver connector X6 or sincos connector X7[1)]	Sensor connection is routed in encoder cable
P 0733	MON_MotorI2t	Motor I2t protection parameters	I^2t characteristic setting
(0)	I_{nom}	Rated current FNom	Rated current of the motor
(1)	I_0	Rated current (0 Hz)	First current interpolation point of motor protection characteristic: Maximum permissible standstill current
(2)	I_1	Rated current (f1)	Second current interpolation point of motor protection characteristic referred to maximum characteristic current

Table 16.1

P. no.	Parameter name/ settings	Designation in DM5	Function
(3)	f_1	Interpolation point-only ASM	First frequency interpolation point of motor protection characteristic
(4)	f_N	Nominal frequenzy	Rated frequency
(5)	I_{max}	Motor maximum currrent	Max. overload current referred to rated motor current
(6)	t_{max}	Motor maximum currrent	Overload time t_{max} at I_{max}

[1)] With the YukonDrive® the temperature sensor cable can be connected to both X6 and X7. The temperature sensors must be equipped with basic insulation when connected to X5 and with reinforced insulation according to EN 61800-5-1 when connected to X6 or X7!

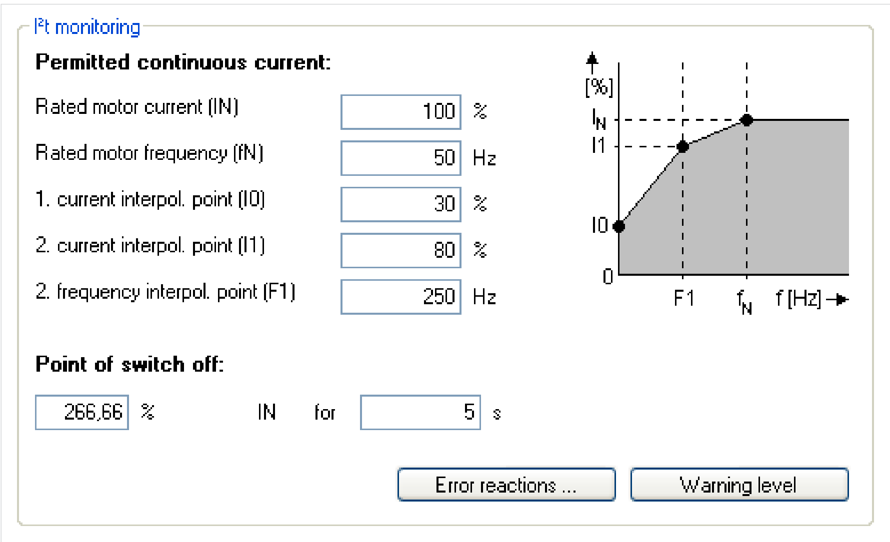
Current/time monitoring by the I²xt-characteristic

The I²xt monitor protects the motor against overheating throughout the speed range. When set correctly, the I²xt monitor replaces a motor circuit-breaker. The characteristic can be adapted to the operating conditions by way of the interpolation points.

Characteristic setting for an asynchronous motor (ASM)

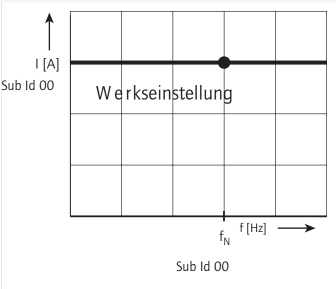
The following diagram shows a typical characteristic setting for an internally cooled asynchronous machine. For third-party motors the motor manufacturer's specifications apply.

Illustration 16.2 I²xt protection ASM



It is necessary to adapt the I²t characteristic because the factory settings mostly do not exactly map the current motor. The difference between factory setting and the characteristic configured above is shown in the following illustration.

Illustration 17.1 left: Constant characteristic / Illustration right: Characteristic with interpolation points



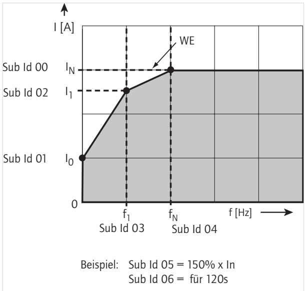


Table 17.2

Frequency	Motor current
f_0 = 0 Hz	I_0 = 30% von I_N
f_1 = 25 Hz	I_1 = 80% von I_N
f_N = 50 Hz	I_N = 100%

The shut-off point to VDE 0530 for IEC asynchronous standard motors is

150 % x IN for 120 s.

For servomotors, it is advisable to set a constant characteristic. The switch-off point defines the permissible current-time area up to switching off.

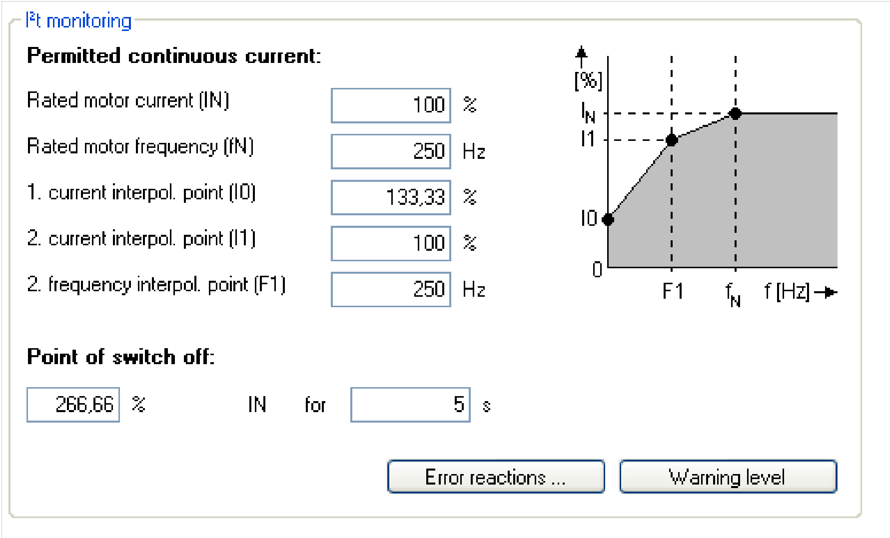
Note:
For servomotors, always refer to the motor manufacturers' specifications.

Note:
The limits are specified in the servocontroller as percentages of the rated quantities (e.g. current, torque, speed,...), so that following calculation logical default settings are available. The default settings refer to 100% of the rated values and the parameters must thus be adapted to application and motor.

Characteristic setting for a synchronous motor (PSM)

A synchronous motor by design has lower loss than the ASMs (because permanent magnets replace the magnetizing current). It is normally not internally cooled, but discharges its heat loss by internal convection. For that reason it has a different characteristic to an asynchronous motor. The following diagram shows a typical setting for the permanently excited synchronous machine.

Illustration 18.1 I²xt protection PSM



It is necessary to adapt the I²xt characteristic because the factory settings mostly do not exactly map the current motor. The difference between factory setting and the characteristic configured above is shown in the following illustration.

Illustration 18.2 Characteristic of PSM

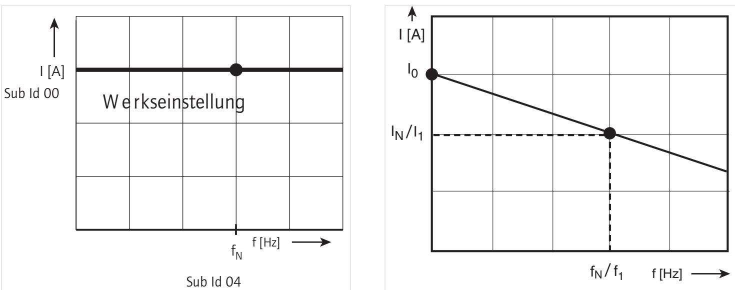


Table 19.1

Frequency	Motor current
f_0 = 0 Hz	I_0 = 133,33 % von I_N
f_1 = 250 Hz	I_1 = 100 % von I_N
f_N = 250 Hz	I_N = 100 %

If the integrator exceeds its limit value, the error **E-09-01** is triggered. The current value of the integrator is indicated in parameter **P 0701 (0)**.

3. Encoder

A range of encoder variants are available to measure the position and speed. The encoder interfaces can be flexibly selected for a specific application.

Selection of encoder channels (CH1, CH2, CH3)

Up to three encoder channels can be evaluated at a time. The evaluation is made via connectors X6 and X7. They are part of the controller's standard on-board configuration. A third channel X8 can be ordered as an optional encoder input.
The screen (illustration 20.1) is used to set the encoders for torque, speed and the position.

Determining the encoder offset

The „Encoder offset/Detect" option accesses a wizard to define the current encoder offset. For the definition the motor is run in „Current control" mode. For a correct definition it is necessary for the motor to be able to align itself freely.

Attention!
The motor shaft must be able to move.

A connected brake is automatically vented, if connected to the brake output. The process takes about 10 seconds. Then the current value of the offset is entered in the display field and the original parameter setting is restored.

Note:
For servo actuators from Harmonic Drive AG, an encoder offset detection is only necessary for actuators for hybrid motor feedback systems and analogue resolution < 128 SIN/COS periods (for example with encoder ordering code -MKE or -SIE.

Note:
For servo actuators of the FHA-C-mini series, the use of the technology option "TTL encoder with commutation signals" is recommended. For encoder input, X8 has to be used.

Interfaces between encoder and control

Illustration 20.1 Interface configuration between encoder channels and control

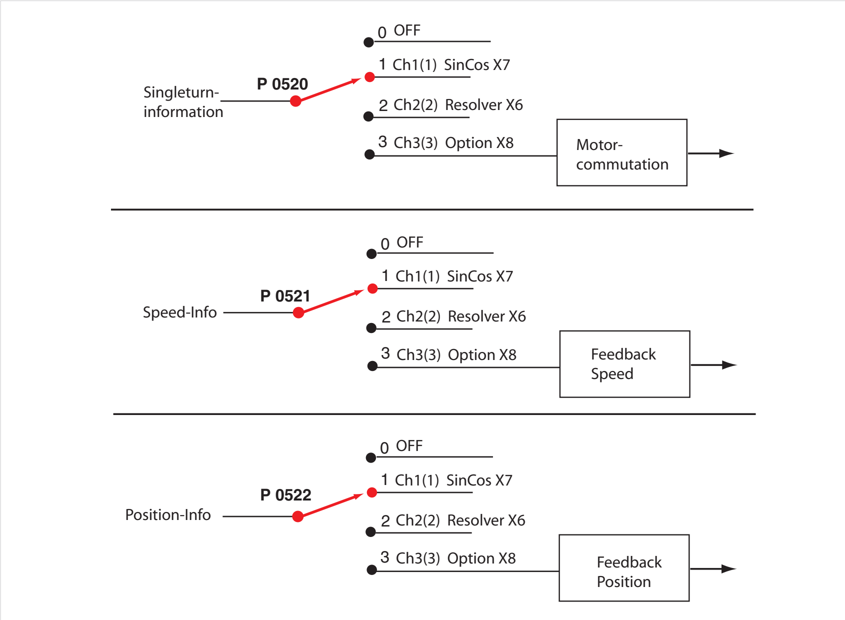
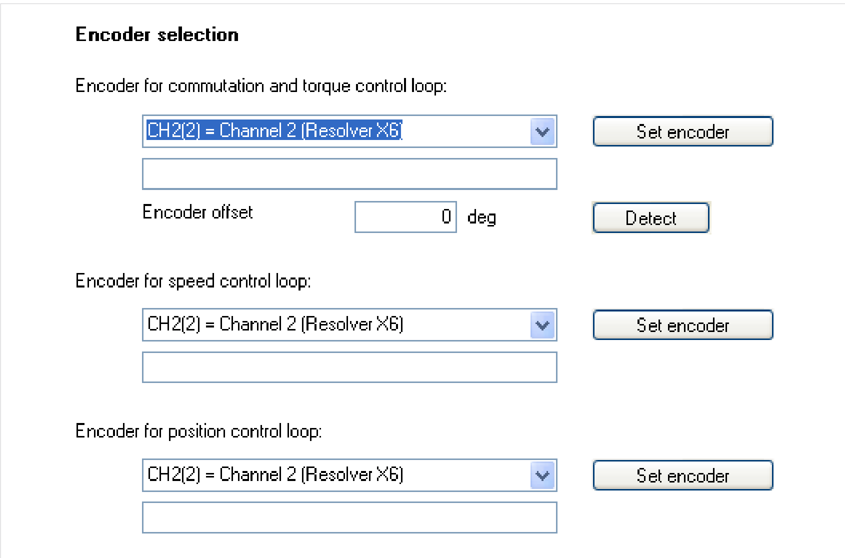


Illustration 20.2 Screen for setting the encoder channel



Assignment of encoder information to control

Table 21.1 Assignment of encoder information to control

P. no.	Parameter name/ settings	Description in DM5	Function
P 0520	ENC_MCon	Encoder: Channel Select for Motor Commutation	Selection of encoder channel for commutation angle (feedback signal for field oriented control)
P 0521	ENC_SCon	Encoder: Channel Select for Speed Control	Selection of encoder channel for speed configuration (feedback signal for speed control)
P 0522	ENC_PCon	Encoder: Channel Select for Position Control	Selection of encoder channel for position information (feedback signal for position control)
		Parameter setting applies to P 0520, P 0521, P 0522	
(0)	Off	No encoder selected	No function
(1)	Channel 1	For SinCos Encoder to X7	Channel 1 SinCos X7
(2)	Channel 2	For resolver to X6	Channel 2 Resolver X6
(3)	Channel 3	For SinCos-, SSI-, TLL-Encoder	Channel 3 Option X8

Note:
When an encoder channel is selected and an encoder physically connected to the controller, the wire break detector is automatically activated.

3.1 SinCos X7 (channel 1)
Encoder channel 1 is used for evaluation of high-resolution encoders. The following encoders are supported:

Incremental encoders:
- SinCos
- TTL

Absolute encoders with digital interface:
- Hiperface
- SSI
- EnDat (only with SinCos signals)
- EnDat 2.2 (full digitall)
- Purely digital SSI encoders (without SinCos signals)

Note:
When using incremental TTL encoders on channel 1, there is no interpolation over time between the TTL lines. The combined method (pulse count, time measurement) is only available on channel 3 for TTL encoders.The signal resolution over one track signal period is 12-bit in the case of multi-turn and 13-bit in the case of single-turn.

Illustration 22.1 Screen for setting channel 1

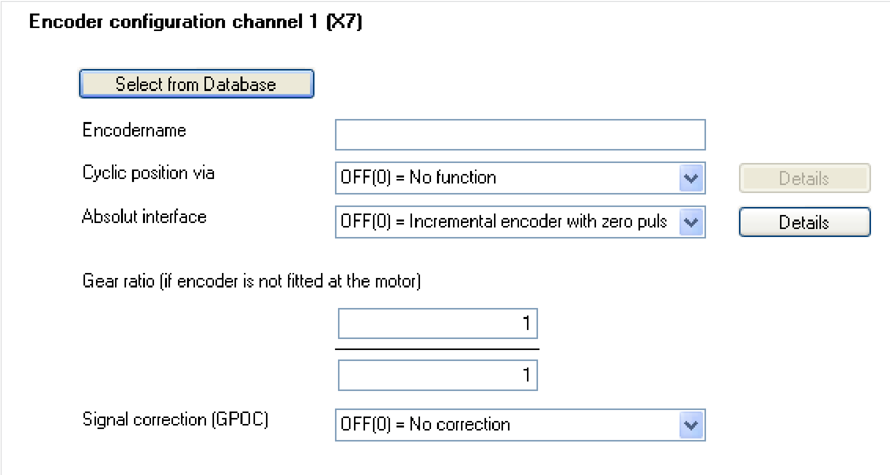


Illustration 22.2 Encoder configuration based on example of channel 1

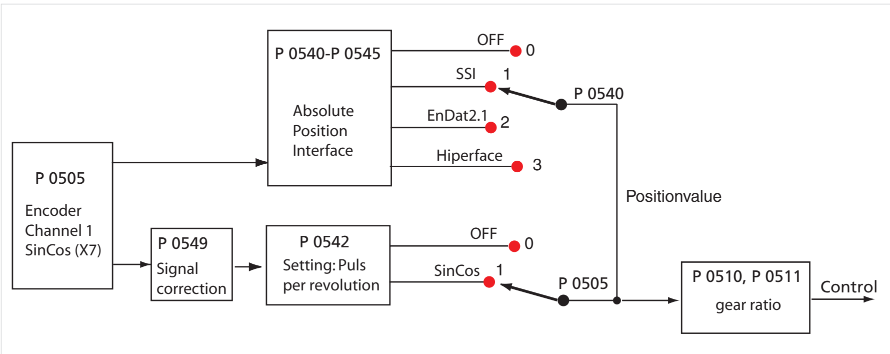


Table 23.1 Overview of parameters for channel 1

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0505	ENC_CH1_Sel	Encoder Channel 1: Select	Configuration of the incremental interface
(0)	OFF	„	No evaluation
(1)	SinCos	„	High-resolution SinCos encoder with fine interpolation
(2)	SSI	„	Purely digital encoder via serial communication
(3)	TTL	„	
P 0542	ENC_CH1_Lines	Encoder Channel 1: Number of Lines SinCos-Encoder	Setting of the incremental number of lines. For encoders with EnDat2.1 and Hiperface protocols the lines per revolution are read out of the encoder and automatically parameterized (1-65535).
	1 - 65535		
P 0540	ENC_CH1_Abs	Encoder Channel 1: Absolute Position Interface	Determining the protocol type: When starting the device and after changing the encoder parameters, the absolute position of an incremental measuring system is read out via a digital interface.
(0)	OFF	„	Purely incremental encoder without absolute value information
(1)	SSI	„	Serial communication to Heidenhain SSI protocol
(2)	EnDat2.1	„	Heidenhain EnDat 2.1 protocol
(3)	Hiperface	„	Stegmann-Hiperface protocoll
P 0541	ENC_CH1_Np	Encoder Channel 1: Index Pulse Test-Mode	Zero pulse evaluation
P 0542	ENC_CH1_Lines	Encoder Channel : Number of Lines SinCos-Encoder	Setting of the incremental number of lines. For encoders with EnDat2.1 and Hiperface protocols the lines per revolution are read out of the encoder and automatically parameterized.
P 0543	ENC_CH1_MultiT	Encoder Channel 1: Number of MultiTurn Bits	Multiturn: Bit width setting
P 0544	ENC_CH1_SingleT	Encoder Channel 1: Number of SingleTurn Bits	Singleturn: Bit width setting
P 0545	ENC_CH1_Code	Encoder Channel 1: Code Select	Selection of coding: Gray/binary

3.1.1 Zero pulse evaluation via encoder channel 1

The zero pulse evaluation via encoder channel CH1 is only set "active" for SinCos encoders with no absolute value interface.

Setting:
P 0505 ENC_CH1_Sel (setting „SinCos encoder")
P 0540 ENC_CH1_Abs (setting „OFF": Incremental encoder with zero pulse):

- Sin/Cos encoders only ever output a zero pulse when no absolute value interface is present.
- TTL encoders always have a zero pulse.
- Resolvers output no zero pulse..

Zero pulse evaluation only works by selecting the intended homing types (see „Homing" in „Motion profile" section).

Test mode for zero pulse detection

Test mode is activated by parameter **P 0541 ENC_CH1_Np =1**. Encoder initialization is triggered manually by **P 0149 MPRO_DRVCOM_Init =1**. Homing runs can also be carried out during test mode.
When homing is completed, or if an error has occurred, detection is aborted even though parameter **P 0541 = 1**. To reactivate test mode, parameter **P 0541** must be reset from 0 to 1 and re-initialized.
To view the zero pulse with the scope function, the variable **CH1-np-2** (index pulse length 1 ms) can be recorded on the digital scope.

⚠

Attention!
The pulse width of the scope signal does not match the pulse width of the actual zero pulse. The representation on the scope appears wider (1 ms when using variable CH1-np-2), enabling better detection of the zero pulse. The decisive factor here is the rising edge of the scope signal.

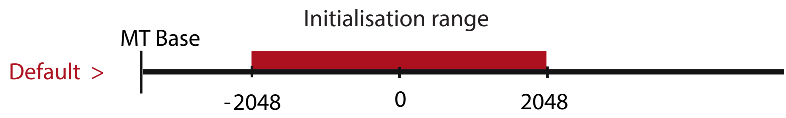
3.1.2 Overflow shift in multiturn range

With this function the multiturn range can be shifted in absolute value initialization so that no unwanted overflow can occur within the travel. The function is available for encoder channels 1 and 3.

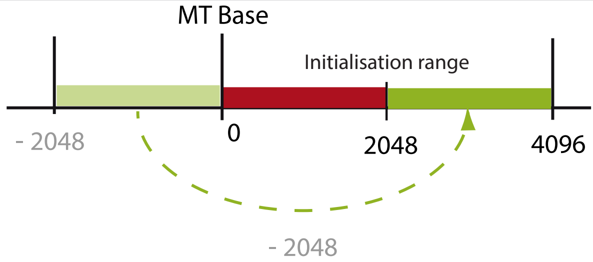
Table 24.1 Parameters:

P. no.	Parameter name/ settings	Description in DM5	Function
P 0547	ENC_CH1_MTBase	ENC CH1	Input of multiturn position "MTBase" in revolutions incl. gearing for channel_1
P 0584	ENC_CH3_MTBase	ENC CH3	Input of multiturn position "MTBase" in revolutions incl. gearing for channel_3

Illustration 25.1 Overflow shift into the multiturn range



Example: If a portion of the travel distance is to the left of the threshold (MT Base), it is appended to the end of the travel range (to the right of the 2048) via parameter P 0547 ENC_CH1 for encoder channel 1 or P 0584 ENC_CH3 for encoder channel 3; unit: encoder revolutions incl. gearing).



3.1.3 Use of a multiturn encoder as a singleturn encoder

By way of parameters P 0548 ENC_CH1_MTEnable = 1 and P 0585 ENC_CH3_MTEnable = 1 a multiturn encoder can be run as a singleturn encoder.

3.1.4 Encoder correction (GPOC)

For each **channel** the correction method GPOC (Gain Phase Offset Correction) can be activated for the analog track signals. This enables the mean systematic gain, phase and offset errors to be detected and corrected. GPOC weights the amplitude of the complex pointer described by the track signals by special correlation methods. The dominant errors can thereby be determined very precisely, with no interference from other encoder errors, and then corrected. There are two GPOC variants to use. Track signal correction can be used with stored values (CORR) or with online tracked values (ADAPT). Where multiple encoders are in use, it is advisable to apply the method for the encoder used to determine the speed signal.

Table 26.1 Parameters

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0549 P 0561	ENC_CH1/2_Corr	Encoder Channel 1/2: Signal Correction	Selection of correction method
0	OFF	No reaction	No method
1	CORR	Correction with saved values	Activate correction with stored values
2	ADAPT	Auto correction	Auto correction
3	RESET	Reset correction values	Reset values
P 0550, P 0562	ENC_CH1/ 2_CorrVal	Encoder Channel 1/2: Signal Correction Values	Signal correction
0	Offset A	Offset, track A	Defined offset of track signal A
1	Offset B	Offset, track B	Defined offset of track signal B
2	Gain A	Gain track A	Determined gain correction factor for track signal A
3	Gain B	Gain track B	Defined gain correction factor for track signal B
4	Phase	Phase	Calculated phase correction between track signals A and B

Carrying out encoder correction:

- Open the open-loop control window and set speed-controlled mode.
- Set the optimization speed:
  Resolver: approx. 1000 to 3000 rpm
  SinCos encoder: approx. 1 to 5 rpm
- Adjust scope: Plot actual speed value
- Switch to „ADAPT“ during operation and wait about 1-3 minutes for the compen sation algorithms to reach their steady state. The speed ripple should decrease after about 1 minute (observed with scope).
- Apply setting and save secure against mains power failure.
- 1. Procedure: Access the stored values with „CORR“ or
- 2. Procedure: Use current correction values with „ADAPT“
- With the „Reset“ setting the values are restored to their factory defaults.

Note:
The setting made with „ADAPT“ applies only to the motor with which the function was executed. If the motor is replaced by another of the same type, this method must be applied again.

3.2 Resolver X6 (channel 2)

Channel 2 evaluates the resolver.

Functions of encoder channel 2: A 12-bit fine interpolation over one track signal period takes place. The pole pairs are set via **P 0560 ENC_CH2_Lines**.

Use of a SinCos encoder / Hall sensor via encoder channel 2

By way of resolver input X6 a low-track (up to 128 lines) SinCos encoder or Hall sensor can be evaluated. Points to note:

- The interface assignment in this case is different to that for the resolver (section 3.6, Pin assignment).
- Resolver excitation must be disabled via parameter P 0506 ENC_CH2_Sel = 2 „SINCOS".
- Analog Hall sensors with 90° offset sinusoidal signals are supported (corresponding to a low-track SinCos encoder).

Illustration 27.1 Screen for setting channel 2

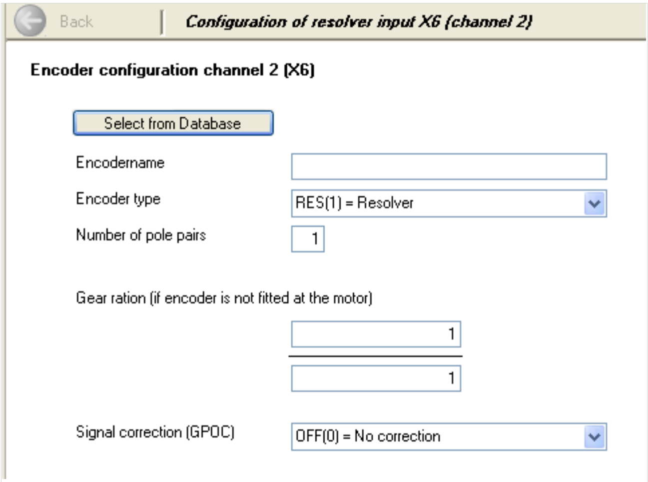


Table 28.1

P. no.	Parameter name/ Settings	Description in DM5	Function
P 0564	ENC_CH2_Info	Encoder information ch2	Encoder-name
P 0506	ENC_CH2_Sel	Encoder Channel 2: Select	Interface configuration
	OFF (0)		No evaluation
	RES (1)		Resolver evaluation
	SinCos(2)		Resolver excitation shut-off; evalu-ation of a SinCos encoder or Hall sensor possible.
P 0512	ENC_CH2_Num	ENC CH2: Gear Numerator	Numerator of transmission ratio
P 0513	ENC_CH2_Denom	ENC_CH2: Gear Denominator	Denominator of transmission ratio
P 0560	ENC_CH2_Lines	Encoder Channel 2: Number of Pole Pairs	Parameterization of number of pole pairs of resolver
P 0561	ECC_CH2_Corr	ENC_CH2: Signal correction type	Activation of encoder correction function GPOC
P 0565	ENC_CH2_LineDelay	Line delay compensation	Correction of phase shift in the case of line lengths > 50 m (Only following consultation with Harmonic Drive AG).

Correction of a resolver signals phase shift
In the case of long resolver lines, a phase shift occurs between the exciter signal and tracks A/B due to the line inductance. This effect reduces the amplitude of the resolver signals after demodulation and inverts their phase in the case of very long line lengths.
The phase shift can be equalized with parameter **P 0565 ENC_CH2_LineDelay**.

Attention!
Approvals have been issued for lines up to max. 50 m. Longer line lengths are only permitted following explicit approval by Harmonic Drive AG.

3.3 Optional encoder module X8 (channel 3)

With the optional channel 3 it is possible to evaluate encoder types such as EnDat2.1/SinCos, TTL- and SSI.
For details, please refer to the specification of the optional encoder module.

Note:
When using the optional encoder interface (channel 3), the speed feedback encoder should be connected to channel 1 and the position encoder to channel 3.

3.4 Encoder gearing

For channels 1 and 3 one gear ratio each can be set for the encoder:
- Adaptation of a load-side encoder to the motor shaft
- Inversion of the encoder information

With encoder channel 2 it is assumed that the resolver is always mounted on the motor shaft. The adjustment range is therefore limited to 1 or -1, i.e. the encoder signal can only be inverted.

Table 29.1 Parameters of encoder gearing:

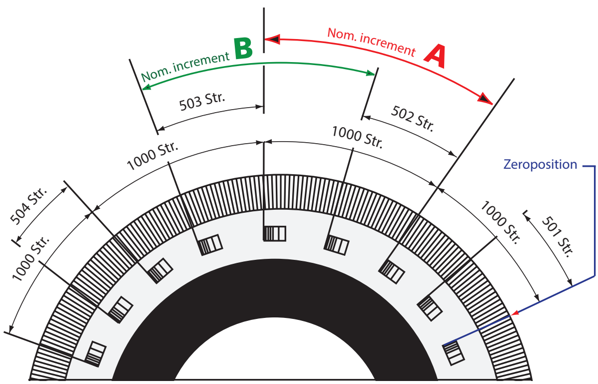
P. no.	Parameter name/ Settings	Designation in DM5	Function
P 0510	ENC_CH1_Num	Encoder Channel 1: Gear Nominator	Denominator in channel 1
P 0511	ENC_CH1_Denom	Encoder Channel 1: Gear Denominator	Nominator in channel 1
P 0512	ENC_CH2_Num	Encoder Channel 2: Gear Nominator	Denominator in channel 2
P 0513	ENC_CH2_Denom	Encoder Channel 2: Gear Denominator	Nominator in channel 2

P. no.	Parameter name/ Settings	Designation in DM5	Function
P 0514	ENC_CH3_Num	Encoder Channel 3: Gear Nominator	Denominator in channel 3
P 0515	ENC_CH3_Denom	Encoder Channel 3: Gear Denominator	Nominator in channel 3

3.5 Increment-coded reference marks

In the case of incremental encoders with increment-coded reference marks, multiple reference marks are distributed evenly across the entire travel distance. The absolute position information, relative to a specific zero point of the measurement system, is determined by counting the individual measuring increments between two reference marks. The absolute position of the scale defined by the reference mark is assigned to precisely one measuring increment.
So before an absolute reference can be created or the last selected reference point found, two reference marks must be passed over.
To determine reference positions over the shortest possible distance, encoders with increment-coded reference marks are supported (e.g. HEIDENHAIN ROD 280C).The reference mark track contains multiple reference marks with defined increment differences. The tracking electronics determines the absolute reference when two adjacent reference marks are passed over – **that is to say, after just a few degrees of rotation**.

Illustration 29.2 Circular graduations with increment-coded reference marks, rotary system



Rotary measurement system:

Basic increment **reference measure A**: (small increment e.g. **1000**)
corresponding to parameter P 0610 ENC_CH1_Nominalincrement A

Basic increment **reference measure B**. (large increment e.g. 1001)
corresponding to parameter **P 0611 ENC_CH1_Nominal Increment B**

The number of lines is entered in parameter **P 0542 ENC_CH1_Lines**. A sector pitch difference of +1 and +2 is supported. One mechanical revolution is precisely one whole multiple of the basic increment A.

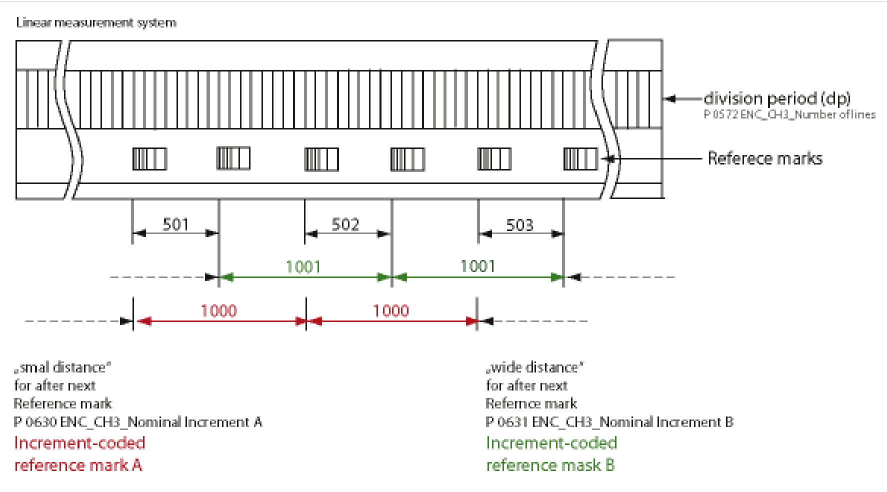
Example of a rotary measurement system

Table 30.1

Number of lines P 0542	Number of reference marks	Basic increment Nominal Increment AP 0610	Basic increment Nominal Increment BP 0611
18 x 1000 lines	18 basic marks + 18 coded marks = ∑36	Reference measure A: 1000 lines, corresponding to 20°	Reference measure 1001 lines

Linear measurement system:

Illustration 30.2 Schematic view of a linear scale with increment-coded reference marks



3.6 Pin assignment for X6 and X7/X8

Table 31.1 Pin assignment, connector X6

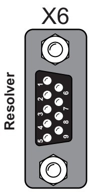
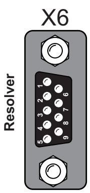
	X6 / PIN	Resolver	Description
	1	Sin +	(S2) Analog differential input track A
	2	Refsin	(S4) Analog differential input track A
	3	Cos +	(S1) Analog differential input track B
	4	US +5 V +12 V	max 150 mA: In the case of a Hiperface encoder on X7 (that is, when "Us-Switch" is jumpered via X7.7 and X7.12)+12V / 100mA is connected to X6.4
	5	ϑ +	(PTC, KTY, Klixon)
	6	Ref +	(R1) Analog excitation at 8 kHz, 7 V_{ss}
	7	Ref -	(R2) Analog excitation
	8	Refcos	(S3) Analog differential input track B
	9	ϑ –	(PTC, KTY, Klixon)

Table 31.3 Pin assignment, connector X6, for SinCos encoder/HalL sensor

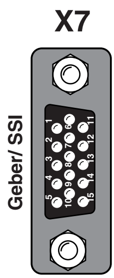
	X6 / PIN	Resolver	Pin assignment X6 for SinCos encoder/Hall sensor
	1	Sin-	B- (***)
	2	Sin+	B+ (***)
	3	Cos +	A+
	4	US +5 V +12 V	+ 5 V/max 150 mA (*) + 12 V/max 100mA (**)
	5	ϑ +	(PTC, KTY, Klixon)
	6		reserved: WARNING: Do not connect!
	7	GND	
	8	Cos-	A-
	9	ϑ –	(PTC, KTY, Klixon)

(*) max. 150 mA together with X7

(**) In the case of a Hiperface encoder on X7 (that is, when US Switch is jumpered via X7.7 and X7.12), +12 V is connected to X6.4 rather than +5 V.

(***) The Sin is applied negated

Table 32.1 Pin-Belegung Steckverbindung X7



	X7 PIN	SinCos	Absolute encoder SSI / EnDat 2.1	Absolute encoder HIPERFACE©
	1	COS- (A-)	A-	REFCOS
	2	COS+ (A+)	A+	+ COS
	3	+ 5 V / max 150 mA	+ 5 V / max 150 mA	Jumper between pins 7 and 12 produces a voltage of 12V / 100 mA on X7/3
	4	R -	Data +	Data +
	5	R +	Data -	Data -
	6	SIN- (B-)	B -	REFSIN
	7		-	Us-Switch
	8	GND	GND	GND
	9	ϑ –	-	-
	10	ϑ +	-	-
	11	SIN+ (B +)	B +	+ SIN
	12	Sense +	Sense +	Us-Switch
	13	Sense -	Sense -	-
	14	-	CLK +	-
	15	-	CLK -	-

⚠

Attention!
A jumper between X7/7 and 12 delivers a voltage rise up to 11.8 V on X7/3 (only for use of a Hiperface encoder).

⚠

Attention!
Encoders with a 5 V +5% voltage supply must have a separate Sense cable connection. The sense cables are required to measure a supply voltage drop on the encoder cable. Only use of the sensor cables ensures that the encoder is supplied with the correct voltage. Always connect the Sense cables!

If a SinCos encoder is not delivering Sense signals, connect pins 12 and 13(+ / -Sense) to pins 3 and 8 (+ 5 V/ GND) on the encoder cable end.

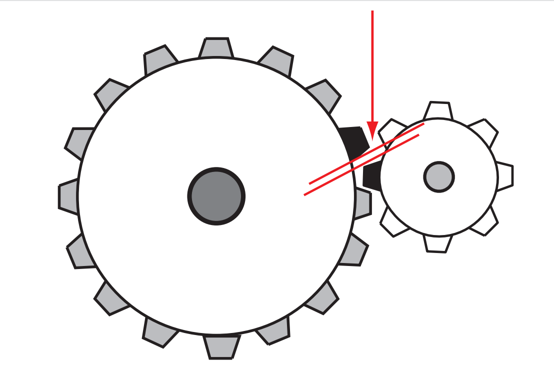
3.7 Axis correction

The actual position value delivered by the encoder system and the real actual position value on the axis may vary for a number of reasons.

Possible causes

- Inaccuracy of the measuring system
- Transfer inaccuracies in mechanical elements such as the gearing, coupling, feed screw.
- Thermal expansion of machine components.

Illustration 33.1 Axis correction



Such non-linear inaccuracies can be compensated by axis correction (use of position- and direction-dependent correction values). For this, a correction value table is populated with values for each of the two directions. The respective correction value is produced from the current axis position and the direction of movement by means of cubic, jerk-stabilized interpolation. The actual position value is adapted on the basis of the corrected table. Both tables contain 250 interpolation points.

The correction range is within the value range delimited by parameters P 0591 “Start position” and P 0592 “End position correction”. The start position is preset on the user side; the end position is determined on the drive side.

Equation 33.2

End position = interpolation point pitch x number of interpolation points (table values) + start position (only if start position $\neq$ 0).

Table 34.1 Required parameters:

P. no.	**Parameter name/ settings**	Designation in DM 5	Function
P 0530	ENC_Encoder1Sel	ENC: Channel selection as SERCOS encoder 1	Channel selection for the 1st encoder
P 0531	ENC_Encoder2Sel	ENC: Channel selection as SERCOS encoder 2	Channel selection for the 2nd encoder
P 0590	ENC_ACOR_Sel	Axis Correction: Select	Selection of the encoder whose actual position value is to be changed. Setting range 0 = OFF 1 = 1st encoder 2 = 2nd encoder
P 0591	ENC_ACOR_PosStart	Axis Correction: Start Position	Definition of correction range: The range is defined by parameters P 0591 Start Position and P 0592 End Position. The start position is user-specified; the end position is determined on the device side from the maximum value of correction table interpolation points used P 0595, P 0596 and the interpolation point pitch P 0593.
P 0592	ENC_ACOR_PosEnd	Axis Correction: End Position	
P 0593	ENC_ACOR_PosDelta	Axis Correction: Delta Position	Interpolation point pitch: The positions at which the correction interpolation points are plotted are defined via parameters P 0593 Interpolation point pitch and P 0591 Start position. Between the correction interpolation points, the correction values are calculated by cubic spline interpolation.
P 0594	ENC_ACOR_Val	Axis Correction: Actual Position Value	Actual position
P 0595	ENC_ACOR_VnegTab	Axis Correction: Table for neg. speed	Values of the correction table for negative direction of rotation in user units.
P 0596	ENC_ACOR_VposTab	Axis Correction: Table for pos. speed	Values of the correction table for positive direction of rotation in user units.

Execution:

- With **P 0530** channel selection for SERCOS: 1st encoder
- With **P 0531** channel selection for SERCOS: 2nd encoder
- Selection of the encoder whose actual position value is to be changed, with **P 0590**
- Enter interpolation point pitch in **P 0593**
  The correction values are determined using a reference measurement system (e.g. laser interferometer). The interpolation points for the various directions within the desired correction range are approached one after another and the corresponding position error is measured.
- The interpolation point-specific correction values are entered manually in tables P 0595 (pos. direction) and **P 0596** (neg. direction).
- Save data

- Restart

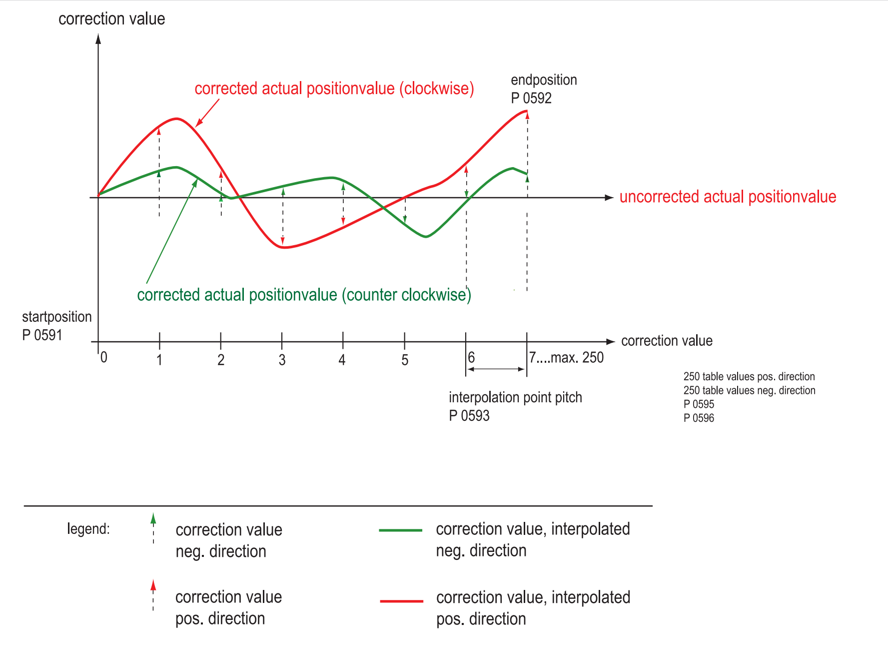
- **P 0592** now shows the position end value of the correction range
- Start control (in position control execute homing) and then move to any position.
- The momentary correction value is written to P 0594. This value is subtracted from the approached position value. This applies to all positions being approached.

Determining the direction of movement:

Position control:
The direction of movement is produced when the time-related change in position reference (speed feedforwar value) has exceeded the amount of the standstill window in the positive or negative direction.

Speed control::
The direction of movement is produced when the speed reference has exceeded the amount of the standstill window in the positive or negative direction.

Illustration 36.1 Correction value formation from the defined correction interpolation correction



Note:
Parameterization is carried out in the selected user unit for the position as integer values.

Note:
It is advisable to use the same number of correction interpolation points for the positive and negative directions. The first and last correction values in the table must be zero in order to avoid instability (step changes) of the actual position value. Differing correction values for the positive and negative directions at the same interpolation point will lead to instability in the associated actual position value when the direction is reversed, and so possibly to a step response adjustment to the reference position.

3.8 Battery buffered EnDat Multiturn encoder

YukonDrive® with Firmware 4.15-31 or higher supports the battery handling (monitoring, error handling) of HEIDEN-HAIN encoders EBI135 / EBI1135.

This section describes the specifics when commissioning and the handling of warnings and errors in relation to the external buffer battery of servoactuators with motor feedbacksystem MZE on YukonDrive®.

Note:
It is recommended to use the DriveManager 5.5.32 only.

To take the battery and to connect the feedback system to the YukonDrive®, a battery box and a connecting cable is available:

Table 37.1

Designation		Material No.
Battery box for MZE		1024385
Connecting cable Batt.box/Yukon X7	0,5 m	1025481
	1,0 m	1025482
	2,0 m	1025483

Requirements:
- Cognition of EnDat warning „battery charge“
- Cognition of EnDat error „M ALL Power Down“ according to EnDat Application Note, Doc. Nr. D722024-03-A-01, HEIDENHAIN
- Reset of warning
- Reset of error

Implementation:

1. Premise

- Servo actuator with motor feedbacksystem MZE (EBI135, EBI1135) connected to YukonDrive® via X7 or X8
- Motor feedbacksystem connected to buffer battery (recommendation from HEIDENHAIN: Lithium-Thionylchlo-ride-Battery, 3,6 V, 1200 mAh)
- YukonDrive® supplied with 24 VDC

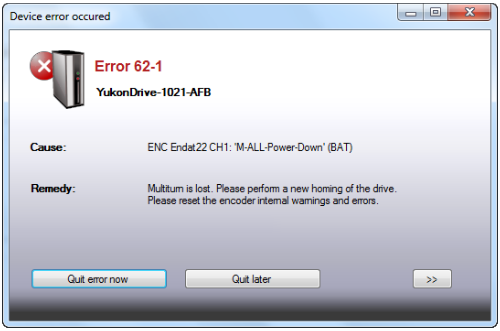
2. Initial commissioning

Connect to the YukonDrive® via DriveManager5

Note:
The YukonDrive® is already configured for the specific actuator (motor data, feedback data, initial setting of the control)

During the first startup, the drive displays error 62-1 as neither main supply voltage nor the battery have been connected to the encoder before.

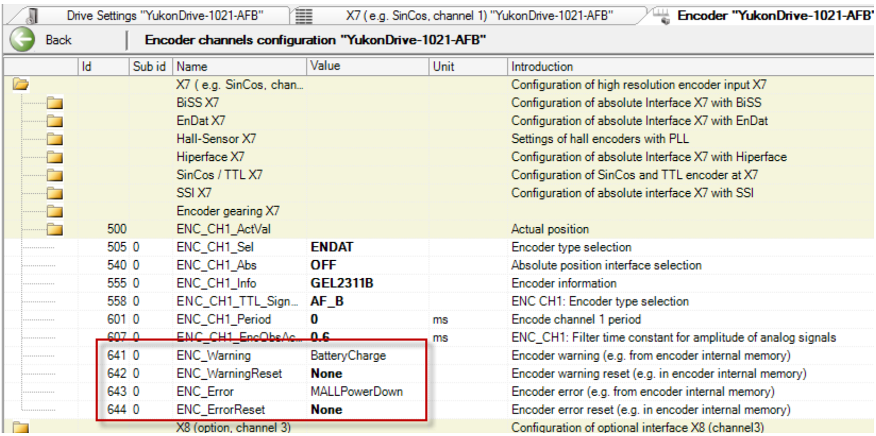
Illustration 38.1



3. Procedure to reset the encoder

Go to subject area Encoder, switch to list view

Illustration 38.2



Id	Sub id	Name	Value	Unit	Introduction
		X7 (e.g. SinCos, chan...			Configuration of high resolution encoder input X7
		BiSS X7			Configuration of absolute Interface X7 with BiSS
		EnDat X7			Configuration of absolute Interface X7 with EnDat
		Hall-Sensor X7			Settings of hall encoders with PLL
		Hiperface X7			Configuration of absolute Interface X7 with Hiperface
		SinCos / TTL X7			Configuration of SinCos and TTL encoder at X7
		SSI X7			Configuration of absolute interface X7 with SSI
		Encoder gearing X7			
500		ENC_CH1_ActVal			Actual position
505	0	ENC_CH1_Sel	ENDAT		Encoder type selection
540	0	ENC_CH1_Abs	OFF		Absolute position interface selection
555	0	ENC_CH1_Info	GEL2311B		Encoder information
558	0	ENC_CH1_TTL_Sign...	AF_B		ENC CH1: Encoder type selection
601	0	ENC_CH1_Period	0	ms	Encode channel 1 period
607	0	ENC_CH1_EncObsAc...	0.6	ms	ENC_CH1: Filter time constant for amplitude of analog signals
641	0	ENC_Warning	BatteryCharge		Encoder warning (e.g. from encoder internal memory)
642	0	ENC_WarningReset	None		Encoder warning reset (e.g. in encoder internal memory)
643	0	ENC_Error	MALLPowerDown		Encoder error (e.g. from encoder internal memory)
644	0	ENC_ErrorReset	None		Encoder error reset (e.g. in encoder internal memory)
		X8 (option, channel 3)			Configuration of optional interface X8 (channel3)

- Set parameter 642[0] und 644[0] to 1 („Reset EnDat … „)
- Save settings non volatile in the drive
- Select actual device => restart (conduct two times!)
    - After setting the parameters to 1 and restart, the encoder becomes initialised, the status is read and afterwards errors / warnings become resetted. Thus, the drive first starts again with the error 62-1. After the second restart, the encoder status becomes read again: as the error has been reset before, the drive starts without an error.

Axis is ready afterwards
- Conduct HOMING, Homing Method (-13)

4. Reset battery warning

If the battery voltage drops below 2,7 V (typically), with the next power-up of the 24 VDC supply, the warning „battery charge“ is read from the encoder.
In parameter 641[0] „BatteryCharge“ is displayed and bit 31 of the Device warnings status word (parameter 34[0]) is set to 1.

The axis is functional w/o limitation, a change of the battery should be conducted as soon as possible.

5. Battery change

The battery should be changed with 24 VDC supply powered up, but disabled power stage (ENPO = off). This ensures that no „AllPowerDown“ error occurs, uncontrolled movement of the axis is avoided and no HOMING becomes necessary

To change the battery, please refer to the documentation of the corresponding actuator.

Afterwards, the warning „BatteryCharge“ can be reset as follows:

- Set parameter 642[0] to 1
- Save changes non volatile
- Restart device

6. Reset the encoder after AllPowerDown

If the battery supply as well as the main supply for the encoder have been down, the error „AllPowerDown“ is set in the encoder and the drive comes up with error 62-1 (refer 2.).

Procedure to reset the AllPowerDown error see 3.

3.9 Buffering multiturn overflows

When the ratio of the encoders countable revolutions and the gear ratio is not an integer, the absolute position of the gear output is not securely restorable after a power cycle. If the number of motor revolutions is counted within the drive, the absolute position can be restored after a power cycle.

Implementation:

1) Set normalisation according to the DS402 profile

2) Set encoder to modulo and set positions and options as necessary

4) check „consider multiturn overflow“

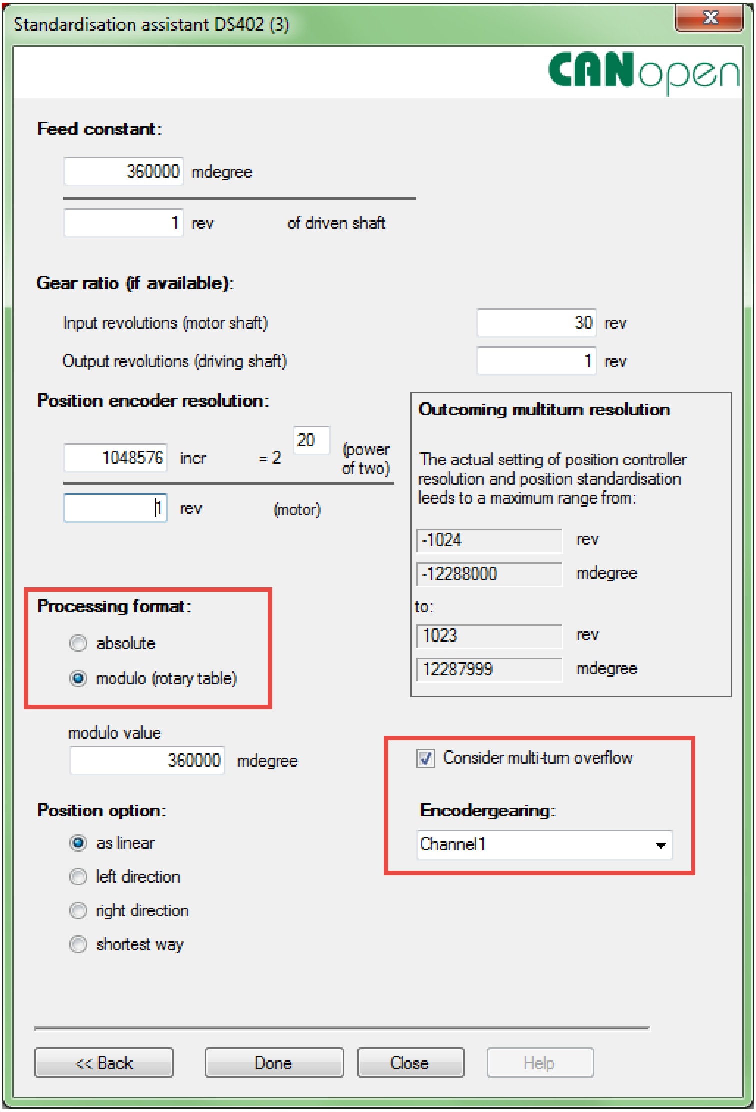
5) select position encoder

5) conduct HOMING, using HOMING method Type (-13) (mandatory!)

6) set position on reference position

Note:
The functionality works with that homing method only!

Illustration 41.1



Save settings into the drive and conduct a reset.

The drive starts up with the position defined at the reference point.

Note:
A turn of the axis in switched off condition is allowable in both directions within half the multiturn detection range. When exeeding this range, the position cannot be restored correct.

Internally, the multiturn position becomes counted as a int32 value. After a power cycle, the position becomes calculated and the value becomes resetted.

For continous movement for example, the overflow occures at:

$$P_{OS\ Multiturn} = 2^{32} = 4294967296 \text{ revolutions}$$

For a motor turning with 6000 rpm continously:

$$P_{OS\ in\ min} = \frac{2^{32}}{6000min^{-1}} = 715827.8$$

$$P_{OS\ in\ hours} = \frac{715827.88}{60} = 11930.46$$

$$P_{OS\ in\ days} = \frac{11930.46}{24} = 497.10$$

4. Control

4.1 Control basic setting

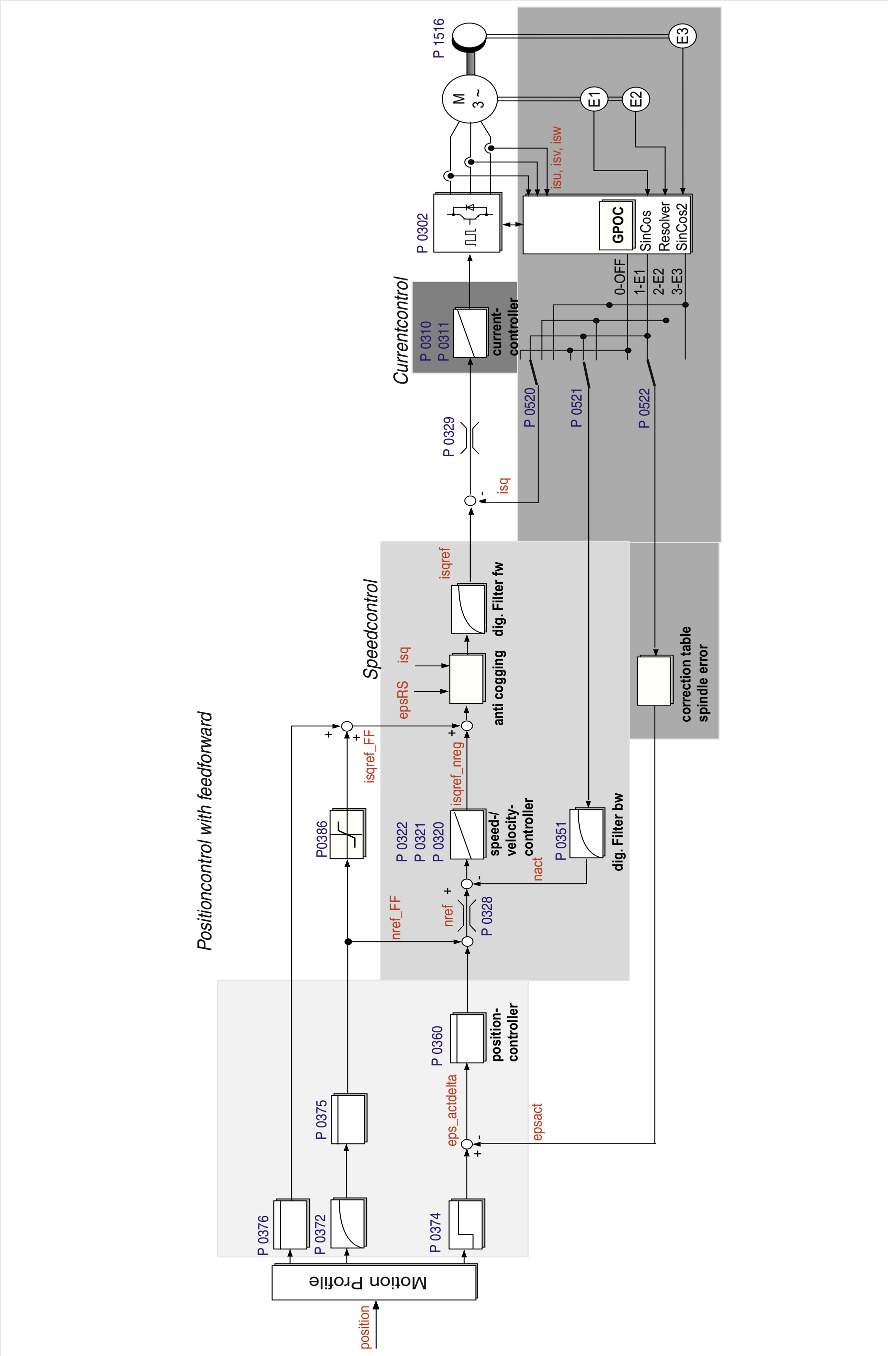
A servocontroller works on the principle of field-oriented regulation. In the motor the current is injected so that the magnetic flux is at the maximum and a maximum torque can be generated on the motor shaft or on the carriage of a linear motor.

Specified properties:

- Constant speed (synchronism)
- Positioning accuracy (absolute and repeatable)
- Hygh dynamism
- Constant torque
- Disturbance adjustment

When using a standard motor data set, the control parameters are preset for the specific motor model. If using third-party motors, a manual setting must be made for the drive by way of the motor identification or by calculation in order to get the appropriate control parameters for the motor model (see „Motor“ section).
The individual controllers for position, speed and current are connected in series. The matching control loops are selected by the control mode.

Illustration 44.1 Control structure



Note:
Synchronous and asynchronous machines and also synchronous linear motors (ironless/iron-core) can be controlled.

The following sequence should always be observed in order to optimize controllers:

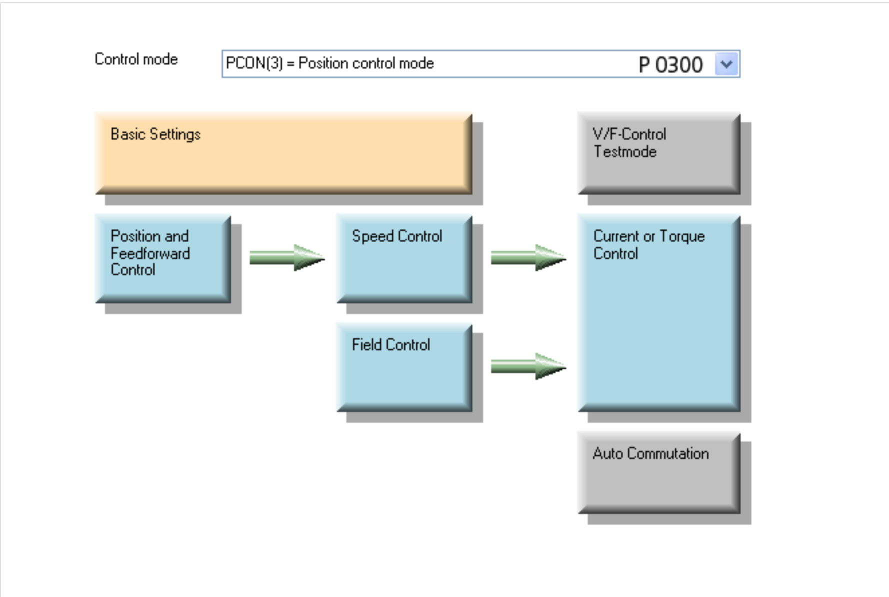
1. Current control loop: For Harmonic Drive AG motors with motor encoder optimization of the current controller is not needed because the corresponding control parameters are transferred when the motor data set is loaded. For linear motors and third-party motors the motor must be calculated or identified (section 3, „Motor").

2. Speed controller: The settings of the speed controller with the associated filters are dependent, firstly, on the motor parameters (mass moment of inertia and torque/force constant) and, secondly, on mechanical factors (load inertia/mass, friction, rigidity of the connection,...). Consequently, either a manual or automatic optimization is often required.

3. Position control loop: The position control loop is dependent on the dynamism of the underlying speed controller, on the setpoint (reference) type and on the jerk, acceleration and interpolation methods.

Basic settings are made on the following screen.

Illustration 45.1 Basic settings screen for selection of the control parameters



Parameter **P 0300 CON_CFG_Con** specifies the control mode with which the drive is to be controlled. **This parameter takes effect online**. Uncontrolled online switching can cause an extreme jerk, a very high speed or an overcurrent, which may cause damage to the system.

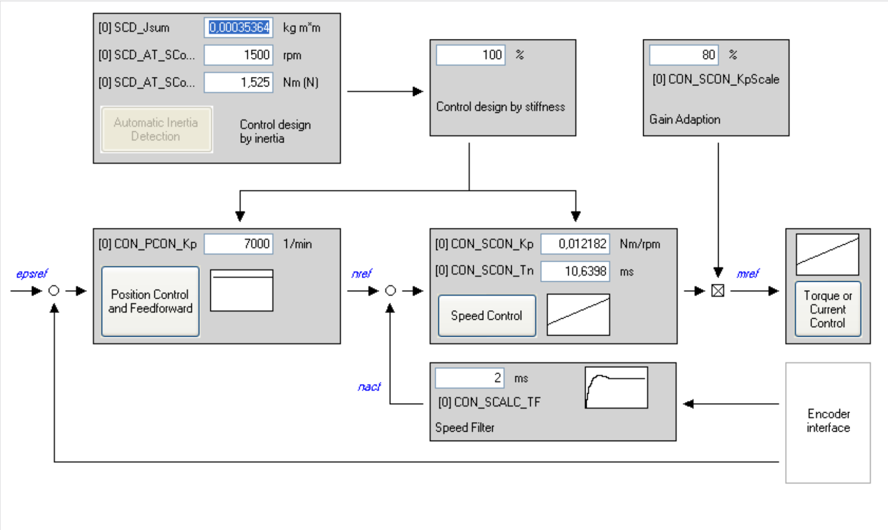
Selection of control mode:

- Current control TCON(1)
- Speed control SCON(2)
- Position control PCON (3)

The basic settings include:

- Setting the mass moment of inertia of the plant
- Setting the rigidity and scaling the speed controller
- Setting the current/speed/position control gain factors
- Setting the speed filters

Illustration 46.1 Basic setting screen



Adjustment to the stiffness of the mechanics

The adaption to the stiffness of the mechanics can be done after successful determination of the moment of inertia P1516 by setting the parameter P1515 for the stiffness of the control. By setting of a value in percent, the stiffness and phase margin of the speed control loop is affected. With the values for stiffness (as given in P1515), the moment of inertia and the speed filter time constant P0351, the PI speed controller (P0320, P0321) and the P position controller (P0360) will be set. Also, the observer for a single mass system is set, but not yet activated. Speed feedback still is linked via the delaying digital filter.

4.2 Current control

By optimizing the current controller it can be adapted to the special requirements of the drive task. For dynamic applications it is highly advisable to design the current controller as dynamically as possible with a short rise time. For noise-sensitive applications, a less dynamic setting with a longer rise time is recommended.

Current controller optimization

In order to optimize the current control loop, two rectangular steps must be preset. The first step (stage 1, time 1) moves the rotor to a defined position. The second step (stage 2, time 2) is used to assess the current control (step response). This should correspond to the rated current of the motor. The “Start Test Signal” button opens a screen containing a safety notice before the step response can be generated. The necessary setting of the scope function is made automatically by the wizard. The time base can be set manually.

Illustration 47.1 Screen for the current control loop

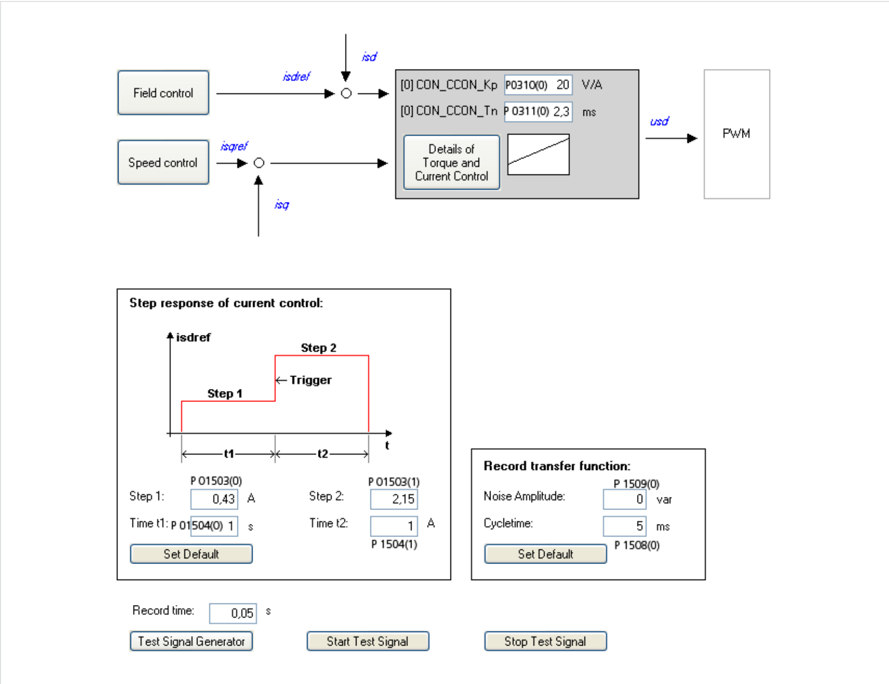
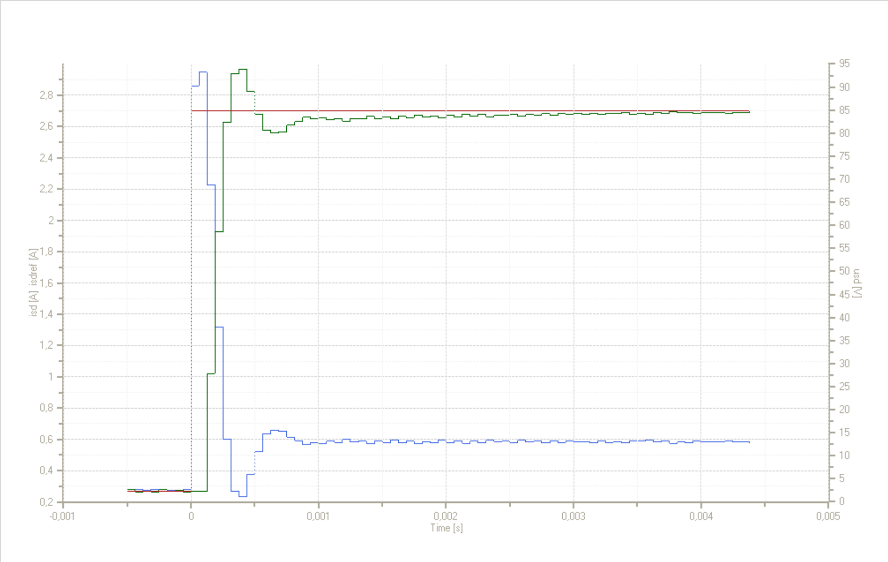


Illustration 48.1 Step response to rated current



The faster the actual value approaches the setpoint (reference), the more dynamic is the controller setting. During settling, the overshoot of the actual value should be no more than 5-10 % of the reference setpoint.
The current controller can also be set by way of the test signal generator. This controller optimization method is described in more detail in section 4.7, Commissioning.

Determining the mass inertia of the motor:

- Open the Loop control screen
- Activate hardware enable (ISDSH, ENPO)
- Click the „Basic setting" button (the screen in figure 27 opens up)
- Click the „Automatic determination of mass inertia" button (hardware enable required)
- The new value of the mass inertia is displayed in **P 1516 SCD_Jsum**.
- Save setting in device

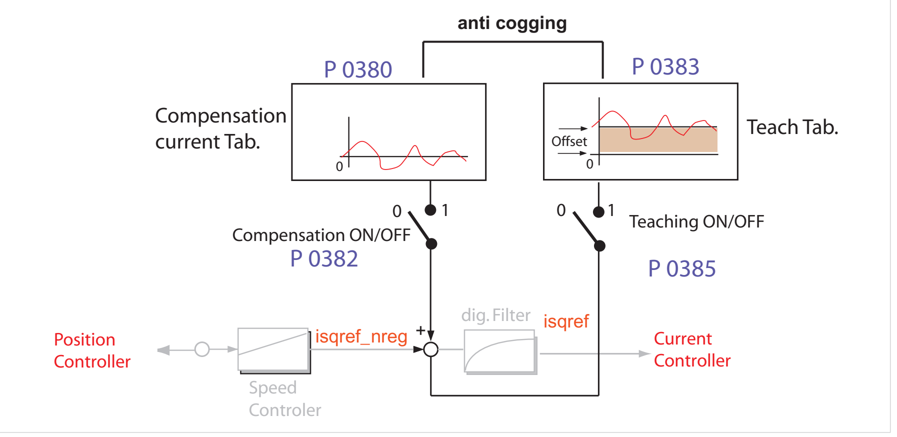
⚠

Attention!
The motor shaft may move jerkily.

4.2.1 Detent torque compensation/Anti-cogging

In order to compensate for detent torques (caused by non-sinusoidal EM curves), the torque-forming q-current is entered in a table and „taught-in" for one pole pitch division.
After elimination of the offsets (compensated table), the q-current is inverted and fed-in as the feedforward value of the control (see figure 4.6 m. The compensation function can be described by means of compensating currents (q-current, scope signal isqref) dependent on a position (electrical angle, scope signal epsrs). A „teach-in" run imports the values into a table with 250 interpolation points. Parameter P 0382 CON_TCoggComp activates the function (ON/OFF).

Illustration 49.1 Schematic for detent torque compensation



Teach-in
The teach-in run is initiated via parameter **P 0385 CON_TCoggTeachCon**. The teach procedure to determine the detent torque characteristic is as follows.

Performing the teach-in:

- Open manual mode window
- Set speed control
- Set parameter P 0385 to „TeachTab(1)
- Start control
- Move the motor at low speed until table P 0383 has been completely populated
- Set parameter P 0385 to „CalCorrTab(3)". This imports all values into the compensation table.
- Stop control
- Import compensation table values with P 0382 = EPSRS (1) (Electrical angle) or ABSPOS(2) (Absolute position) into the device
- Save device data

The interpolation between the table values is linear. The characteristic is not saved automatically; it must be saved manually.
The progress of the teach process and the compensation can be tracked on the scope. The signal isqCoggTeach indicates the current output value of the teach table during teach mode, while isqCoggAdapt contains the current value from the compensation table.

The following parameters are available to activate this process:

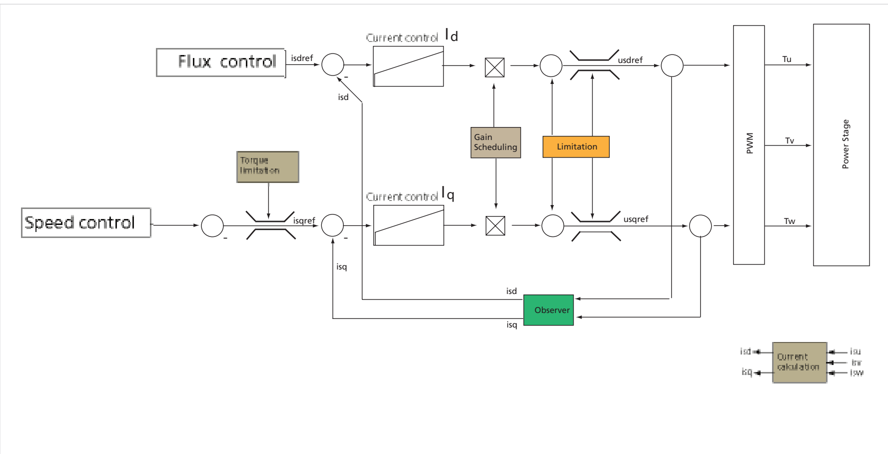
Table 50.1 Option card PROFIBUS

P. no.	Parameter name/ Settings	DM5 description	Function
P 0380	CON_TCoggAddTab	Anti Cogging - compensation current table	Table with compensated values
P 0382	CON_TCoggComb	Anti Cogging - compensation on/off	Compensated table values are imported into the control
(1)	EPSRS	Compensation on, dependent on el. angle	Compensation referred to electrical angle Example – three-pole-pairs motor: The table in P 0380 is populated three times within one mechanical motor revolution. The compensation is effected with the averaged table values
(2)	ABSPOS	Compensation on, dependent on absolute Position.h	Compensation referred to one mechanical motor revolution. Example: Three-pole-pairs motor: The table in P 0380 is populated once within one mechanical motor revolution.
P 0383	CON_TCoggTeach1	Anti Cogging - recorded currents at teaching	The characteristic of the q-current is averaged by a special filter and imported into the table of parameter P 0383 CON_TCoggTeach1..
P 0385	CON_TCoggTeachCon	Anti Cogging - teach control word	Start of teach function to fill table

4.2.2 Advanced torque control

There are additional functions to improve the control performance of current and speed controllers. Here the **>Limitation, >Gain Scheduling,** and **>Observer** functions are described.

Illustration 50.2 Block diagram of current and speed control



Limitation

Limitation of the voltage components usqref and usdref.
This also enables so-called overmodulation (limitation to hexagon instead of circle) in order to make better use of the inverter voltage.

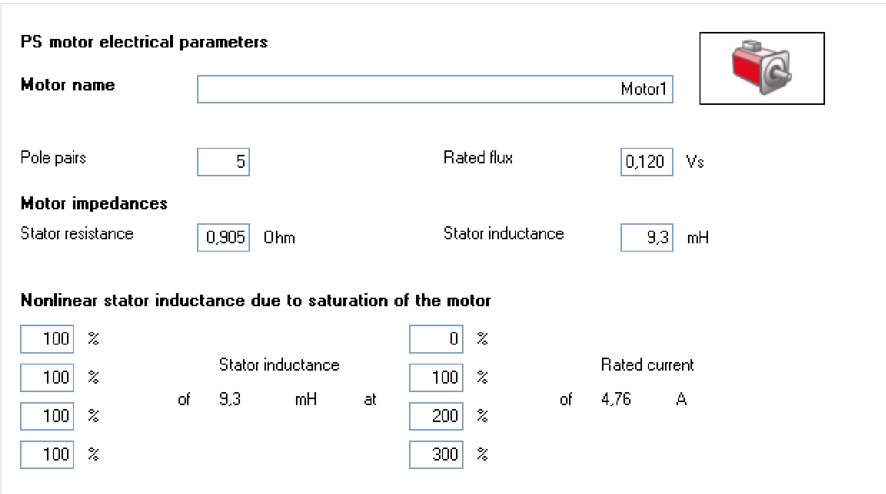
Table 51.1

P.no	Parameter name/ settings	Description in DM 5	Function
P 0432	CON_CCONMode	Select current control / limitation mode	Voltage limitation of $us_{q,ref}$ und $us_{d,ref}$.
(0)	PRIO(0)	Hard-Change-over of priority	Hard switch from d-priority (motorized) to q-priority (regenerative)
(1)	PRIO_RES(1)	Priority with reserve (CON_ CCON_VLimit)	Expert mode: Switch from d-priority (motorized) to q-priority (regenerative). A portion of the voltage is held in reserve; the amount can be specified via parameter P 0431 CON:CCON_VLimit.
(2)	Phase(2)	CON_CCONOV_Mode:Phase	Phase-correct limitation
(3)	HEX_PHASE (3)	Hexagon modulation, limitation with correct phase angle	Hexagon modulation with phase-correct limitation. More voltage is available for the motor. The current exhibits a higher ripple at high voltages however.

Adaptation of current control/Gain scheduling

In the high overload range, saturation effects reduce the inductance of many motors. Consequently, the current controller optimized to the rated current may oscillate or become unstable.
As a remedy, it can be adapted to the degree of magnetic saturation of the motor. The gain of the current controller can be adapted to the load case over four interpolation points.

Illustration 51.2 DM5 screen for adaptation to current controller



In the lower area of the screen the values for the interpolation points are entered. On the left are the inductance values, and on the right the values for the overload (> 100 % of rated current).

Illustration 52.1 Example of current control adaptattion

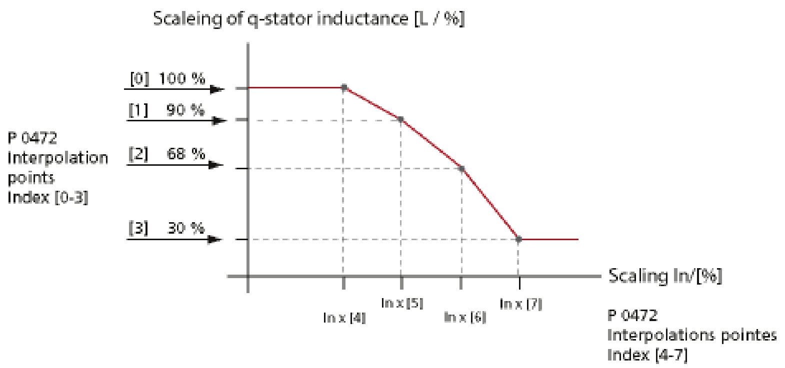


Table 52.2

P. no.	Parameter name/ settings	Description in DM 5	Function
P 0472	MOT_LsigDiff	q-Stator inductance variation in % of MOT_Lsig	Scaling of q-stator inductance
0-3	100%	Lsig_q 0-3	Scaling of q-stator inductance in [%]; interpolation points [0-3]
4-7	100%	Current 0-3	Scaling of rated motor current in [%]. Interpolation points [4-7]

Note:
Between the interpolation points the scaling factor is interpolated in linear mode. The current scaling of the inductance is plotted in the scope variable “Is_ActVal_under Control, Flux Model”.

Observer, Current Calculation

To increase the current control dynamism and reduce the tendency to oscillation, there is a so-called observer. It predicts the current.

Table 53.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0433	CON_CCON_ObsMod	Select current observer mode	Switching the observer on and off for current control
(0)	OFF(0)	Observer not used	
(1)	Time Const(1)	Use observer design acc. time contant	The currents determined from the observer are used for the motor control. The configuration is based on setting of a filter time constant in **P 0434, index 0**
(2)	Direct(2)	Use observer preset of Kp and Tn	Direct parameterization of the observer feedback via P 0434 index 1 (KP) and 2 (Tn)

4.2.3 Current control with defined bandwidth

It is possible, based on the bandwidth, to carry out a current controller draft design. In this, the controller gains can be determined by activating test signals (Autotuning). The calculations and the relevant autotuning are carried out in the drive controller.
The advanced settings are made in parameters **P 1530, P 1531** and **P 1533**.

Table 53.2 Optionskarte PROFIBUS

P. no.	Parameter name/ Settings	Designation in DM5	Funktion
P 1530	SCD_SetMotorControl	Selection of standard motor control design method	
(3)	3- SCD_SetCCon_by Bandwidth	Design current control for given bandwidth	Setting 3: CalcCCon_PI Calculation of the current controller parameters based on the motor data and the specified bandwidth
(4)	SCD_SetCCon_Deadbeat	Design dead beat current control	This setting parameterizes a dead-beat controller. The structure is switched to feedback with observer, the observer is designed (to a specific equivalent time constant – for setting see parameter CON_CCON_ObsPara – index 0) and the current controller gains are calculated accordingly.
P 1531	SCD_Action_Sel	Selection of commisioning method	
(6)	SCD_Action_Sel_TuneCCon	Tune current control for given bandwidth	Setting 6: TuneCCon Activation of sinusoidal test signals and adap-tation of the current controller parameters based on the specified bandwidth
P 1533	SCD_AT_Bandwidth	Desired bandwith for control design	Bandwidth specification for current control loop: Setting range: 10 - 4000 Hz

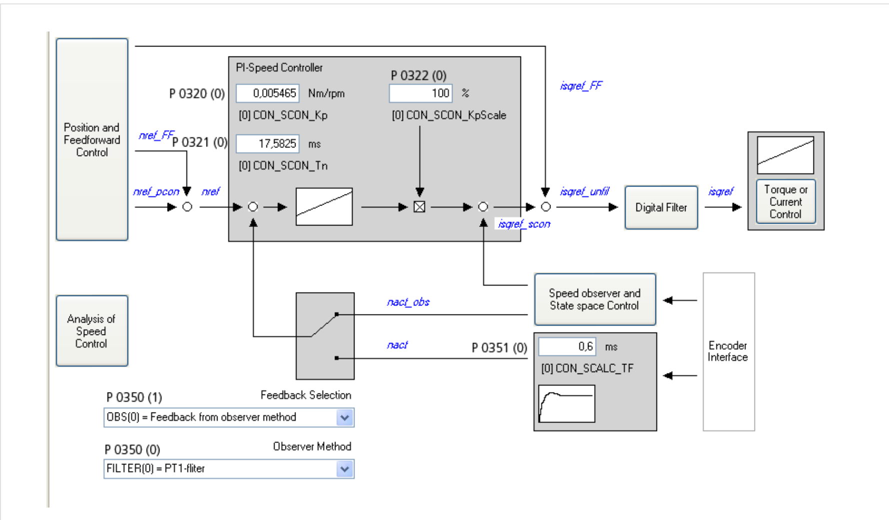
4.3 Speed control

If the travel range is not limited, it is advisable to optimize the speed controller by means of step responses. In this, the motor model must be adapted precisely to the individual motor. In the standard motor data set the speed controller is preset for a moderately stiff mechanism.
The speed controller may still need to be adapted to the moment of inertia and the stiffness of the mechanical system. For load adaptation the coupled mass moment of inertia of the system is equal to the motor's moment of inertia (load to motor ratio 1:1).

The screen (figure 34) can be used to set the control parameters of the speed controller:

- Gain
- Lag time
- Gain scaling
- Filter time
  Low value for speed filter = high control dynamism
  High value for speed filter = control dynamism lower/smooth running quality improves
- Speed limitation

Illustration 54.1 Speed controller screen



All parameters take effect online. The scaling parameter **P 0322** is transferred in defined real time (according to the speed controller sampling time).

- With this the gain can be adapted via the field bus or an internal PLC to respond to a variable mass moment of inertia.
- By selecting the scaling there is always a refer-back to the reference setting of 100%.

Speed controller optimization using step responses

The speed controller is always set up using step responses. They are recorded with the oscilloscope and used to analyze the setup quality of the speed controller. To activate step responses the controller should be operated in speed control mode “SCON”. The important factor here is that the speed controller shows low-level signal response, which means that the q-current reference does not reach the limitation during the step. In this case the magnitude of the reference step P 0402 must be reduced.

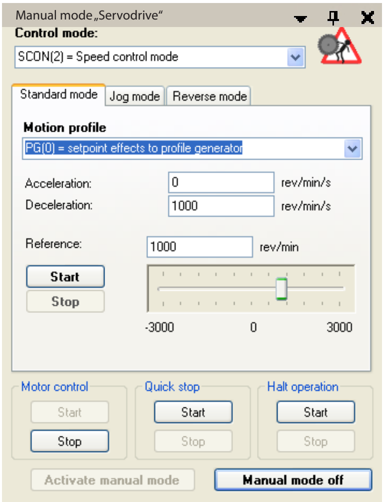
Table 55.1 Parameters:

P. no.	Parameter name/ Settings	Designation DM 5	Function
P 0165	MPRO_REF_SEL	TAB(3) = via table	Selection of reference source
P 0300	CON_Cfg_Con	SCON(2)	Speed control activated
P 0320	CON_SCON_Kp		Speed controller gain
P 0321	CON_SCON_Tn		Speed controller lag time
P 0322	CON_SCON_KpScale	100 %	Gain scaling
P 0328	CON_SCON_SMax		Speed limitation
P 0351	CON_SCALC_TF	Recommended setting: 0,6 to 1,2 ms	Actual speed filter
P 0402	CON_SCON_AddSRef	Speed reference	Speed reference

Execution via "Manual mode" window:

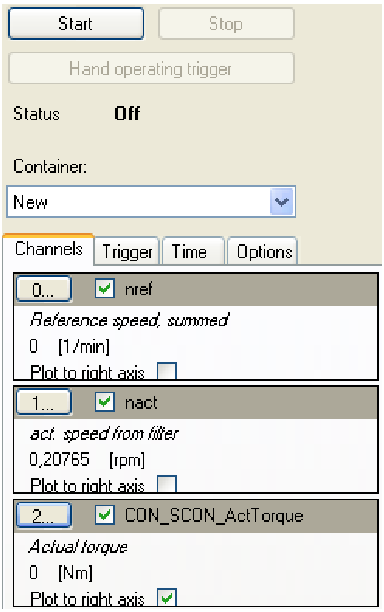
The reference steps necessary for optimization can be executed in a user-friendly way via the „Manual mode" window. The following settings are required for the manual mode window and the oscilloscope:

Illustration 56.1 Optimizing the speed controller



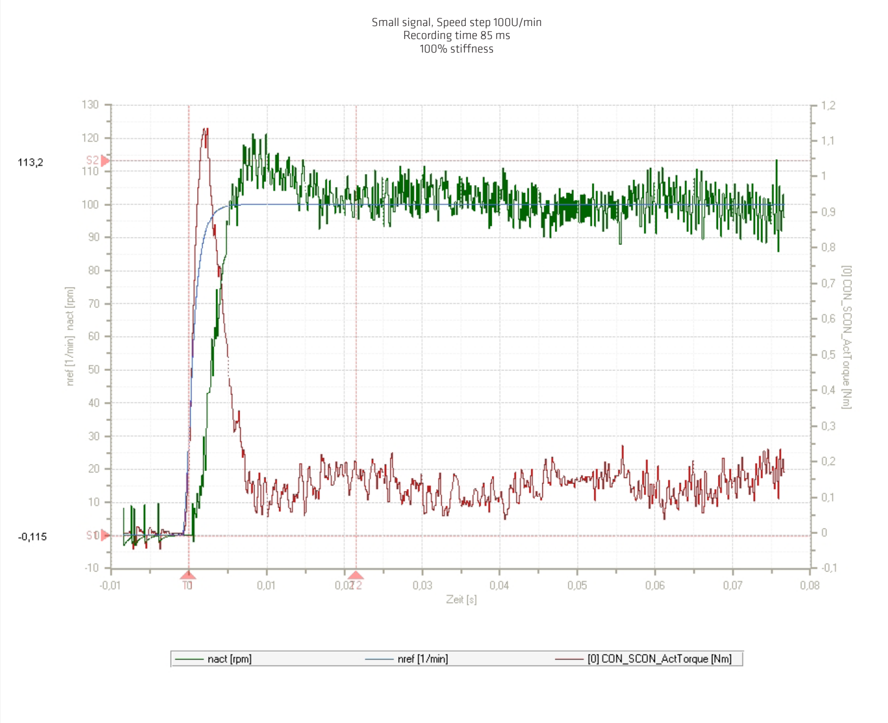
- Open control window
- Make settings:
  - Control mode = (SCON) Speed-controlled
  - Acceleration ramp = 0

Illustration 56.2 Setting the channels on the oscilloscope



Open scope:
Setting:
Channels:
CH 0 = speed reference (nref)
CH 1 = actual speed (nact)
CH 2 = actual torque (mact)
Trigger:
Trigger signal: Speed reference (nref)
Mode: Rising edge
Level: 30 rpm
Pretrigger: 0 %
Time:
Samplingtime: = base time (6.25E-0.5 s)
Recording time = 0,2 s

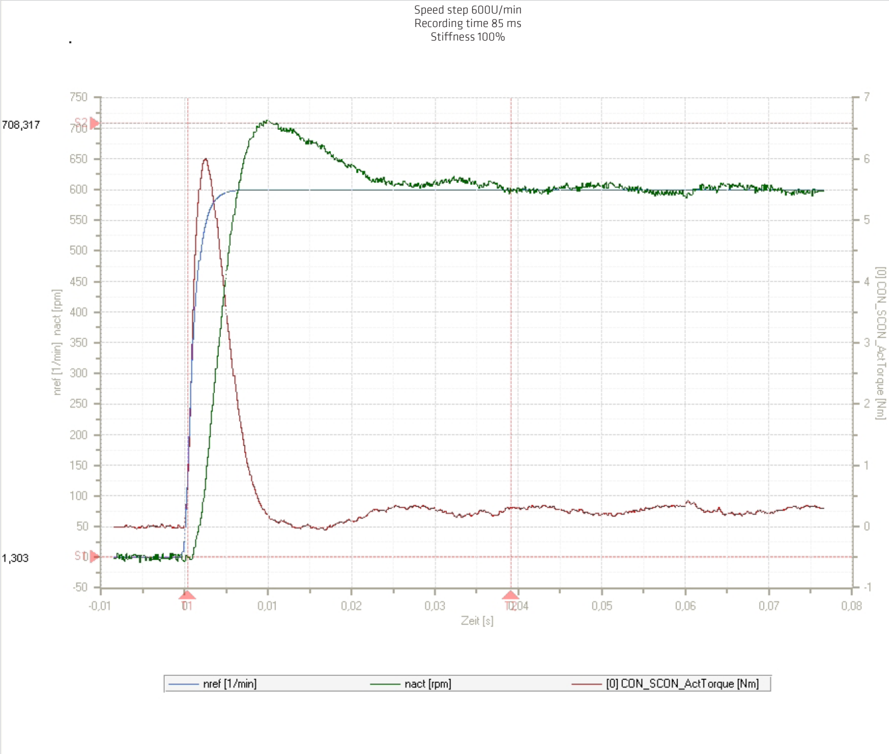
Illustration 57.1 Small signal response: Speed step 100 rpm



	T1	T2	Differenz
Zeit [s]	0	0,022	0,022
Reference speed, summed [1/min]	32,755	100	67,245
act. speed from filter [rpm]	-0,003	101,839	101,842
Istdrehmoment [Nm]	0,259	0,179	-0,08

This view shows a typical speed step response (n = 100 rpm) with a rise time of 5 ms and an overshoot of approximately 13 %.
The reference of the current must not reach the limit during the step. This can be identified by its assuming a constant value over a certain time during the acceleration phase. In this case either the maximum torque **P 0329 CON SCON_TMax Tmax** must be increased or the level of the reference reduced.

Illustration 58.1 Speed step: 600 rpm



	T1	T2	Differenz
Zeit [s]	0	0,039	0,039
Reference speed, summed [1/min]	48,856	600	551,144
act. speed from filter [rpm]	-5,806	601,993	607,799
Istdrehmoment [Nm]	0,151	0,307	0,156

Scaling the control parameters

The parameters for gain, lag time and actual speed filter time can be set by way of the scaling factor **P 0322 CON_SCON_KpScale**. The default setting of the scaling factor is 100 %. A change in scaling causes a change in the three variable at an appropriate ratio. The recommended setting of the actual speed filter P 0351 CON_SCALC_TF for a synchronous motor is 0.6 to 1.2 ms

Speed controller gain reduction at low rotation speeds

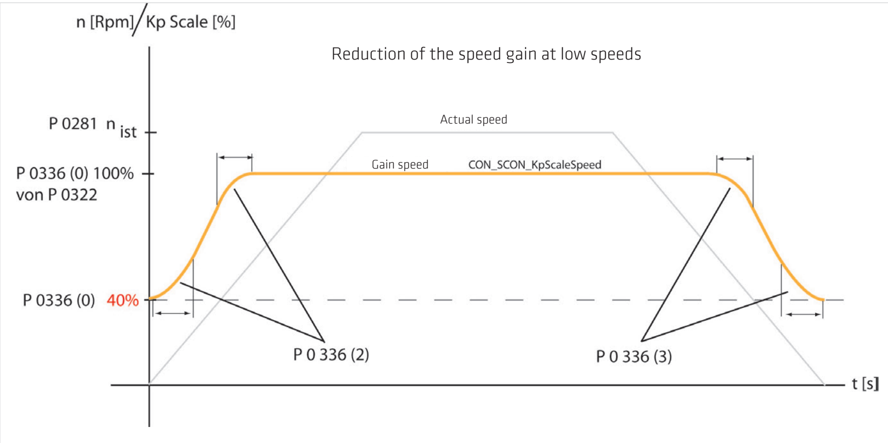
To avoid standstill oscillations with a simultaneously highly dynamic speed control setting during a short positioning cycle, the speed control gain can be adapted at „low speeds“ or „speed zero“ (especially effective with TTL encoders).

- Speed gain reduction at low speeds
- Prevents „hum“ or rough running

Table 59.1 Parameters

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0336	CON_SCON_KpScaleSpeed-Zero	Adaptation of speed control gain @ zero speed	Reduction of speed controller gain at low speeds or speed 0
(0)	Index 0 [%]	Gain for low/zero speed	Weighting of the speed controller gain reduction in percent
(1)	Index 1 [rpm]	Definition of the speed limit to detect zero speed	Weighting of the speed controller gain reduction in rpm
(2)	Index 2 [ms]	Filter time for change from zero to higher speed	Filter time for the speed transition from 0 to n_{max}
(3)	Index 3 [ms]	Filter time for change from higher to zero speed filter time for change from higher to zero speed	Filter time for the speed transition from n_{max} to 0

Illustration 59.2 Speed controller gain reduction



Single-mass observer to determine actual speed value
With the single-mass system observer, the phase displacement over time in the feedback branch generated by the jitter filter can be reduced, thereby considerably enhancing speed controller performance.

During basic setting of the speed controller by means of the calculation assistant P 1515 SCD_ConDesign a singlemass system observer with medium dynamism has already been calculated.

The observation algorithms are calculated as soon as the selector P 0350 Index 1 is set to „Filter(1)". The PT1 filter and the selected observer type are then calculated in parallel.

Feedback via the PT1 filter or via the observer can then be toggled by the selector **P 0350 index 1**.

Observer optimization:

- The mass moment of inertia must be determined correctly.
- The dynamism is set via the equivalent time constant P 0353-Index 0, which behaves in a similar way to the actual speed filter time constant: Increasing the time constant enhances the noise suppression, but also reduces the dynamism
- By writing the calculation assistant P 0354 = Def the observer is reconfigured. This change takes effect online.
- An optimization can be made iteratively (in steps) by adapting the equivalent time constant, linked with rewriting of the calculation assistant.

Table 60.1 Parameters

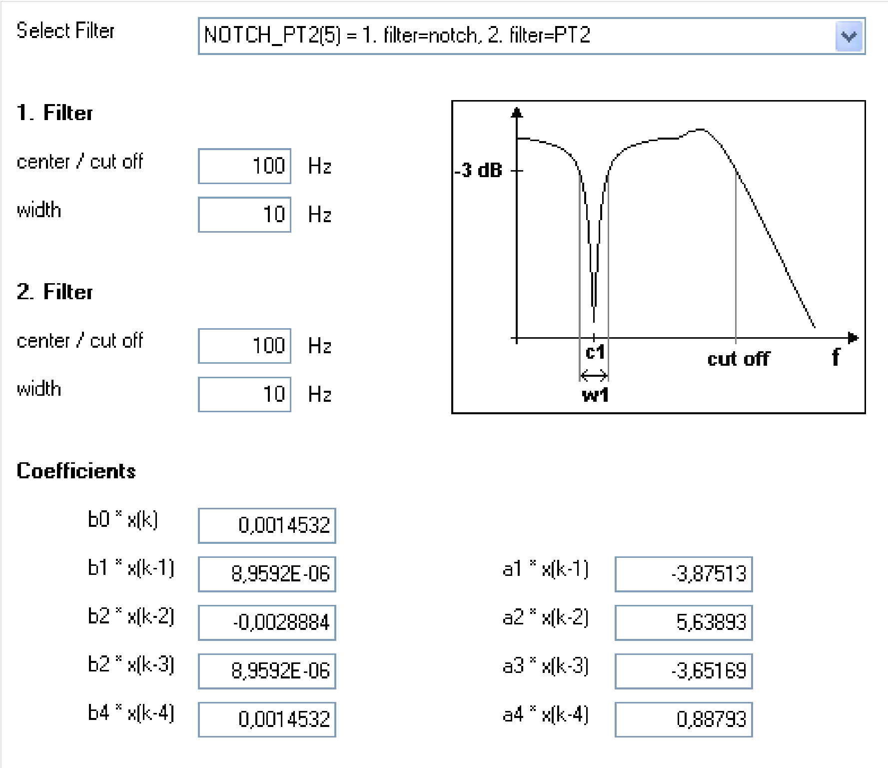
P. no.	Parameter name/ Settings	Designation in DM5	Function
P 0350	CON_SCALC_SEL	Selection of Speed calculation method	Selection of speed calculation method
(0)	SEL_ObserverMethod	„	„
	Filter(0)	PT-Filter	Signal from observer system; actual value filter activated
	OBS1(1)	One mass observer	Single-mass observer
	OBSACC(2)	Observer with acceleration sensor	Observer with acceleration sensor
	OBS2(3)	Two mass observer	Dual-mass observer
(1)	SEL_FeedbackMethod		
	OBS(0)	Feedback from Observer method	
	Filter(1)	Feedback from Filter	
P 0353	CON_SCALC_Obs DesignPara	Observer design parameters	Equivalent time constant of observer
(0)	TF	Time constant of observer	Time constant 1 ms
1	Alpha	Damping coefficient	
2	Load point	Load torque is applied	as V 3.0
3	TF1	Time constant of speed filtering	as V 3.0
4	TF2	Time constant of load torque adaption	as V 3.0
5	TFosc	Time constant of oscillation adaption	as V 3.0
6	AccGain	Acceleration measurement gain	as V 3.0
P 0354	CON_SCALC_ObsDesignAssi	Observer design assistent	Calculation assistant for observer
0	USER	User definied design	as V 3.0
1	DEF	Default design for selected observer	Start calculation with default design rule
2	DR	Observer design by double ration	as V 3.0
3	TIMES	Observer design by time constant	as V 3.0

Digital filter

To suppress potential disturbance frequencies (resonances) which might cause a system to oscillate, it is possible to activate two filter types.
For this, there are two general digital filter with the following time-discrete transfer function is implemented in the forward branch of the speed controller:

- y(k) = B(4)*x(k-4)+ B(3)*x(k-3)+ B(2)*x(k-2) + B(1)*x(k-1) +B(0)*x(k)
  - A(4)*x(k-4)+ A(3)*x(k-3)+ A(2)*y(k-2) - A(1)*y(k-1)

Illustration 61.1 Screen for setting the digital filters



With parameter **P 0326 CON_SCON_FilterAssi** it is possible to select a filter type to suppress unwanted frequencies. The blocking frequency and bandwidth are required for this.
When writing the parameter, the corresponding coefficients of the transfer function in **P 0327** are changed.
For parameterization of standard filters, field parameter **P 0325 CON_SCON_FilterReq** is provided to specify limit frequencies and bandwidths.

Settings for assistance parameter P 0326 CON_SCON_FilterAssi::

Table 62.1

P. no.	Parameter name/ Settings	Description in DM 5	Function
P 0325	CON_SCON_FilterFreq	Filter frequencies of digital filter	Limit frequencies
(0)	1 - 8000 Hz	1 st center/cutoff	1. Mid/blocking frequency
(1)	1 - 1000 Hz	1 st width	Width
(2)	1 - 8000 Hz	2 nd center/cutoff	2. Mid/blocking frequency
(3)	1 - 1000 Hu	2 nd width	Wide
P 0326	CON_SCON_FilterAssi	Digital filter design assistant	
(0)	OFF(0)	Reset & switch off filter	No filter active
(1)	USER(1)	Direct (write parameter CON_ DigFilCoeff)	manualy write of filter coefficient
(2)	Notch(2)	1. filter=notch, 2. filter=OFF	Selection of a notch filter with the blocking frequency from **P 0325(0)** and the bandwidth from **P 0325(1)**..
(3)	NOTCH_NOTCH(3)	1. filter=notch, 2. filter=notch	Selection of a notch filter with the blocking frequency from **P 0325(0)** and bandwidth from **P 0325(1)** in series with a notch filter with the blocking frequency from **P 0325(2)** and bandwidth from **P 0325(3)**.
(4)	NOTCH_PT1(4)	1. filter=notch, 2. filter=PT1	NOTCH_PT1(4) und NOTCH_PT2(5): Ein Notchfilter mit der Sperrfrequenz in **P 0325(0)** und Bandbreite in **P 0325(1)** in Reihe mit einem Tiefpassfilter mit der Grenzfrequenz in **P 0325(2)**.
(5)	NOTCH_PT2(5)	1. filter=notch, 2. filter=PT2	
(6)	PT1(6)	1. filter=OFF, 2. filter=PT1	PT1(6), PT2(7), PT3(8), PT4(9): A low-pass filter with limit frequency in P 0325(2) For lower frequencies the use of higher order filters (PT3, PT4) is not recommended.
(7)	PT2(7)	1. filter=OFF, 2. filter=PT2	
(8)	PT3(8)	1. filter=OFF, 2. filter=PT3	
(9)	PT4(9)	1. filter=OFF, 2. filter=PT4	
P 0327	CON_SCON_FilterPara	Coefficients of digital filter	Coefficients of the digital filter
(0)		a0*x(k)	
(1)	USER	a1*x(k-1)	
(2)	USER	a2*x(k-2)	
(3)	USER	a3*x(k-3)	
(4)	USER	a4*x(k-4)	
(5)	USER	b1*y(k-1	
(6)	USER	b2*y(k-2)	
(7)	USER	b3*y(k-3)	
(8)	USER	b4*y(k-4)	

Illustration 63.1 Frequency responses of PT1, PT2, PT3, PT4 filters

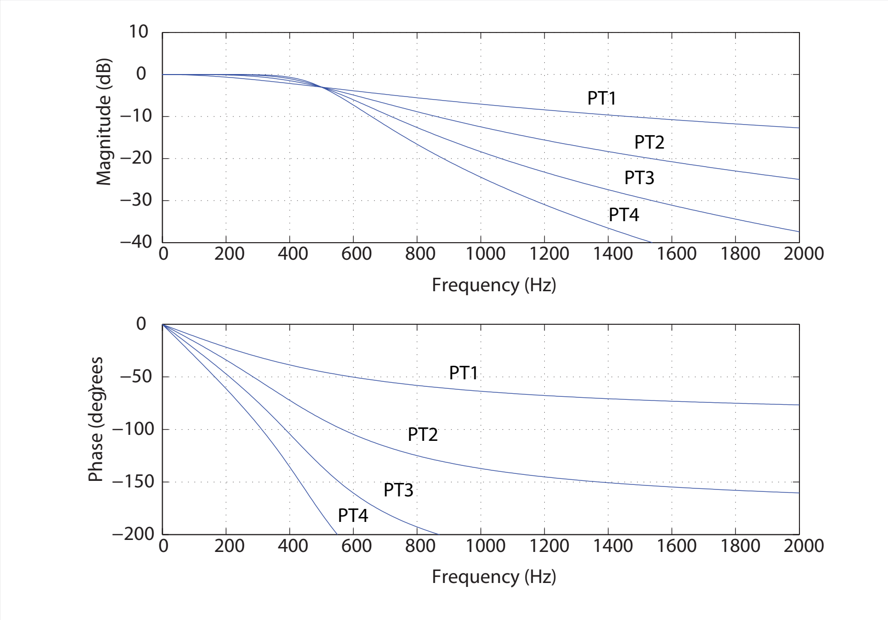
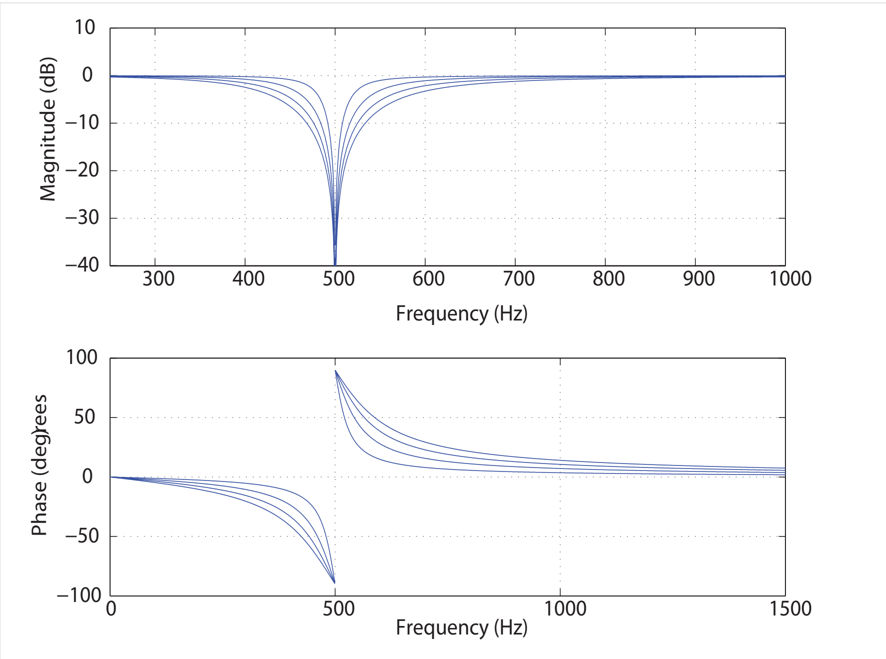


Illustration 63.2 Notch filter: Blocking frequency 500 Hz and bandwidths 25, 50, 75 and 100 Hz



Note that the filters not only have an effect on the amount but also on the phase of the frequency response. At lower frequencies higher-order filters (PT3, PT4) should not be used, as the phase within the control bandwidth is negatively influenced.

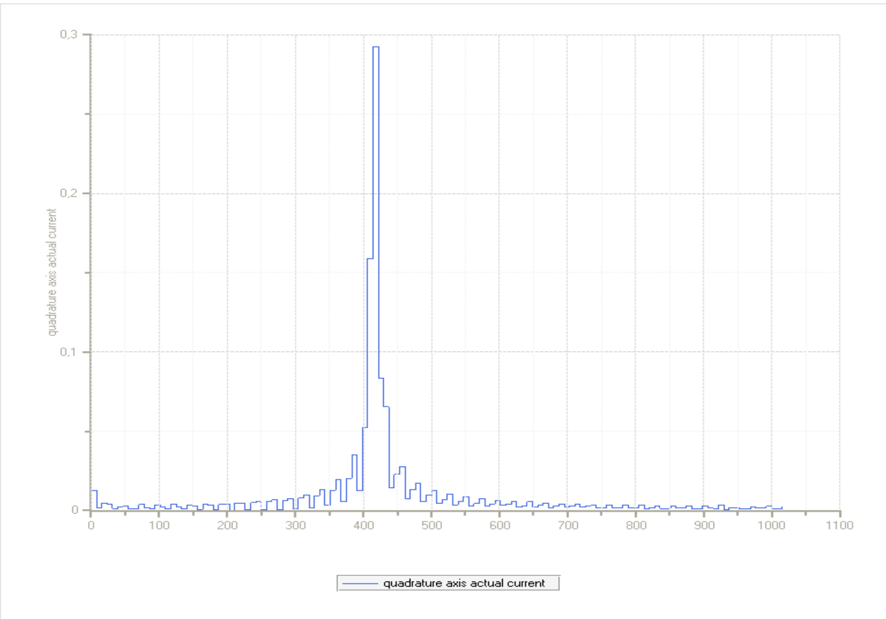
Note:
The coefficients can also be specified directly via parameter **P 0327 CON_SCON_FilterPara**. They take effect directly, so changing them is only recommended when the control is switched off.

Procedure:

- **Scope setting:**
  Isq (unfiltered, torque-forming current)
  Set shortest sampling time
- **Create scope plot without notch-filtering**
  Click "Mathematical functions" > FFT (Fourier analysis) icon. From the following pop-up menu choose isq. Disturbance frequency is displayed.
- **Select filter:** Select filter
- **center/cutoff:** Enter disturbance frequency
- **width:** Enter the bandwidth of the disturbance frequency; the width has no effect when using PTx filters
- **Create scope plot with notch-filtering**

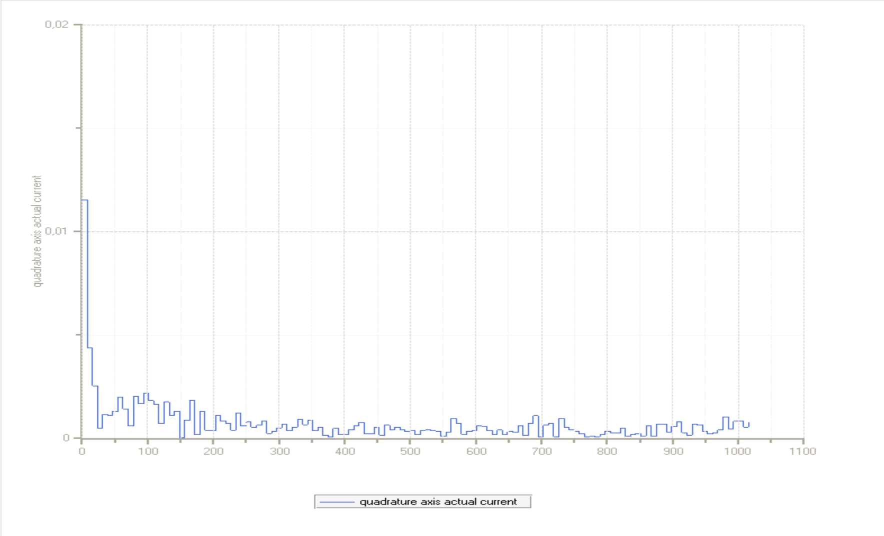
Note:
A higher bandwidth results in less attenuation of the blocking frequency because of the filter structure.

Illustration 64.1 Oscillation of a motor shaft under current at standstill without filter



Oscillation suppression by a notch filter:

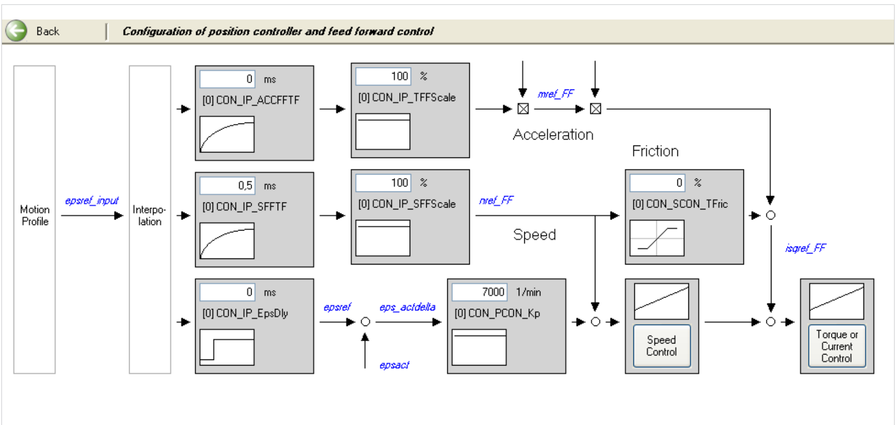
Illustration 65.1 Motor shaft under current at standstill with activated notch filter (width f= 40Hz, mid-frquency f = 420 Hz)



4.4 Position control

The higher the dynamism of the speed controller, the more dynamically the position controller can be set and the tracking error minimized. In order to improve the dynamism and performance of the position controller, the parameters listed in the screen below are available to optimize the speed and acceleration feedforward.

Illustration 65.2 Position controller setup screen

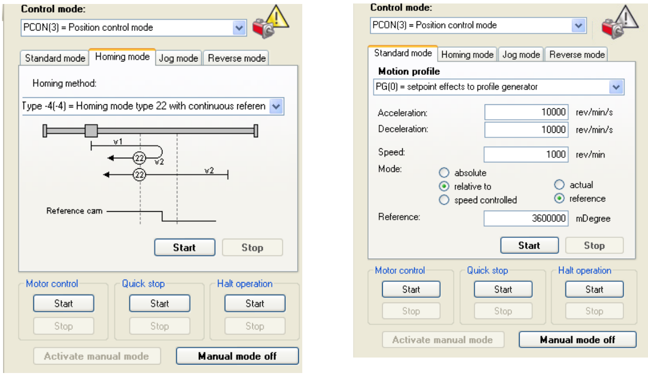


Note:
When adjusting the stiffness, feedforward will be aligned accordingly.

Position controller optimization:
The reference values for the necessary reference steps for controller optimization can be easily preset by way of a reference table or the Control window (see also „Motion profile“ section).

Reference via manual mode window

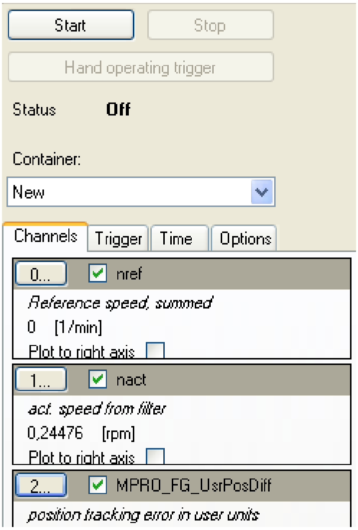
Illustration 66.1 Setting for Control window and scope in position controller optimization



- Control mode „PCON“
- Select homing method -1. Type -1 sets the current position as the zero.
- Start the power stage via „START“(motion control)
- Start/stop homing mode

- Select standard mode
- Set ramps
- Specify position reference
- Activate scope function (see Scope screen)
- Start motion

Illustration 67.1 Oscilloscope settings



Open scope:
Setting:
Channel:
CH 0 = speed reference (6 nref)
CH 1 = actual speed (13 nact)
CH 2 = tracking error in user units (279 UsrPosDiff)

Trigger:
Trigger signal: Speed reference (6 nref)
Mode: Rising edge
Level: 30 rpm
Pretrigger: 10 %

Time:
Samplingtime: = base time
(6,25E-0,5 s)
Recording time = 1,0 s

The position controller gain:
When a standard motor data set is read-in, the position controller gain is also adopted. The setting equates to a controller with a medium rigidity.

Note:
In the default setting no smoothing is selected!

Illustration 68.1 Position gain after read-in of a standard motor data set

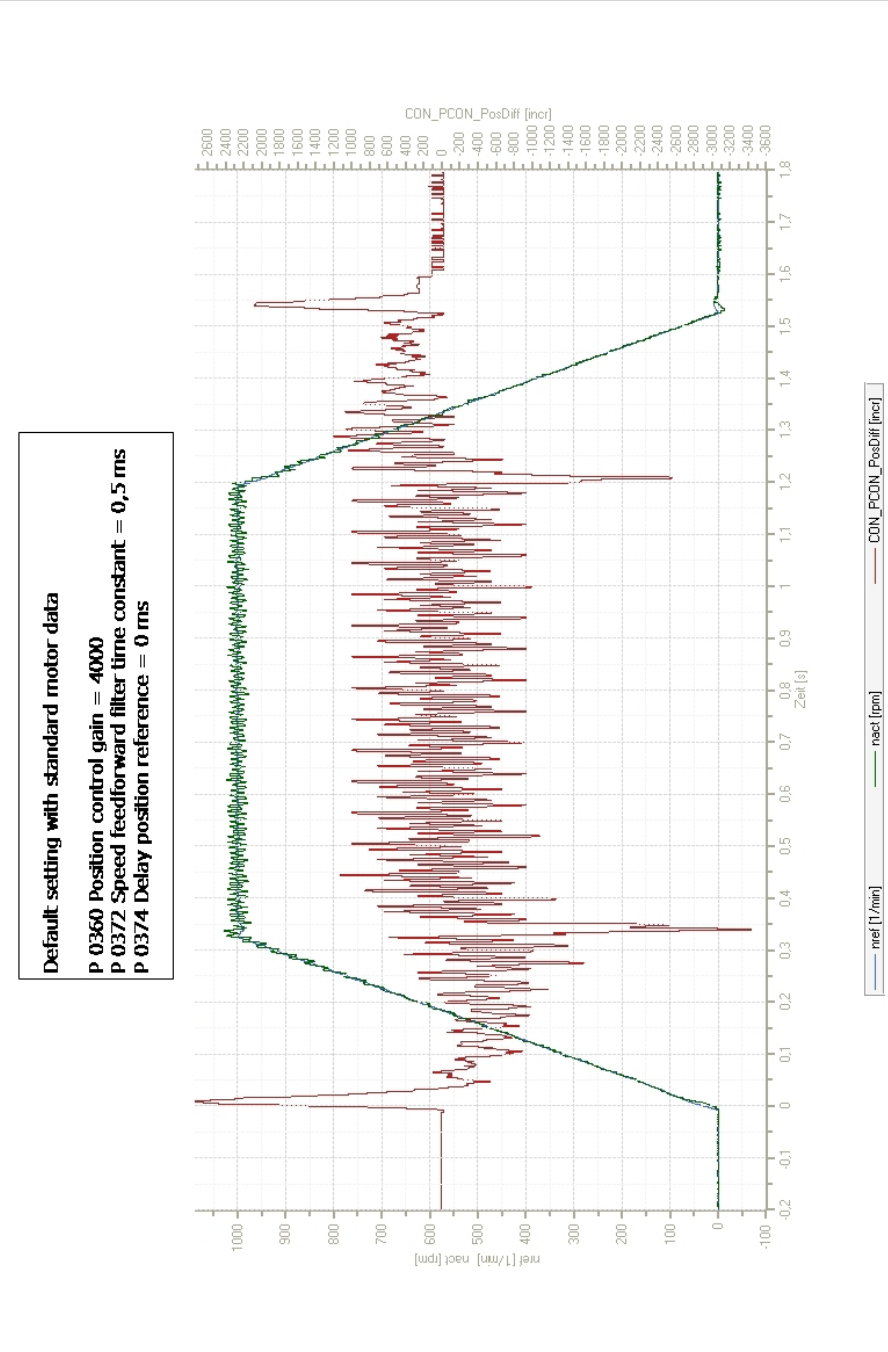
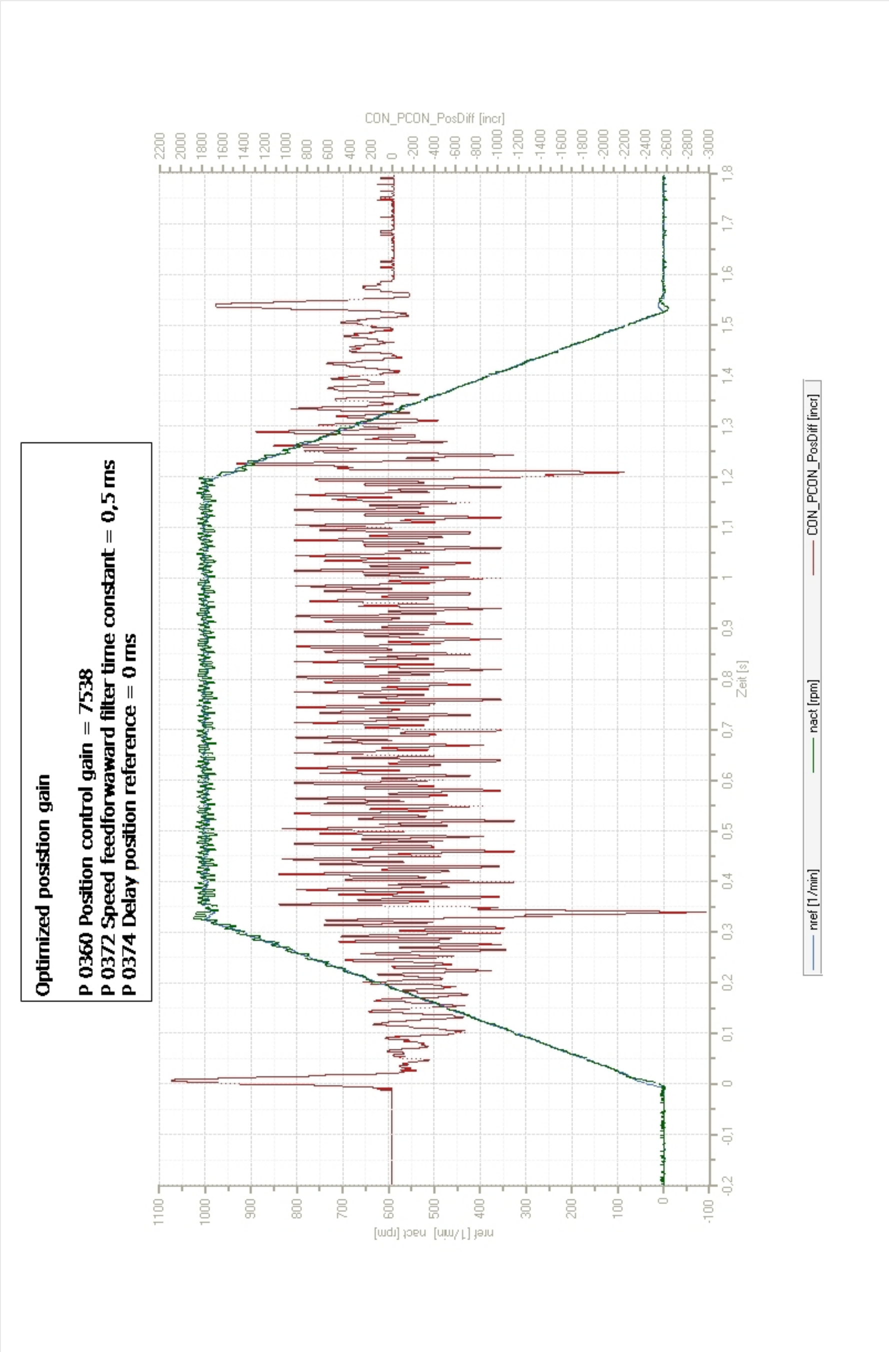


Illustration 69.1 Optimized position gain: KP position from 4000 to 7538



Feedforward of speed, torque/force
The feedforward of the acceleration torque relieves the strain on the speed controller and optimizes the control response of the drive. To feedforward the acceleration torque, the mass inertia reduced to the motor shaft must be known.

If the parameter for the overall mass inertia of the system **P 1516** has a value unequal to 0, that value will be automatically used to feedforward the acceleration torque.

The feedforward of the speed reference is preset by default to 100 % via parameter **P 0375 CON_IP_SFF_Scale**. This value should not be changed.

The acceleration torque feedforward can be optimized with **P 0376 CON_IP_TFF_Scale**. Reducing this reduces the feedforward value; conversely, increasing this value also increases the feedforward value.

The position tracking error can be further reduced by predictive torque and speed feedforward – that is, in advance of the position reference setting. Owing to the time-discrete mode of operation of the control circuits and the limited dynamism of the current control circuit, this prediction is necessary to prevent the individual control circuits from oscillating against one another. Prediction in feedforward is achieved by delaying the speed and position controller reference setpoints.

Table 70.1 Feedforward parameters:

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0360	CON_PCON_KP	Position control gain	Gain of position controller
P 0372	CON_IP_SFFTF	Speed feedforward filter time for position control	Filter time for position controller feedforward
P 0374	CON_IP_EpsDly	Position delay time	Delay time for position control feedforward
P 0375	CON_IP_SFFScale	Speed feedforward scaling factor	Speed control feedforward scaling factor
P 0376	CON_IP_TFFScale	Torque/Force feedforward scaling factor	Torque control feedforward scaling factor
P 0378	CON_IP_ACC_FFTF	Acceleration feed forward filter time	Filter time for acceleration feedforward
P 0386	CON_SCON_TFric	Friction compensation scaling factor	Scaling factor for friction compensation
P 1516	SCD_Jsum	Total inertia of motor and plant	Reduced mass inertia of motor and machinet

⚠

Attention!
When using linear interpolation, feedforward is inactive.

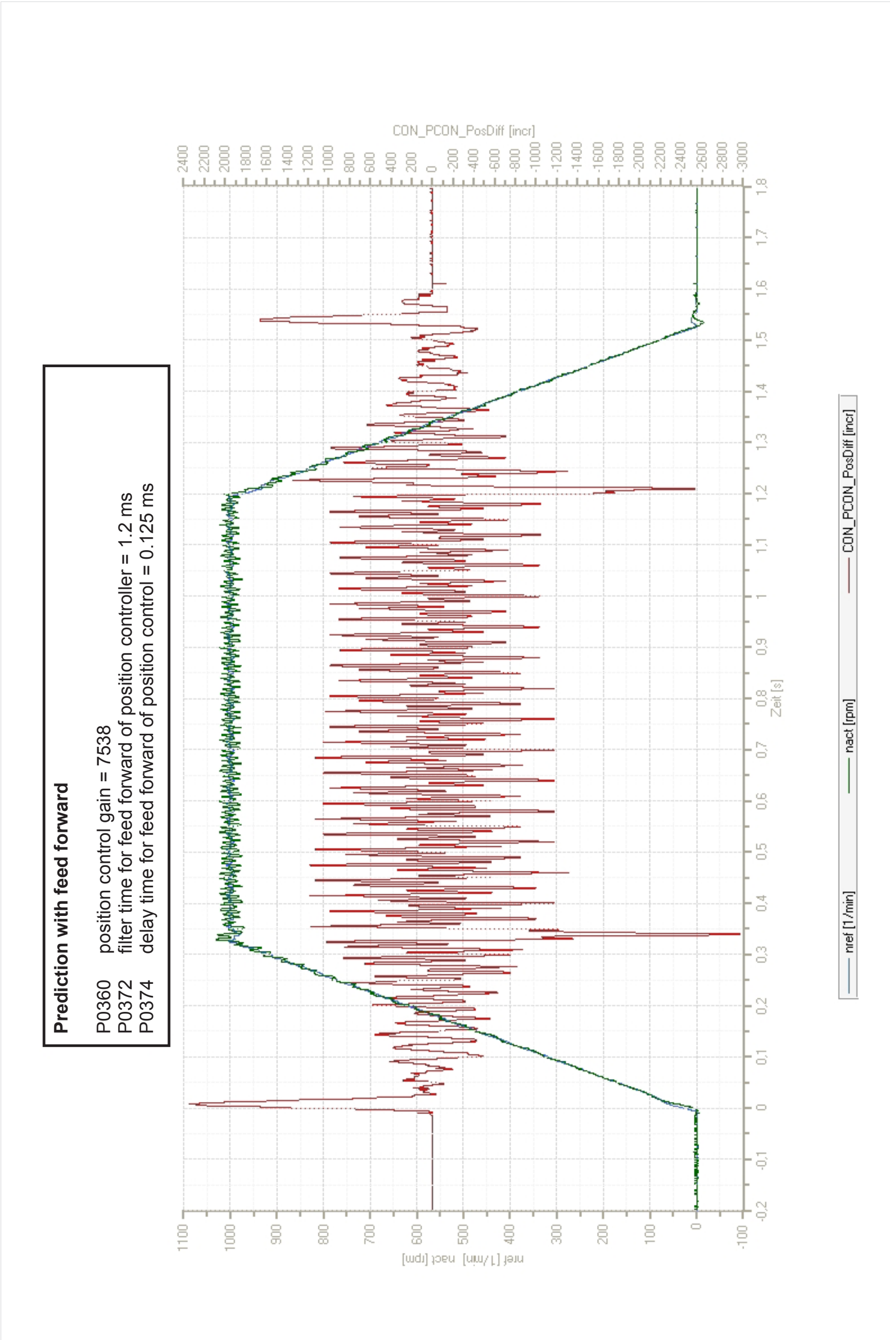
Note:
The overall mass moment of inertia in **P 1516** must not be changed to optimize the feedforward, because this would also have an effect on other controller settings!

⚠

Attention!
In multi-axis applications requiring precise three-dimensional axis coordination, such as in the case of machine tools, the delay of the position signal must be equally set on all axes via parameter **P 0374-IP_EpsDly**. Otherwise the synchronization of the axes may suffer, leading to three-dimensional path errors..

The value in **P 0372 CON_IP_SFFFT** for the PT1 filter to delay the speed feedforward value should be chosen slightly larger than the value for the actual speed value filter **P 0351 CON SCALC_TF**.
Useful values for floating mean value filters to delay the position reference setpoint are between 0.0625 ms and 1.5 ms.

Illustration 72.1   Prediction with feedforward



Friction torque
It is advisable to compensate for higher friction torques in order to minimize tracking error when reversing the speed of the axis. The drive controller permits compensation for Coulomb friction components by means of a signum function dependent on the reference speed **„nref_FF“**. The speed controller can compensate for the other (e.g. viscous) friction components because of their lower change dynamism. The compensation can be effected step-by-step as a percentage of the rated motor torque by means of **P 386 CON_SCON_TFric**.

The following graph shows a good match between the feedforward torque reference and the actual torque value.

Illustration 73.1 Graph of feedforward torque reference and actual torque value

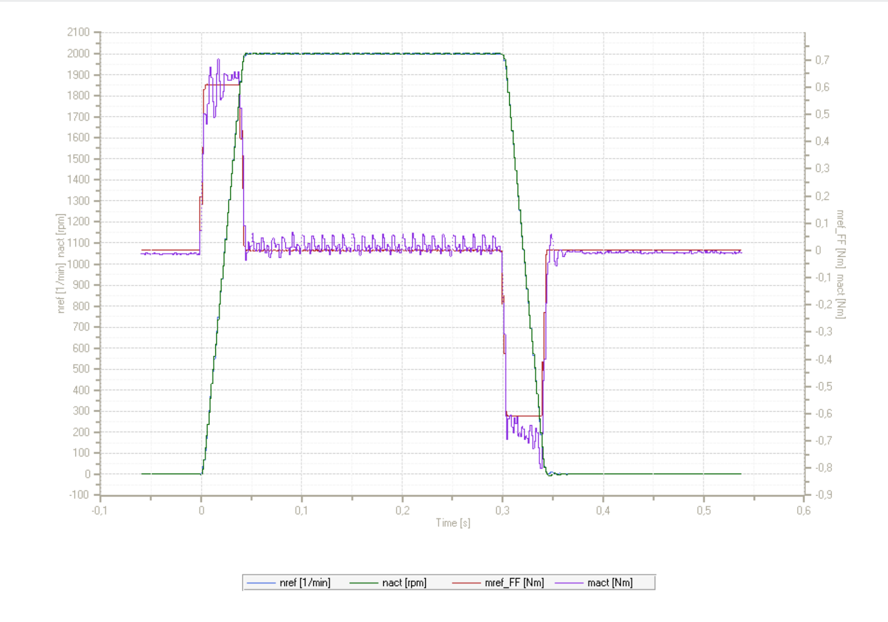


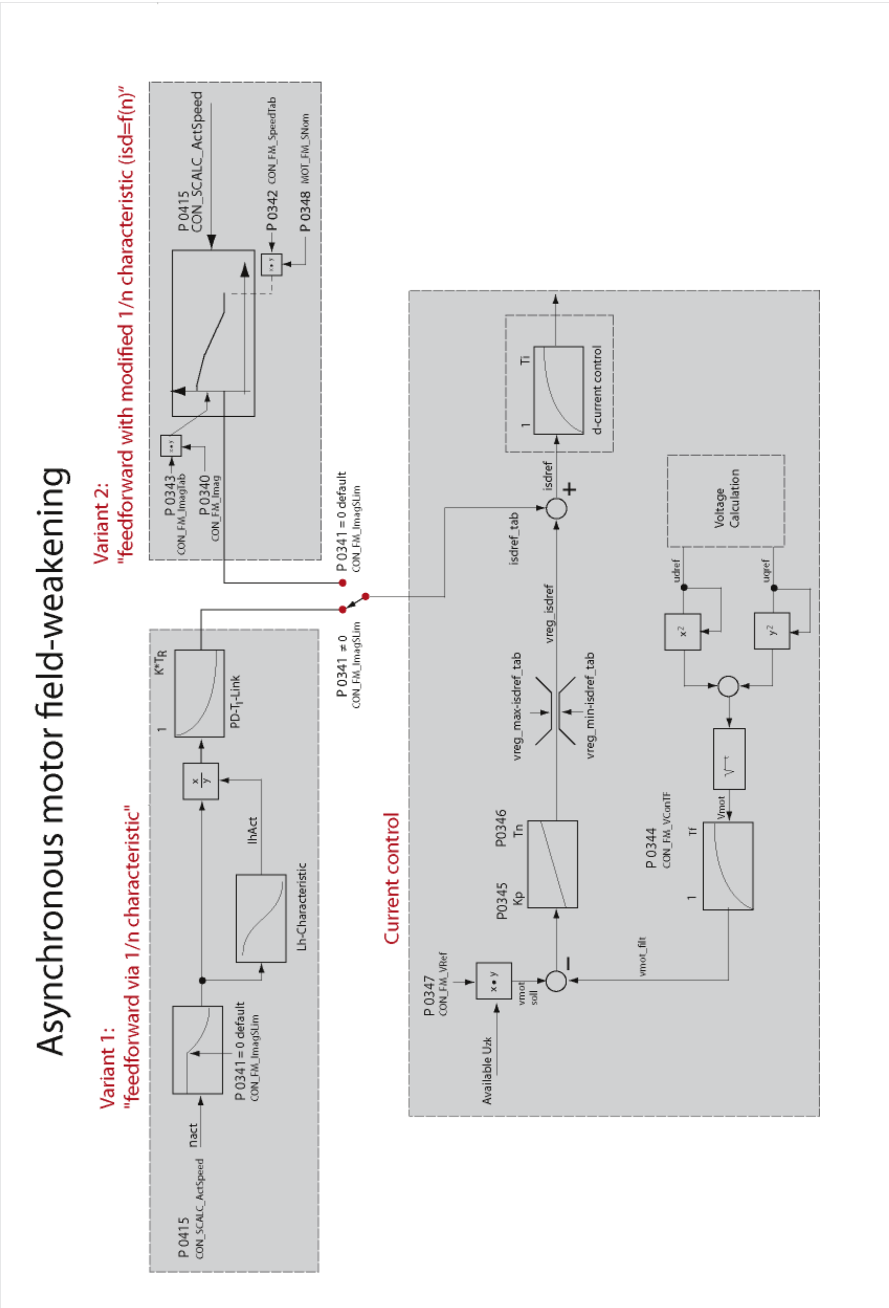
Table 74.1

P. no.	Value	Function
P 0351	1,2 ms	Speed controller filter time
P 0360	30000	Position controller gain
P 0372	1,2 ms	Filter time for position controller feedforward
P 0374	0,125 ms	Delay time for position control feedforward
P 0375	100 %	Speed control feedforward scaling factor
P 0376	100 %	Torque control feedforward scaling factor
P 0386	6 %	Compensation of friction torques
P 1516	0,00014 kgm2	Mass inertia

4.5 Asynchronous motor field-weakening

For field-weakening of asynchronous motors, the motor parameters must be known very precisely. This applies in particular to the dependency of the main inductance on the magnetizing current.
It is essential to carry out a motor identification for field-weakening mode.
In the process, default values for the control circuits and the "magnetic operating point" are set based on the rated motor data and the magnetizing current presetting in **P340 CON_FM_Imag**. Two variants are available for operation in field-weakening mode.

Illustration 75.1 Asynchronous machine field-weakening



Variant 1 (recommended setting):
Combination of „**feedforward via 1/n characteristic“ + voltage controller**. The motor identification sets the voltage controller so that the voltage supply in a weakened field is adequate. If the drive controller is at the voltage limit, it reduces the d-current and thus the rotor flux.
Since the controller has only limited dynamism, and starts to oscillate if larger gain factors are set, there is a second option.

Variant 2:
Combination of „**feedforward with modified 1/n characteristic (isd=f(n)**“ + voltage controller.
This characteristic describes the magnetizing current as a percentage of the nominal value of P 0340 CON_FM_Imag dependent on the speed.
The choice between the modified 1/n characteristic and the static characteristic is based on parameter P 0341 **CON_FM_ImagSLim**.
P 0341 ≠ 0 signifies selection of the 1/n-characteristic (default)
P 0341 = 0 signifies selection of the modified 1/n characteristic isd = f(n).
Following a motor identification the voltage controller is always active, as the controller parameters are preset (**P 0345 = 0** deactivates the voltage controller).

Parameterizing of Variant 2
Setting the d-current dependent on the speed. The speed is specified relative to the rated speed in **P0458 MOT_SNom**, the d-current relative to the magnetizing current in parameter **P 0340 CON_FM_Imag**. Up to the field-weakening speed, a constant magnetizing current is injected **P 0340**.

Procedure:

- **P 0341 = 0** (selection of modified characteristic) + voltage controller
- Approach desired speeds slowly
- Adjust scope: Isdref /
- SQRT2*Imag = %-value of speed
  The maximum amount of the "field-weakening" d-current is defined by parameter **CON_FM_Imag P340** (specification of effective value).
- Enter values in table **P 0342** Example:

Table 76.1 Example:

Index (0-7)	**P 0348 Rated speed P 0340 I_{mag}eff**	**P 0342 (0-7) Field-weakening speed in[%]**	**P 0343 (0-7) Magnetizing current in field-weakening mode in [%]**
(0)	n_{nenn} = 1800 rpm I_{mag} eff = 100 %	100	100
(1)		110	100
(2)		120	100
(3)		130	100
(4)		140	90
(5)		150	70
(6)		160	55
(7)		170	0

Table 77.1

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0340	CON_FM_Imag	Magnetization current (r.m.s)	Effective value of the rated current for magnetization
P 0341	CON_FM_ImagSLim	Only valid for ASM	Field-weakening activation point (as % of **P 0348 MOT_SNom)**. This effects the switch to the 1/n characteristic **P 0341 ≠ 0**. For **P 0341 = 0** the field-weakening works via the modified characteristic isd = f(n). For a synchronous machine this value must be set to 0.
P 0342	CON_FM_SpeedTab	Speed values for mag. current scaling	Speed values scaled as % of **P 0458** n_{nenn} to populate the modified table
P 0343	CON_FM_ImagTab	Mag. current scaling vs. speed	d-current scaled as % of P 0340 I_{mag} eff. to populate the modified table

Voltage controller parameters
The voltage controller is overlaid on the selected characteristic. When using the voltage controller, a portion of the available voltage is used as a control reserve. The more dynamic the running, the more control reserve is required. In this case it may be that the voltage for rated operation is not sufficient, and also that the controller starts to oscillate.

The PI voltage controller can be optimized by adaptation of the P gain **P 0345**, the lag time **P 0346** and the filter time constant for the motor voltage feedback **P 0344**. Parameter **P 0347** sets the voltage reference, though the threshold needs to be reduced in response to rising demands as this maintains a kind of voltage reserve for dynamic control processes.

A certain voltage reserve is necessary for stable operation. It is specified by way of parameter **P347 CON_FM_VRef** (< 100 %). The value should be set high (< = 90 %) where there are high demands in terms of dynamism. For less dynamic response, the maximum attainable torque can be optimized by higher values (> 90 %).

Note:
If the control reserve is too small, the inverter typically shuts off with an overcurrent error.

Table 78.1 Parameters

P. no.	**Parameter name/ settings**	Designation in DM5	Function
P 0344	CON_FM_VConTF	Voltage control filter time constant	Time constant of the voltage controller actual value filter r
P 0345	CON_FM_VConKp	Voltage control gain	Voltage controller gain factor Kp
P 0346	CON_FM_VConTn	Voltage control integration time constant	Voltage controller lag time Tn
P 0347	CON_FM_VRef	Voltage control reference (scaling of max. voltage)	Voltage controller reference (as % of the current DC link voltage) If the value 0 % is set, the controller is not active.
P 0458	MOT_SNom	Motor rated speed	Rated speed of the motor

Table 78.2 Default values:

P 0344	CON_M_VConTf	10 ms
P 0345	CON_FM_VConKp	0,1 A/V
P 0346	CON_FM_VCon_Tn	100 ms
P 0347	CON_FN_VRef	90 %

4.6 Synchronous motor field-weakening

Synchronous motors can also be operated above their rated speed at rated voltage, by reducing their voltage consumption based on injection of a current component.

The following conditions must be met:

1. To effectively reduce the voltage demand, the magnitude of **P 0471** stator inductance multiplied by **P 457** rated current must be large enough relative to **P 0462** rotor flux.

Equation 79.1 Bedingung:

$$C_{Nom} * L_{sig} > \text{Factor} * \text{Flux}_{Nom}$$

$$P\,0457 * P\,0471 > \text{Factor} * P\,0462$$

Reference: Factor > 0,2

Attention!

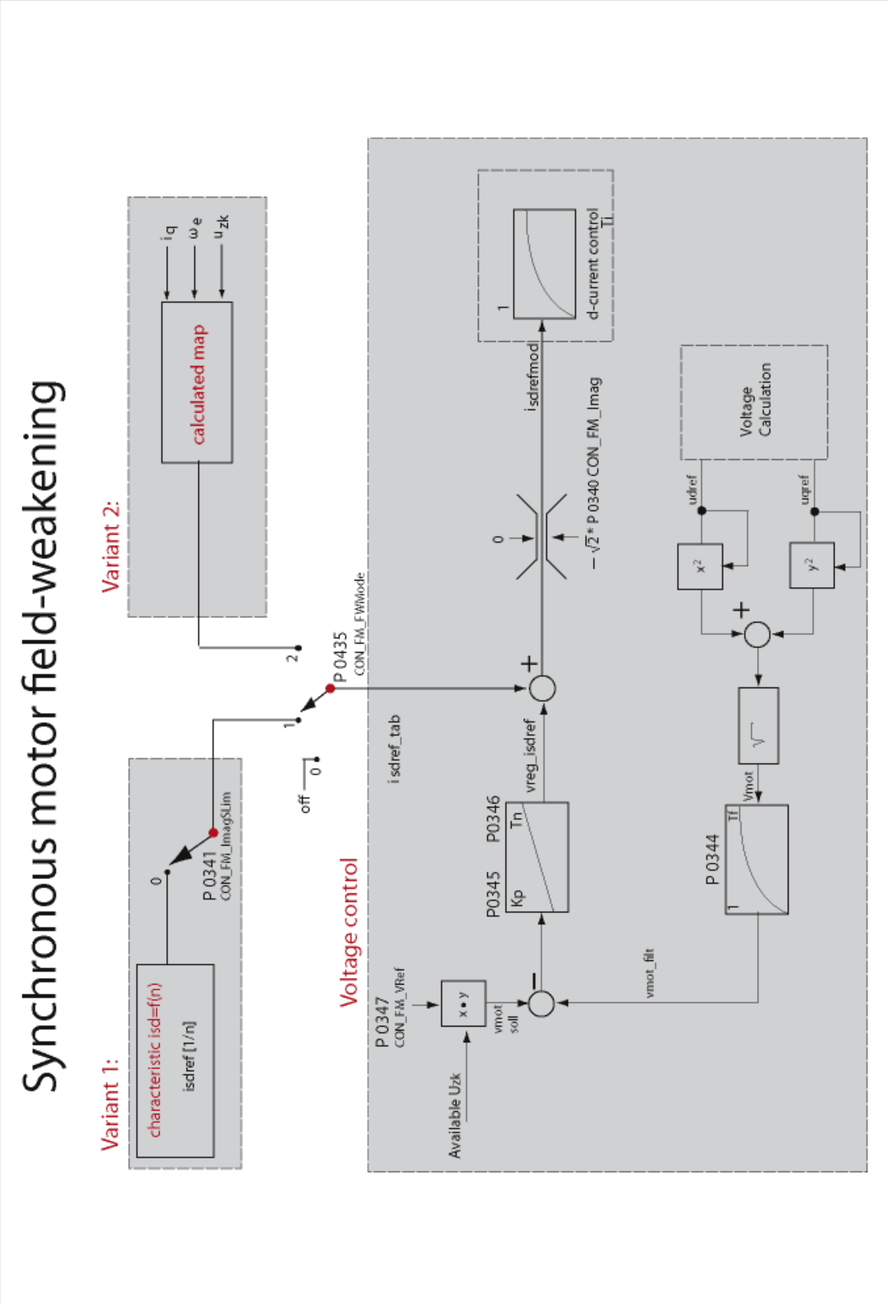
2. If the speed achieved by field-weakening is so high that the induced voltage exceeds the overvoltage threshold of the device (for 400 V devices approximately 800 V, for 230 V devices approximately 400 V), this will result in DESTRUCTION of the servocontroller if no additional external safety measures are applied.

Equation 79.2 Condition:

$$\underset{P\,0462}{\textbf{Rotor flux}} * \left(\underset{P\,458\,*\,P\,0328}{\textbf{Speed}} * \frac{2\Pi}{60}\ \text{(in rad/s)} \right) * \underset{P\,0463}{\text{Number of pole pairs}} * \sqrt{3} < \begin{matrix} \text{800 V (400 V device)} \\ \text{400 V (230 V device)} \end{matrix}$$

3. In contrast to field-weakening of asynchronous motors, synchronous motors can also be operated in the “field-weakening range” with full rated torque at the nominal value of the q-current. Power beyond the rated power output can therefore be drawn from the machine in field-weakening mode, even at rated current. This must be taken into consideration when configuring the motor.

Illustration 80.1 Synchronous machine field-weakening



There are also two variants for field-weakening of synchronous motors. The choice of variant 1 or 2 is made via parameter **P0435 FWMode**.

Table 81.1

P. no.	Parameter name/ settings	Designation in DM5	Function
P 0435	CON_FM_FWMode	Fieldweakening mode for synchrounus motors	Selection mode for field-weakening of synchronous motors
(0)	None	Fieldweakening is disabled	Field-weakening is off, regardless of other settings.
(1)	Table	Isd set by PI Controller and table parameter	Field-weakening is effected by way of a characteristic which specifies the d-current dependent on the speed isd = f(n) (parameters **P 0342** and **P 0343**).
(2)	Calc	Isd set by PI Controller and motor parameters	Field-weakening is effected by way of a characteristic which is set internally via the motor parameters. The d-current reference is then calculated dependent on the speed and the required q-current. The inaccuracies with regard to the motor parameters, the available voltage etc. can be compensated by way of the Scale parameters P 0436.

Note:
In mode 1 and mode 2 the voltage controller can be overlaid. It is also possible in mode 1 to disable the characteristic and run solely with the voltage controller.

Selection of modified 1/n characteristic + voltage controller P 0435 = 1:

- Activate table: **P 0341 = 0**
- **P 0435 CON_FM_FWMode** = (1) Select table
- Approach desired speeds slowly
- Adjust scope: Isdref/SQU2*Imag = % = field-weakening speed. The maximum amount of the “field-weakening” d-current is defined by parameter **CON_FM_Imag P 0340** (specification of effective value).
- Enter values in table **P 0342**

Table 81.2 Example::

Index (0-7)	P 0348 Rated speed P 0340 I_{mag}eff	P 0342 (0-7) Field-weakening speed in [%]	P 0343 (0-7) Flux-forming current I_{sdref} mod in field-weakening mode in [%]
(0)	n_{nenn} = 1800 rpm I_{mag} eff = 100 %	100	0
(1)		110	55
(2)		120	70
(3)		130	90
(4)		140	100
(5)		150	100
(6)		160	100
(7)		170	100

Attention!
The speeds in P 0342 CON_FM_SpeedTab must continuously increase from index 0 -7. If only low dynamism is required, the table should be deactivated **(P 0345 = 0).**

Voltage controller:
If the voltage controller oscillates the gain must be reduced. If substantial variations between the q-current reference and actual values occur during run-up to reference speed in the field-weakening range, the drive may be at the voltage limit. In this case, a check should first be made as to whether the preset maximum value P 0340 has already been reached and can be increased. If the maximum value has not yet been reached, the voltage controller is not dynamic enough and the gain P 0345 must be increased.

If no suitable compromise can be found, the voltage threshold as from which the voltage controller intervenes must be reduced by the scaling parameter **P 0347 CON_FM_VRef**. This then also quadratically reduces the torque available. If the response with voltage controller is unproblematic and no particular demands are made in terms of dynamism, the available torque can be optimized by setting **P 0347** to values up to 98 %.

Selection of "calculated map" + voltage controller P 0435 = 2:

In the case of very rapid speed or load changes in the field-weakening range, the setting
P 0435 CON_FM_FwMode = 2 is selected.
A characteristic for a higher control dynamism is calculated internally.

Features of this method:

- Very fast adaptations, with high dynamism, are possible (open-loop control method).
- Motor parameters must be known quite precisely.
- A badly set table can result in continuous oscillation.

If continuous oscillation occurs, it should first be determined whether the drive is temporarily at the voltage limit. The preset negative d-current value is then not sufficient. In this case the scaling parameter **P 0436** can be used to evaluate the map at higher speeds (**P 0436** > 100 %).

The voltage controller is overlaid on the evaluation of the map. The voltage controller can be set in the same way as described above for setting 1.

The set combination of voltage controller and map entails the highest commissioning commitment, but it enables the best stationary behaviour (highest torque relative to current) and the best dynamic response to be achieved.

Attention!
When configuring projects, it must be ensured that the speed NEVER exceeds the value of **P 0458** $\mathbf{n}_{max}$. In such cases the induced no-load voltage reaches the overvoltage limit.

4.7 Autocommutation

For field-oriented regulation of permanently excited synchronous machines with a purely incremental measuring system, the commutation position must be determined once when the control is started (adjustment of current rotor position to encoder zero [Encoder offset]).

This procedure is executed by the „Autocommutation“ function after initial enabling of the control when the mains voltage has been switched on for the first time. It can also be forced during commissioning by changing a parameter, which causes a complete controller initialization (e.g. change of autocommutation parameters, change of control mode, etc.).

Owing to the differing requirements arising from the applications, various commutation methods are provided. The selection is made via the selector **P 0390 CON_ICOM**.

For synchronous machines with no absolute measuring system, the two methods **IENCC(1)** and **IECON(4)** are recommended. Use of the much more complex **LHMESS(2)** commutation method requires prior consultation with Harmonic Drive AG.

Table 83.1 Selection of commutation method:

P. no.	Parameter name/ settings	Designation in DM 5	Function
P 0390	CON_ICOM	Selection of commutationfind-ing-method	Selection of the commutation method
	OFF(0)	Function off	off
	IENCC(1)	Current injection	Autocommutation IENCC (1) with motion: A method that is easy to parameterize, but which causes the rotor to move as much as half a revolution, or half a pole pitch (with p = 1).
	LHMESS(2)	Saturation of inductance evaluated	2. Autocommutation LHMES (2) with braked machine: During autocommutation the machine must be blocked by a suit-able brake. The occurring torques and forces may attain the rated torque and force of the machine.
	IECSC(3)	Not implemented	Not implemented!
	IECON(4)	Current injection minimized movement	Autocommutation IENCC (4) with minimized motion: In this case, too, the rotor must be able to move. However, with suitable parameterization the rotor movement can be reduced to just a few degrees/mm
	HALLS(5)	Not implemented yet	as from V 3.0

The IENCC(1) method (movement of shaft permitted)

With IENCC the rotor aligns in direction of the injected current and thus in a defined position. The relatively large movement (up to half a rotor revolution) must be taken into consideration.

This method cannot be used near end stops or limit switches! It is advisable to use the rated current I_{nom} for the injected current. The time should be set so that the rotor is at rest during the measurement. For control purposes, the commutation process can be recorded with the DriveManager Scope function.

The IECON(4) method (movement of shaft not permitted)

The motor shaft motion can be minimized by a shaft angle controller. The structure and parameters of the speed controller are used for the purpose. The gain can be scaled via parameter **P 0391 CON_ICOM_KpScale**. This therefore means that the speed control loop must already be set.

- Increasing the gain results in a reduction of the motion.
- An excessively high gain will result in oscillation and noise. In both methods (1) and (4) the flux-forming current „Isdref" is injected as a test signal, the characteristic of which is shown in the diagram. The diagram illustrates the IECON(4) method

Illustration 84.1 Schematic for the IENCC(1) and IECON(4) methods

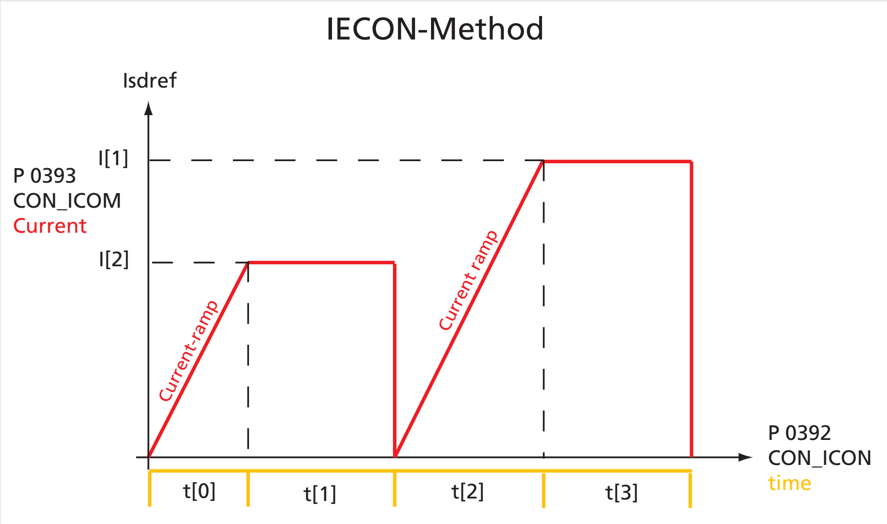


Table 84.2 Parameter setting:

P. no.	Setting	Function
P 0391	0-10000 %	Scaling of dynamism
P 0392	0-10000 ms	Measuring time
(0)	500 ms	Ramp time t[0]
(1)	500 ms	Injected current time t[1]
(2)	500 ms	Ramp time t[2]
(3)	500 ms	Injected current time t[3]
P 0393	Preferential value	
(0)	I[1]	Rated current: I_{nom} Step 1
(1)	I[2]	Rated current: I_{nom} Step 2

For linear motors the values for time and current adjust automatically when calculating the data set.

Note:
- Inexperienced users should always choose the rated motor current (amplitude) as the current and a time of at least 4 seconds.
- The motor may possibly move jerkily during autocommutation. The coupled mechanical system must be rated accordingly.
- If the axis is blocked, i.e. the rotor is unable to align itself, the method will not work correctly. As a result, the commutation angle will be incorrectly defined and the motor may perform uncontrolled movements.

Description of the LHMES(2) method with a braked machine:
With this method, saturation effects in stator inductance are evaluated. Two test signal sequences are used for this purpose, whereby the position of the rotor axis is known after the first sequence and the direction of movement after the second.

This method is suitable for determining the rotor position with braked rotors or motors with a relatively high mass inertia.

Precondition:
The rotor must be firmly braked, so that the motor is unable to move, even when rated current is applied.
The stator of the machine must be iron-core..

Table 85.1 Parameterization of a test signal (example):

Frequency of test signal	f = 333 Hz	P 1506
Amplitude	1 A	P 1505
Number of periods	50	P 1508
Direct component	3,1 A	P 1503

In most cases a good result is achieved with a test signal frequency of 333 Hz, an amplitude of the magnitude of one quarter of the rated current, evaluation of 50 oscillations and a direct component equivalent to the rated current (3.1A).

Attention!
Parameters of the "Autocommutation" subject area must only be changed by qualified personnel. If they are set incorrectly the motor may start up in an uncontrolled manner.

Note:
It is advisable to parameterize speed tracking error monitoring with the "Power stage off" error response. This monitoring feature reliably prevents the motor from racing.

4.8 Commissioning

4.8.1 Autotuning
The drive controller is able to automatically determine the moment of inertia reduced to the motor shaft by means of a test signal. However, this requires that the mass moment of inertia only fluctuates very little or not at all during motion.
The moment of inertia has the following effect on the control response:
- It is taken into account when calculating the speed controller gain.
- In feedforward the moment of inertia is used to translate the acceleration into force/torque or q-current.
- With a parameterized observer it represents a model parameter and the calculation of the observer gain is based on the adjusted value.

To determine the mass inertia, the drive controller generates a pendulum movement of the connected motor complete with the mechanism and uses the ratio of acceleration torque to speed change to determine the mass inertia of the overall system.

After the control has been started, determination of the mass inertia is activated by setting the control word **P 1517 SCD_AT_JsumCon** to the value Start(2). The drive executes a short pendulum movement by accelerating several times with the parameterized torque **P 1519 SCD_AT_SConHysTorq** to the parameterized speed **P 1518 SCD_AT_SConHys-Speed**. If the torque and speed have not been parameterized (setting zero), the process uses default values determined on the basis of the rated speed and nominal torque.

The mass moment of inertia determined for the entire system is calculated after the end of the test signal and entered in parameter **P 1516 SCD_Jsum**.

Table 86.1 Parameters:

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 1515	SCD_ConDesign	Speed and position control dynamic (stiffness)	Rigidity of the mechanism
P 1516	SCD_Jsum	Total inertia of motor and plant	Mass moment of inertia (motor and load)
P 1517	SCD_AT_JsumCon	Autotuning for Jsum estimation, control word	Automatic estimation of mass inertia, control word
P 1518	SCD_AT_SConHysSpeed	Autotuning Jsum, hysteresis speed control, speed limit	Limitation of speed
P 1519	SCD_AT_SConHysTorq	Autotuning Jsum, hysteresis speed control, torque limit	Limitation of torque

4.8.2 Test signal generator (TG)

The TG is a function for optimization of the control loops over a protracted period of motion with a reference value sequence. The TG is particularly well suited to current controller optimization.
Various signal forms can be generated, with the possibility of overlaying different signal forms.

Table 86.2

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0400	CON_FM_AddIsdRef	Additional d-current	d-current reference
P 0401	CON_SCON_AddTRef	Additional torque/force refer-ence value	Torque/force reference
P 0402	CON_SCON_AddSRef	Additional speed reference value, direct without ramp	Speed reference without ramps
P 0403	CON_IP_AddEpsRef	Additional position reference value	Position reference
P 0404	CON_SCON_AddSRamp	Additional speed reference value, via ramp generator	Speed reference with ramp

Note:
By additive reference values pay attention for the control mode.

Illustration 87.1 Structure of the test signal generator

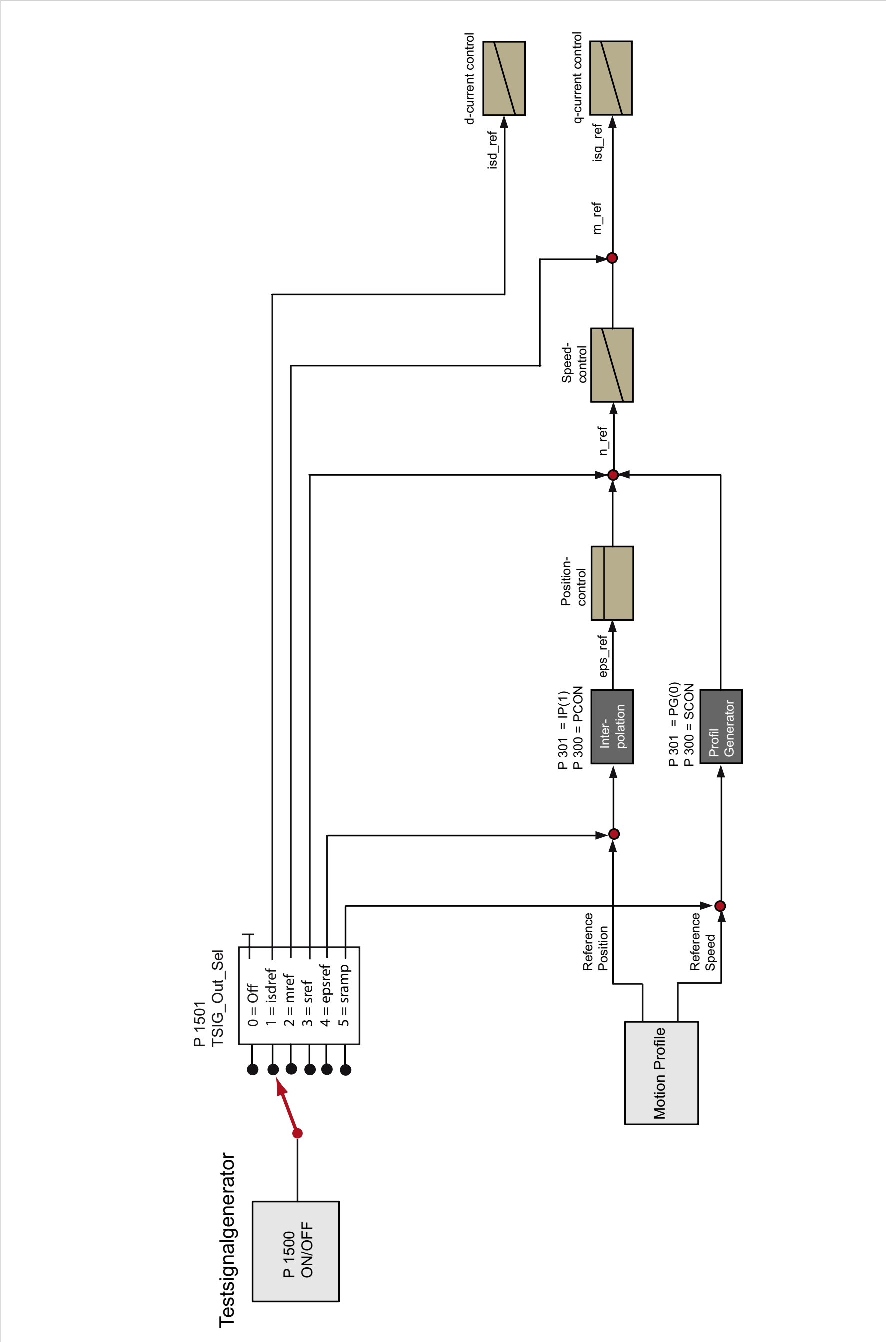
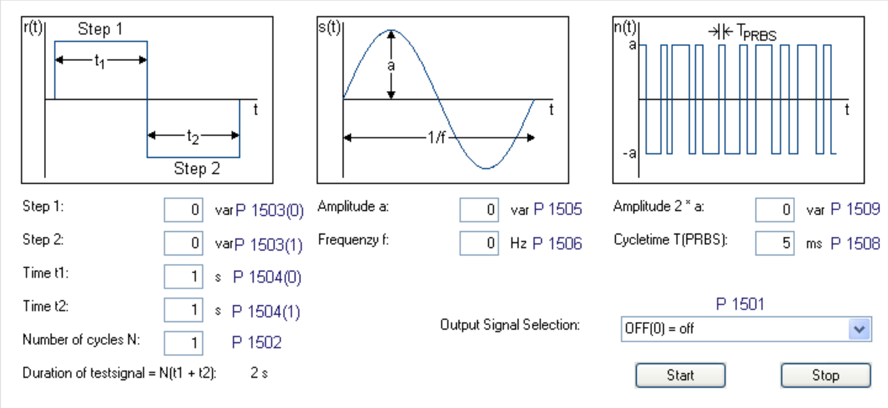


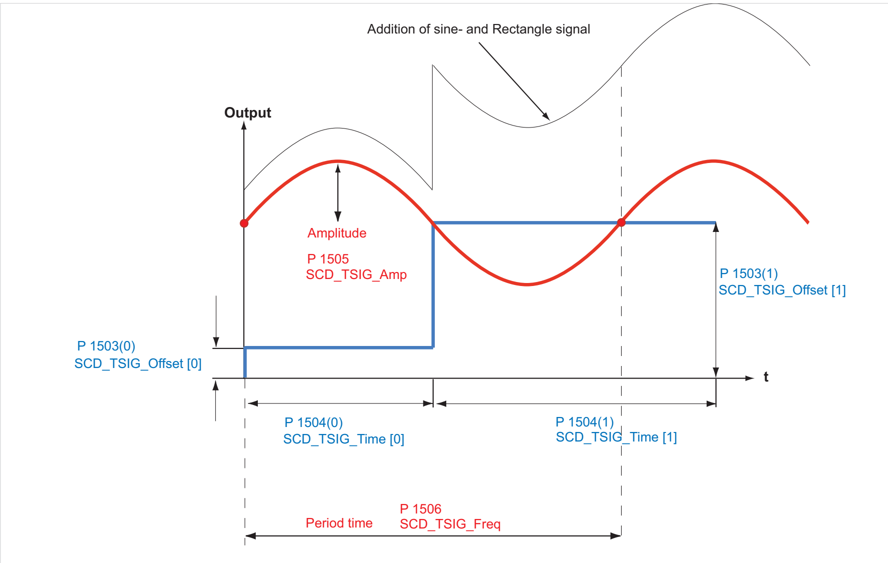
Illustration 88.1 Screen for the test signal generator



The duration of a test signal sequence results from the parameterized times t1, t2 **P 1504 (0.1)**. The number of test cycles **P 1502** for the square signal sequence is set via **P 1502** Number of cycles "Ncyc":

- Square signal sequence: The signal level is set via **P 1503(0.1) SCD_TSIG_Offset** and the times via **P 1504(0.1) SCD_TSIG_Time**.
- Sine generator with presetting of amplitude **P 1505 SCD_TSIG_Amp** and frequency **P 1506 SCD_TSIG_Freq**.
- A PRBS (Pseudo-Random Binary Sequence) noise signal with presetting of amplitu de **P-1509 SCD_TSIG_ PRBSAmp** and sampling time **P-1508 SCD_TSIG_ PRBSTime**. This enables different frequency responses to be plotted.

Illustration 88.2 Addition of sine- and rectangle signal



The PRBS signal is suitable for achieving a high-bandwidth system excitation with a test signal. A binary output sequence with parameterizable amplitude **P 1509 SCD_TSIG_ RBSAmp** and a “random” alternating frequency is generated with the aid of a looped-back shift register.

Illustration 89.1 PRBS signal in time and frequency range

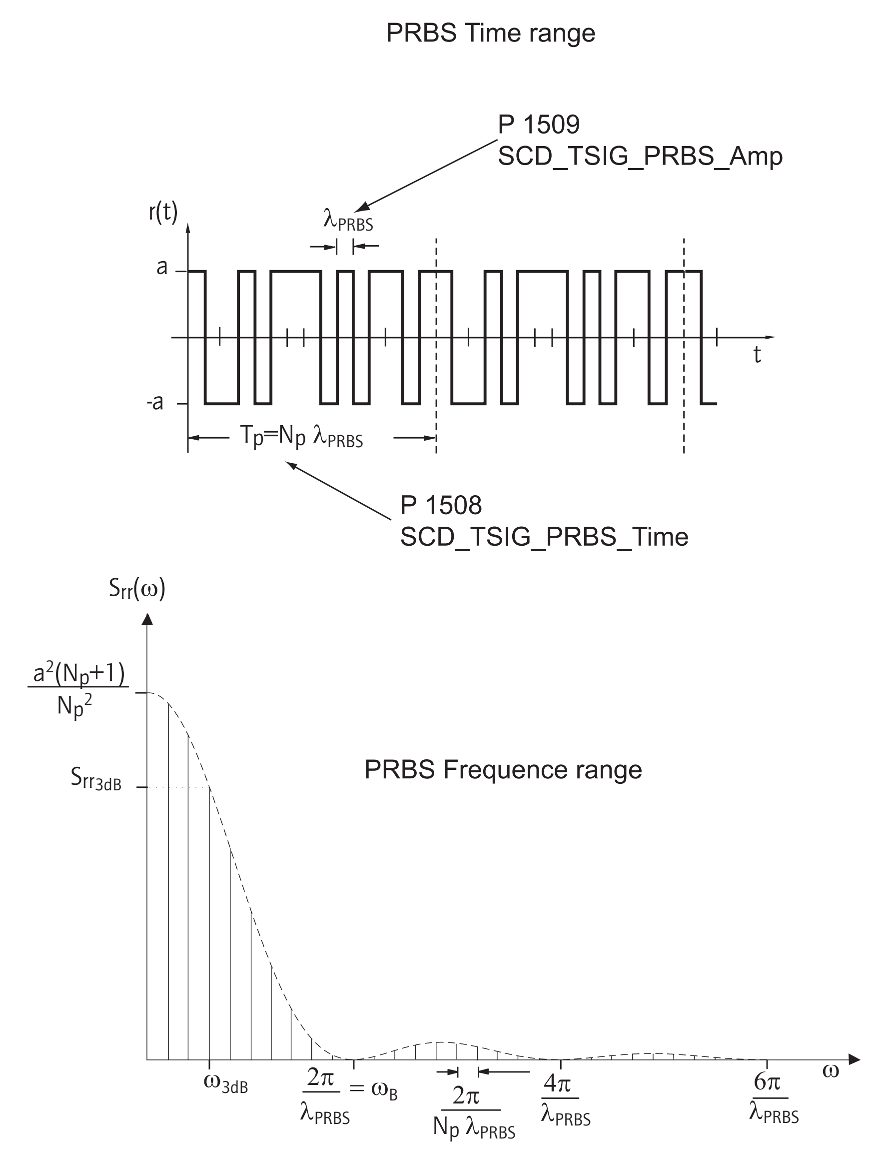


Table 90.1 Test signal generator parameters:

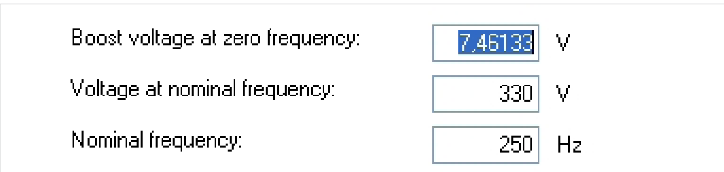
P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 1500	SCD_TSGenCon	Testsignal generator control word	Control word of test signal generator
P 1501	SCD_TSIG_OutSel	Testsignal generator output signal selector	Test signal generator output selector
P 1502	SCD_TSIG_Cycles	Number of Testsignal Cycles	Number of cycles
P 1503*	SCD_TSIG_Offset	Testsignal generator Offsets	Level of square signal
P 1504	SCD_TSIG_Time	Testsignal generator times for rectangular waves	Period of square signal
P 1505*	SCD_TSIG_Amp	Testsignal generator amplitude of sinusoidal wave	Amplitude of sine signal
P 1506	SCD_TSIG_Freq	Testsignal generator frequence of sinusoidal wave	Frequency of sine signal
P 1507	SCD_TSIG_SetPhase	Testsignal generator initial phase for rotating current vector	Start phase of current space vector in VFCON and ICON mode
P 1508	SCD_TSIG_ PRBSTime	Testsignal generator PRBS minimum toggle time	PRBS signal generator, sampling time
P 1509*	SCD_TSIG_ PRBSAmp	Testsignal generator PRBS signal amplitude	PRBS signal generator, amplitude

* In DriveManager only the first seven characters can be changed. As from the eighth character the number is rounded to zero! Only values up to 8388608 exactly can be preset as a matter of principle. After that the number format dictates that rounding is applied.

4.9 Motor test via V/F characteristic

In V/f mode it is possible to run a simple test indicating to the user whether a motor is connected correctly and moving in the right direction of rotation (linear drive: movement to the right / left). If the direction has been reversed, the motor is stopped or executing uncontrollable movements, the termination and the motor data must be checked.

Illustration 90.2 V/f open loop control for test purposes



As a test mode, a voltage/frequency control system is implemented in such a way that the closed-loop speed control circuit is replaced by open-loop control. So the reference in this case is also the speed reference; the actual speed is set equal to the reference. The feed frequency “fref” is calculated by way of the number of pole pairs of the motor P 0463 MOT_PolePairs.

Equation 91.1

$$f_{ref} = \frac{n_{ref}}{60} \times \textbf{P 0463 motor polepair}$$

A linear characteristic with two interpolation points is implemented, with a fixed boost voltage setting **P 0313 CON_VFC_VBoost** at 0 Hertz.
As from the rated frequency **P 0314 CON_VFC_FNom** the output voltage remains constant. An asynchronous machine is thus automatically driven into field-weakening as the frequency rises.

The linked voltages (phase-to-phase voltages) are specified under voltages. The internal voltage reference (space vector variable) is thus:

Equation 91.2

$$\text{usdref} = \text{sqrt(2/3)} \times \text{CON\_VFC\_VBoost} + \frac{\text{CON\_VFC\_VNom}}{\text{CON\_VFC\_FNom}} \times \text{ref}$$

Table 91.3 Parameters

P. no.	Parameters	Function	Description
P 0313	CON_VFC_VBoost	Boost voltage (at zero frequency)	Boost voltage at standstill
P 0314	CON_VFC_FNom	Nominal frequency	Rated frequency
P 0315	CON_VFC_VNom	Voltage at nominal frequency	Voltage at rated frequency

Note:
Default reference value via manual mode.

5. Motion profile

Drive parameterization starts with setting up the reference interface between motion profile and control. The basic settings can be made on the screen.

Illustration 92.1 Reference interface

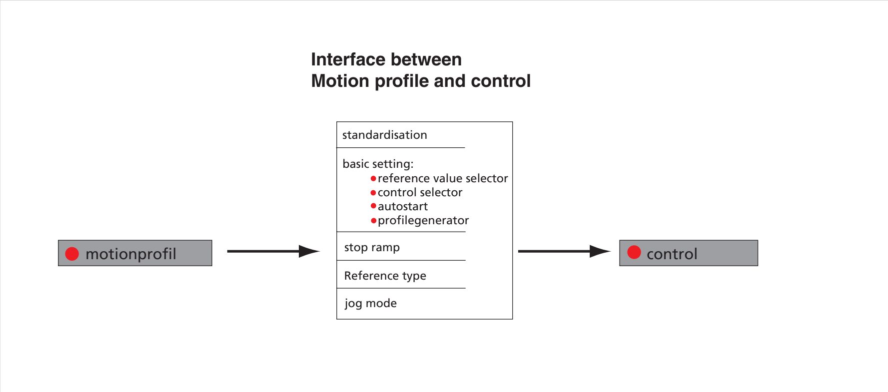
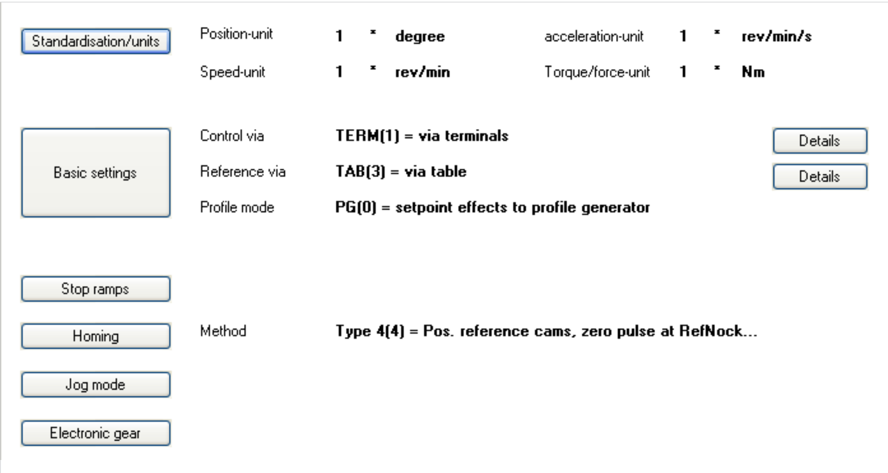


Illustration 92.2 Motion profile screen



5.1 Scaling

By way of Motion Control, reference values must be preset in user-defined travel units. These values are then converted into internal units. A wizard is provided for scaling in the standard/CiA DS402 and SERCOS profiles. To start it, click the „Standardisation/units“ button. Scaling via USER is only possible by way of the Parameter Editor.

Illustration 93.1 Selection of scaling mode

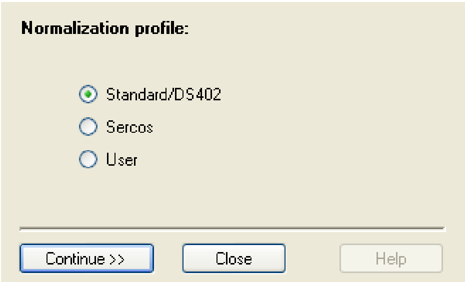


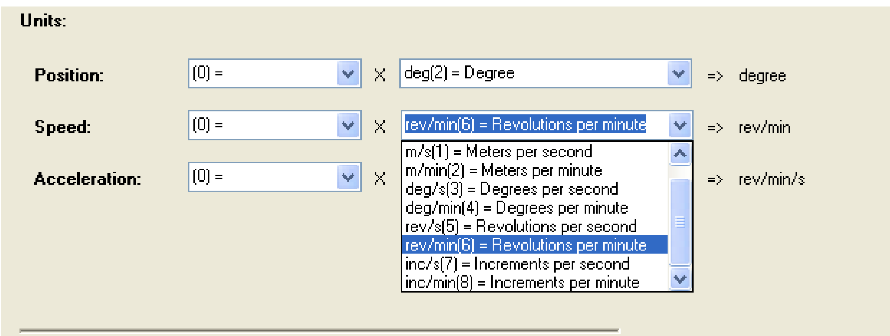
Table 93.2

P. no.	Parameter name/Setting	Designation in DM 5	Function
P 0283	MPRO_FG_Type	Factor group Type selection	Scaling source
(0)	STD_DS402	Standard acc. To CANopen DS402	Scaling is based on the parameters specified in the CIA 402 profile.
(1)	SERCOS	Units acc. To SERCOS	Scaling is based on the parameters specified in the SERCOS profile
(2)	User specific	User defined units	Scaling is based on parameters **P-270** to **P275**

5.1.1 Standard/ DS 402 Profile

Definition of the units for position, speed and acceleration. The scaling is entered using the Exponent syntax.

Illustration 93.3 Scaling for position, speed, acceleration



Definition of direction:
Referred to the motor, the positive direction is clockwise as seen when looking at the motor shaft (A-side bearing plate).

Illustration 94.1 Polarity of command values

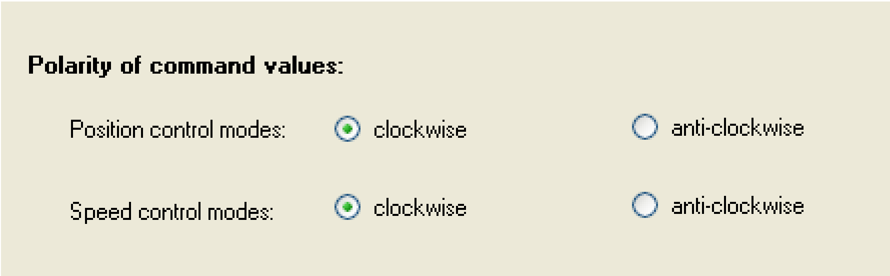
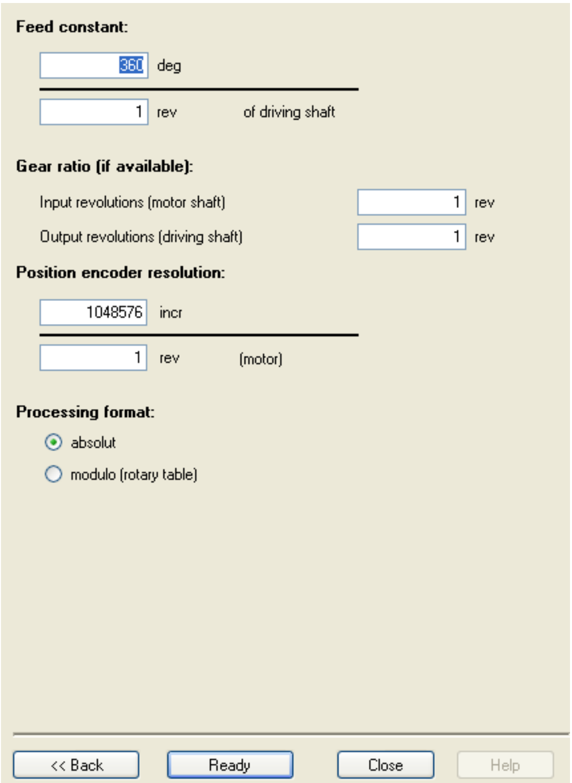


Illustration 94.2 Feed constant, gear ratio, process format



Feed constant:

Feed constant defines the ratio of the feed rate to the output revolution.

Equation 95.1

$$\text{feed constant} = \frac{\text{Feed forward}}{\text{revolution gear output side}}$$

„Gear ratio“

defines the ratio of a motor revolution upstream of the gearing to the number of revolutions on the gear output side..

Equation 95.2

$$\text{gear ratio} = \frac{\text{Motor revolution}}{\text{Revolution gear output side}}$$

“Position encoder resolution”
defines the encoder resolution in increments per motor revolution.

Equation 95.3

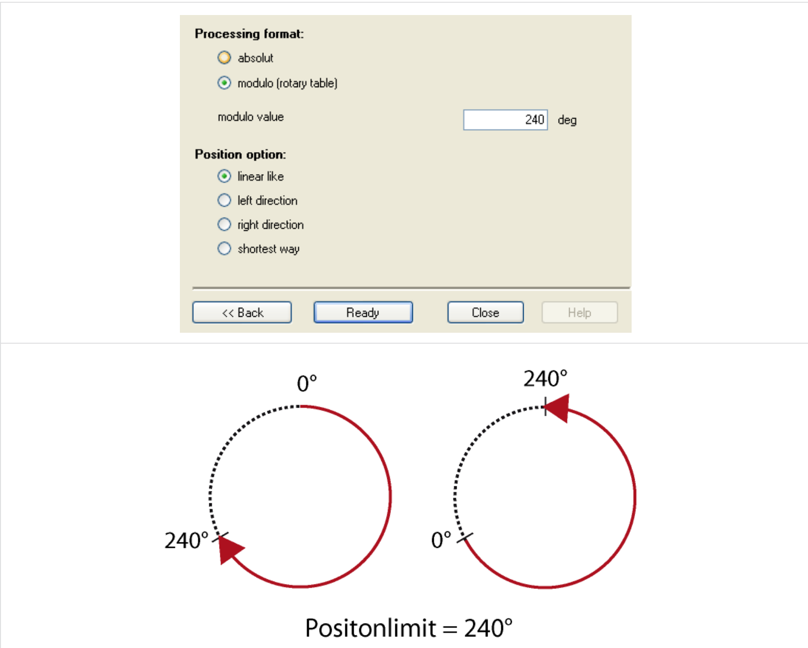
$$\text{Position encoder resolution} = \frac{\text{Encoder Incremente}}{\text{Motor revolution}}$$

Indexing table Modulo
The indexing table function is set up in the Motion Profile-Standardisation subject area. To be able to use the function, a limit value must be entered for the upper position specifying the point at which a revolution is complete.

Linear mode (define position range)
Example: The position limit is set to 240° (direction clockwise). When the 240° position is reached, the position is set to 0° and 240° is approached in the anti-clockwise direction. It is not necessary to preset a negative reference for the reversal of direction.

This application applies to linear and rotary drive systems.

Illustration 96.1 Defining the position range



Example: The position limit value is set to 360°. The drive can perform more than one revolution. There is no limit switch. When 360° is passed the position is reset to 0 how-ever. The clockwise direction is locked.

Absolute reference values are corrected to "anti-clockwise".

Illustration 97.1 "Anti-clockwise" rotation

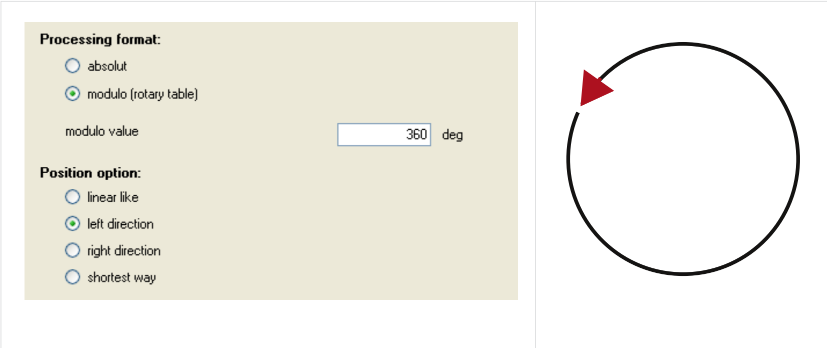
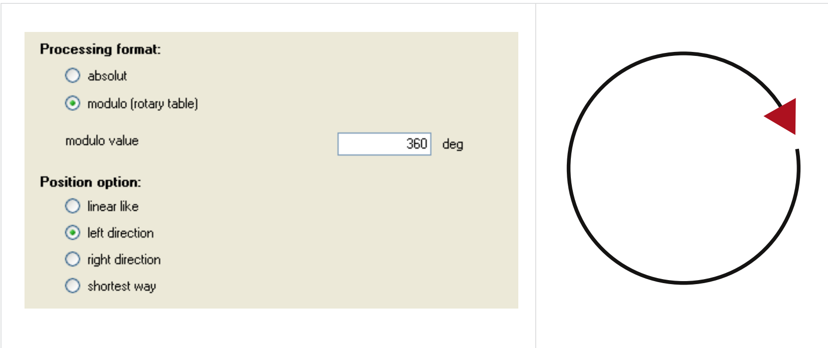


Illustration 97.2 "Clockwise" rotation



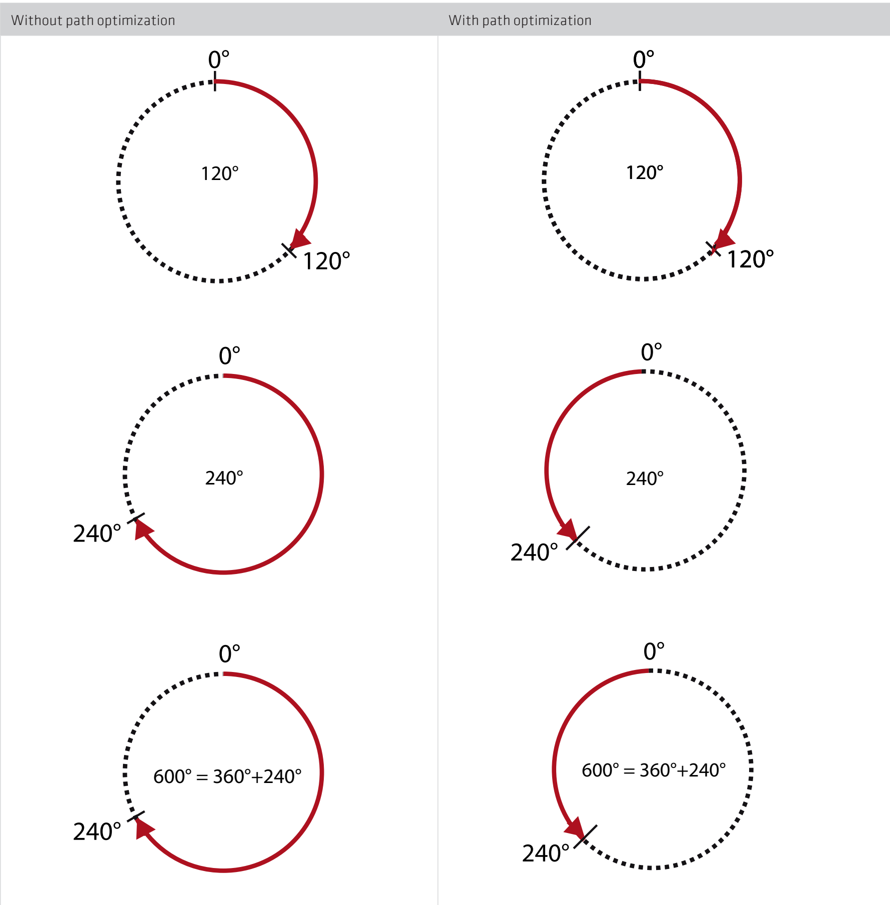
Path-optimized movement:

With „Path optimization“ activated, an absolute target position is always approached by the shortest path.

Table 98.1

Travel range	Effect
Target position less than circumference 120° < 360°	The drive moves to the specified target position.
Target position = circumference 120° = 120°	The drive stops
Target position greater than circumference 600° - (1 x 360°) = 240° 800° - (2 x 360°) = 80°	The drive moves to the position within the circumference (target position - (n x circumference))

Illustration 98.2 Path optimization



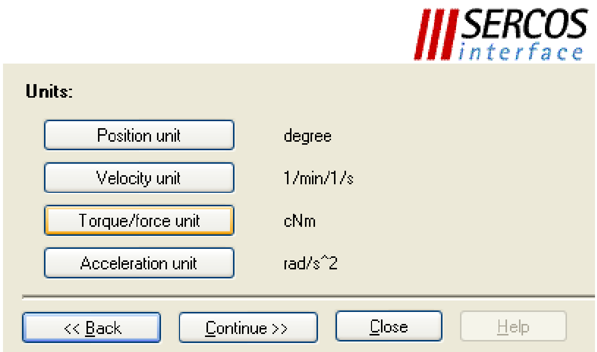
Response of relative positioning jobs:
Relative positioning jobs always relate to the last target position, even if it has not yet been reached, such as when activated during positioning. In the case of relative positioning jobs, paths greater than the circumference are possible if the target position is greater than the circumference.
Example:
Circumference = 360°; relative target position = 800°, start position = 0°. Here the drive performs two full revolutions (720°) and stops on the third revolution at 80° (800° - 720°).

Response of infinite positioning jobs:
In the case of infinite positioning jobs the drive is moved at a preset speed. A target position contained in this driving set is irrelevant. Infinite positioning jobs move at preset speed without taking into account the circumference. On switching to the next driving set (absolute or relative), the new target position is approached in the current direction of movement. Any preset path optimization is ignored.

SERCOS profile
When using the SERCOS profile, the term "weighting" is used in defining the units. The weighting describes the physical unit and number of decimal places with which the numerical values of the parameters exchanged between the master control system and the drives are to be interpreted. The method of weighting is defined by the parameters for position, speed, torque and acceleration weighting.

Illustration 99.1 Weighting wizard for SERCOS

Weighting via the SERCOS profile



This is the start screen of the SERCOS scaling wizard, in which the settings for position, speed, torque and acceleration can be made. From this screen the user is navigated through the scaling parameters.

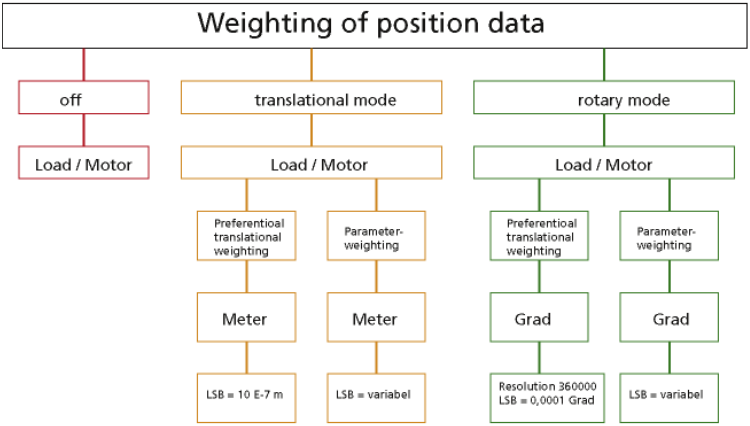
So as not to have to display all individual screens, the following schematic views are presented:

- Schematic 1 : Position data weighting method
- Schematic 2 : Speed data weighting method
- Schematic 3 : Force/torque weighting method
- Schematic 4: Weighting method for acceleration

Weighting of position data

Illustration 100.1 Position data weighting method

Schematic 1: Position data



Position resolution in translational mode:

$$LSB = Unit * Exponent$$

Preferential translational weighting:

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Linear	m	1	-7	0,1 µm

Position resolution in rotary mode:

$$LSB = Unit * \frac{1\ revolution}{rotative\ resolution} \quad exp. \quad \frac{360\ degree}{3\,600\,000}$$

Preferential rotary weighting:

Weighting method	Unit	Rotary position resolution	Weighting exponent	Preferential weighting
Rotary	Degrees	3 600 000	-7	0,0001 Degrees

Modulo weighting

If Modulo (indexing table application) is selected, the number range of the position data (modulo value) must be entered. When the modulo value is exceeded the position is reset to 0.

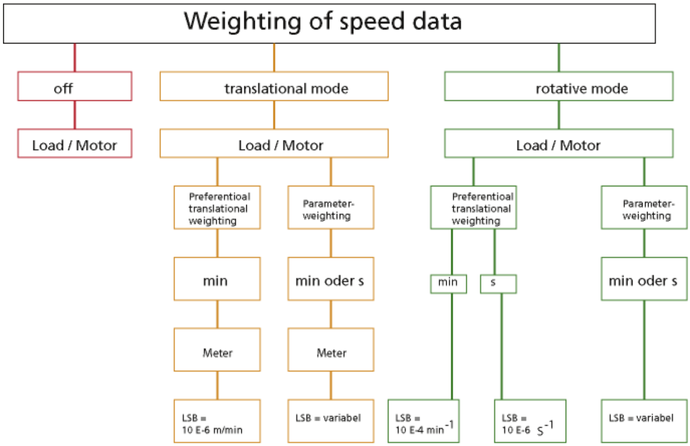
Position polarity:

The polarity of the position data (preceding sign) can be inverted according to the application. A positive position reference indicates clockwise rotation (looking at the motor shaft).

Weighting of speed data

Illustration 101.1 Weighting method for speed data

Schematic 2 : Speed data



If "no weighting is selected", the weighting factor and weighting exponent are irrelevant.

Position resolution in translational mode:

$$LSB = \text{Unit Factor} * \text{Exponent} * \frac{\text{Distance Unit}}{\text{Time Unit}}$$

Preferential translational weighting:

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Linear	m/min	1	-6	0,001 mm/min

Preferential rotary weighting:

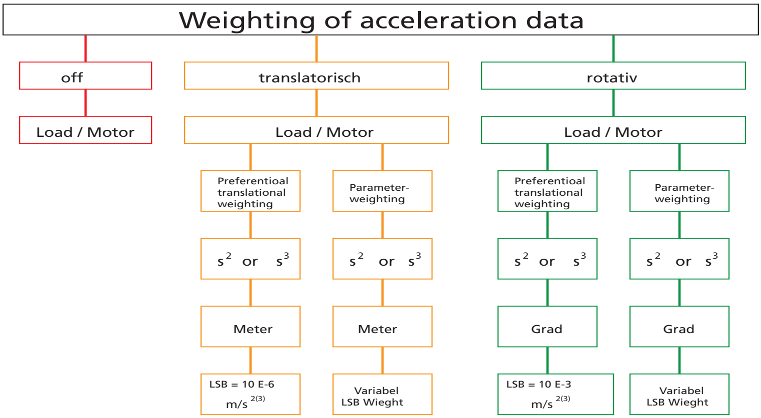
Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Rotary	1/min	1	-4	0,0011/min
Rotary	1/s	1	-6	0,0000011/s

Speed polarity:
The polarity of the speed data (preceding sign) can be inverted according to the application. A positive speed reference difference indicates clockwise rotation (looking at the motor shaft).

Weighting of acceleration data

Illustration 102.1 Weighting method for acceleration data

Schematic 3 : Acceleration data



All acceleration data (reference, actual and limit values) are subject to the preset weighting. If no weighting is selected, the weighting factor and weighting exponent are irrelevant.

Acceleration in translational and rotary mode:

$$LSB = \text{Unit(Factor)} * \text{Exponent} * \frac{\text{distance unit}}{\text{time unit}}$$

Preferential translational weighting

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Translational	m/s^2	1	-6	0,001 mm/s^2

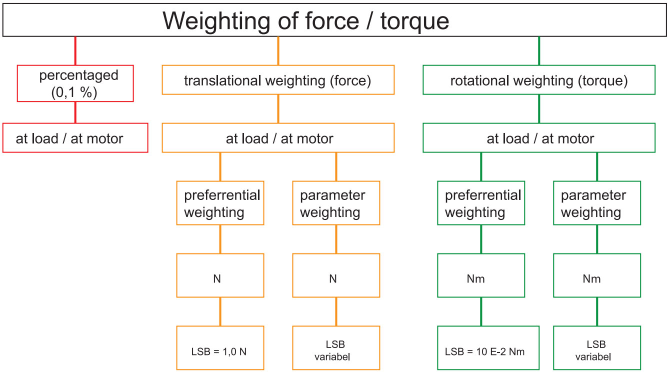
Preferential rotary weighting

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Rotary	rad/s^2	1	-3	0,001 rad/s^2

Weighting of torque and force data

Illustration 103.1 Weighting method for torque and force data

Schematic 4: Torque-, Force Data



In percentage weighting the permanently permissible standstill torque of the motor is used as the reference value. All torque/force data is given in % with one decimal place.

LSB = Unit* Exponent

Preferential translational weighting of force data

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Translational	N	1	-0	1 N

Rotatorische Vorzugswichtung der Kraftdaten

Weighting method	Unit	Weighting factor	Weighting exponent	Preferential weighting
Rotary	Nm	1	-2	0,01 Nm

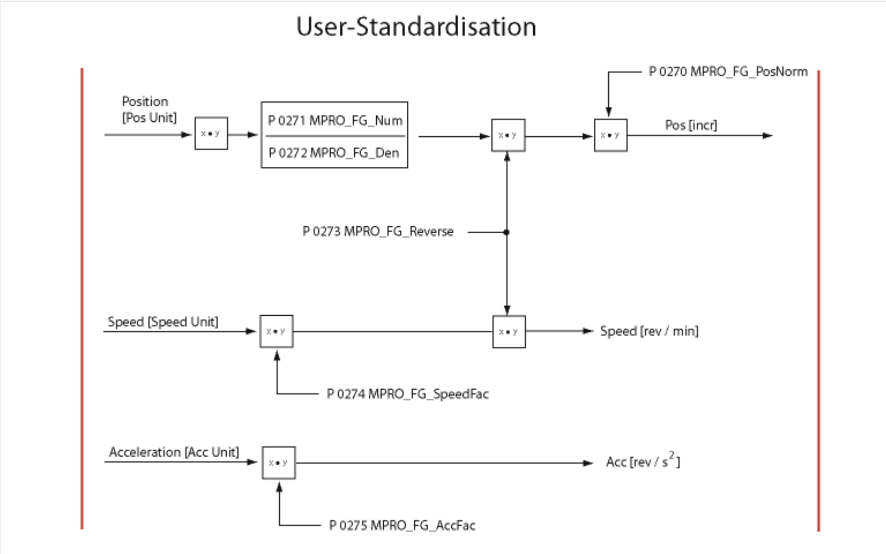
Torque polarity

The polarity is switched outside of a controlled system (at the input and output). A positive torque reference difference and non-inverted polarity means the direction of rotation is clockwise, looking at the motor shaft.

5.1.2 "USER" scaling without scaling wizard

No wizard is available for USER scaling, and it should only be used when scaling using the wizard is not possible. The following schematic is provided as an aid to parameter setting. Calculation of the factors **P 0271 / P 0272** for the position, **P 0274** for speed and **P 0275** for acceleration is dependent on the selected „User Unit" and the feed constant or gear ratio.

Illustration 104.1 Schematic of user scaling



Scaling examples for "USER" scaling:

Rotary motor scaling:

Presetting: 1 motor revolution corresponds to 360° or 1048576 increments

- Speed in [rpm]
- Acceleration in [rpm/s]
- Positioning in [°degrees]

Example:

Given:	Pos Unit:	**P 0284** = µm
	Speed Unit:	**P 0287** = m/s
	Acc Unit:	**P 0290** = m/s2

Feed Constant:	1 mm	= 10 rev
Gearing:	1 drive revolution	= 3 motor revolutions

Parameterization:

Pos Unit:
1 µm = 1/1000 mm = 10/1000 rev (output side) = 30/1000 rev (motor)
P 0271 = 30 or **P 0271** = 3
P 0272 = 1000 or **P 0272** = 100

Speed Unit:
1 m/s = 1000 mm/s = 10 000 rev/s (output side) =
30 000 rev/s (motor)*60 (min) = 1 800 000 rev/min
P 0274 = 1 800 000

Acc Unit:
1 m/s² = 1000 mm/s² = 10 000 rev/s² (output side) =
30 000 rev/s² (motor)*60 (s/min) = 1 800 000 rev/min/s
P 0275 = 1 800 000

Table 105.1 Parameters:

P. no.	Parameter name/ settings	Function	Default setting for rotary motor:	Internal unit
P 0270	**MPRO_FG_PosNom**	Increments per revolution	1048576 [incr/rev]	
P 0271	**MPRO_FG_Nom**	Numerator	1[rev]	Pos/1
P 0272	**MPRO_FG_Den**	Denominator	360° [POS]	Position per revolution
P 0273	**MPRO_FG_Reverse**	Reverse direction	False = clockwise	
P 0274	**MPRO_FG_SpeedFac**	Speed factorr	1[rpm]	rpm
P 0275	**MPRO_FG_AccFac**	Acceleration factor	1/60 = 0,01667 [rpm/s]	U/s^2

Linear motor scaling:
Example: Scaling of the linear motor:
Given: Travel in [µm]
Speed in [mm/sec]
Acceleration in [mm/s²]
One revolution corresponds to 32mm pitch
See P 0274, P 0275

Table 105.2

P. no.	Parameter name/ settings	Description	Default setting for linear motor:
P 0270	**MPRO_FG_PosNorm**	Increments/revolution	1048576
P 0271	**MPRO_FG_Num**	Numerator	1
P 0272	**MPRO_FG_Den**	Denominator	32000 µm
P 0273	**MPRO_FG_Reverse**	Direction of rotation	False (clockwise)
P 0274	**MPRO_FG_SpeedFac**	Speed factor	**1,875 U/s entspr. 1mm/s**, 1/32 mm = 0,03125 rps^2 0,03125 rps^2*60 s = 1,875 rps
P 0275	**MPRO_FG_AccFac**	Acceleration factor	1/32 mm = **0,03125 rps^2** **corresponding to 1 mm/s²**

Selection screen for the required motion profile. Setting of control location, reference source, start condition, profiles and a possible directional limitation.

Illustration 106.1 Selection screen for control and reference

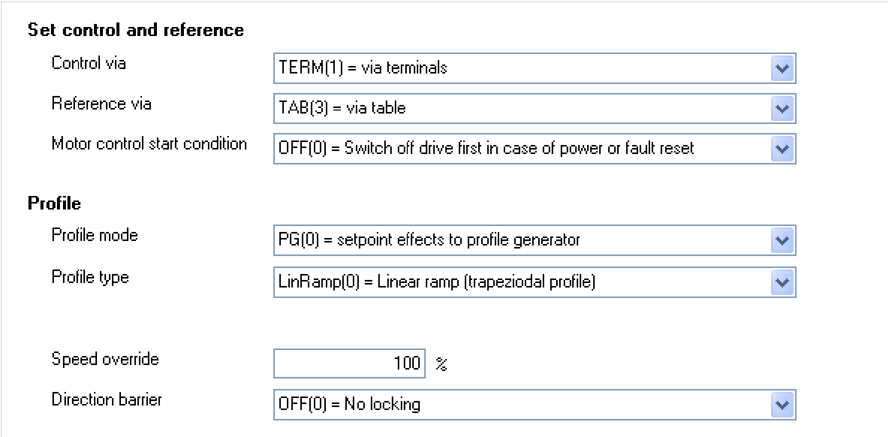


Table 106.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0159	MPRO_CTRL_SEL	Motion control selection	Selection of control location
(0)	OFF(0)	No control selector defined	No control location selected
(1)	TERM(1)	Via terminals	Control via terminal
(2)	PARA(2)	Via parameter interface	via parameter
(3)	(3)	Not defined	Not defined
(4)	PLC(4)	Via IEC 61131 program	IEC 1131
(5)	CiA 402(5)	Via CiA 402 motion profile (CANopen/EtherCAT)	DS402
(6)	SERCOS(6)	Via SERCOS motion profile	SERCOS
(7)	PROFIBUS(7)	Via PROFIBUS DPV motion profile	PROFIBUS
P 0144	MPRO_DRVCOM_Auto_start	DriveCom: Auto start of system	Autostart function
(0)	Off(0)	Switch off drive first in case of power or fault reset	Normal operation: The drive is stopped by cancelling the start condition or in the event of an error.
(1)	ON(1)	Start/Restart drive automaticly in case of power or fault	The drive automatically starts immediately on completion of initialization, provided the mains voltage is connected.

Table 107.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0165	MPRO_REF_SEL	Motion profile selection	Selection of reference source
(0)	OFF(0)	No setpoint	No reference selected
(1)	ANA0(1)	Via analog channel ISA0	Analog input ISA0
(2)	ANA1(2)	Via analog channel ISA1	Analog input ISA1
(3)	TAB(3)	Via table	Table values
(4)	PLC4)	Basic Library PLC open	CoDeSys IPLC
(5)	PLC(5)	Via IEC 61131 program	CoDeSys IPLC
(6)	PARA(6)	Via Parameterdefinition	The reference is preset by parameter
(7)	CiA 402(7)	Via CiA CiA 402 motion profile	DS402
(8)	SERCOS(8)	Via SERCOS motion profile	SERCOS
(9)	PROFIBUS(9)	Via PROFIBUS DPV motion profile	PROFIBUS
P 0301	Con_Ref_Mode	Select Reference Mode	Selection of interpolation mode
(0)	PG(0)	Setpoint effects to profile generator	PG(0): The internal reference is generated by the Profile Generator. In it, all ramp functions, such as acceleration and braking ramps, jerk, smoothing are implemented. Internal generation always takes place with a sampling time of 1 ms.
(1)	IP(1)	Setpoint effects directly to control loop (without ramp)	IP(1): The reference assignment of the higher-level control leads directly to the fine interpolator. Adaptation of the sampling time between the PLC and the drive controller is essential.
P 0306	CON_IpRefTS	Sampling time for interpolation	Adaptation of Sampling Time between ext. Control and drive controller
	0,25 ms - 1000 ms		
P 0370	CON_IP	Interpolation type control	Selection of interpolation method
(0)	NoIp(0)	No interpolation	The interpolation methods are described in section 1.2.
(1)	Lin(1)	Linear interpolation	Linear interpolation
(2)	SplineExtFF(2)	Interpolation with external feed forward	Interpolation with external pre-control value
(3)	SplineII(3)	Cubic spline interpolation	Cubic spline interpolation
(4)	NonIPSpline(4)	Cubic spline approximation	Cubic spline approximation

5.2.1 Control location, control source/Set control and Reference

- **P 0159:** Selection of control location
- **P 0165:** Selection of reference source
- **P 0144:** Selection of controller start condition (Autostart)

5.2.2 Profiles

- **P 0301:** Selection of reference processing via Profile Generator or interpolated position mode
- **P 2243:** Setting of different smoothing curves (only in PG mode)
- **P 0166:** Setting of smoothing time (only in PG mode)
- **P 0167:** Setting of speed override dependent on the maximum preset reference value (only in PG mode)
- **P 0335:** Reversing lock

5.2.3 Profile Generator/Interpolated position mode

The Profile Generator calculates the motion profile in two stages:

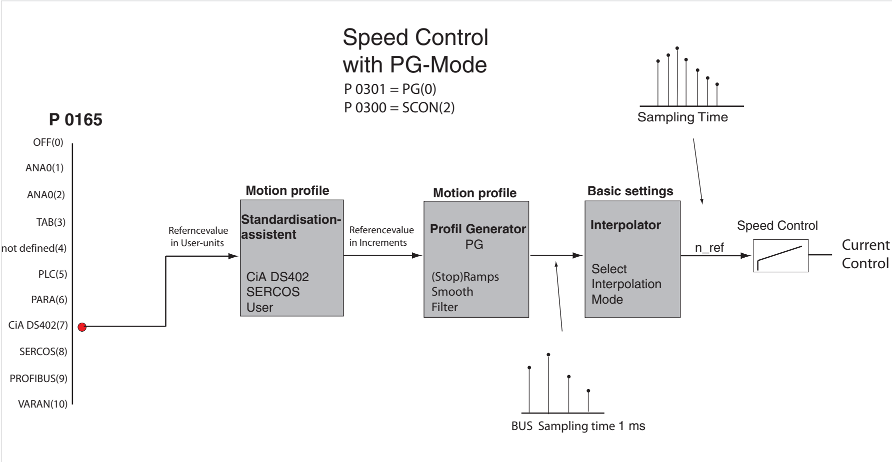
1. Speed Profile Generator
   Calculation of the speed profile taking into account a_{Max} and v_{Max}, followed by integration of the speed to get the travel profile.

2. Mean value filter:
   In order to limit the jerk time, a mean value filter is used to smooth the travel profile of the speed Profile Generator. The jerk time is proportionate to the filtering depth of the mean value filter. The longer the jerk time, the lower the resulting jerk. A jerk time of 0 means that the max. permissible acceleration can be directly used for starting or braking (the mean value filter is inactive).

5.2.4 Speed control via the Profile Generator (PG-Mode)

To use the Profile Generator in speed control mode, the two parameters **P 0301 = PG(0)** and **P 0300 = SCON(2)** must be set.
When the reference source has been selected the reference is scaled to the matching user unit. The reference is transferred in increments to the Profile Generator (motion profile) and passes via the fine interpolator (basic settings) to the speed controller.

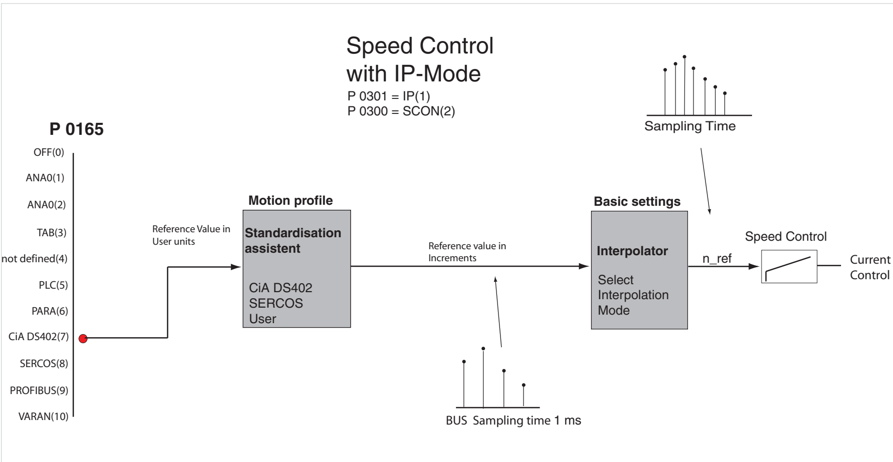
Illustration 109.1 Speed control in PG mode



5.2.5 Speed control via IP mode

In speed control via IP mode (Interpolated Velocity mode), the reference values from the reference source are scaled, always interpolated in linear mode, and switched to the control loops. No pre-control values are generated!

Illustration 109.2 Speed control in IP mode



5.2.6 Position control via the Profile Generator (PG mode)

In position control mode in PG mode, the positioning commands are transmitted to the internal Profile Generator. The setting is made in the motion profile „Basic setting“ subject area.

A positioning command consists of:

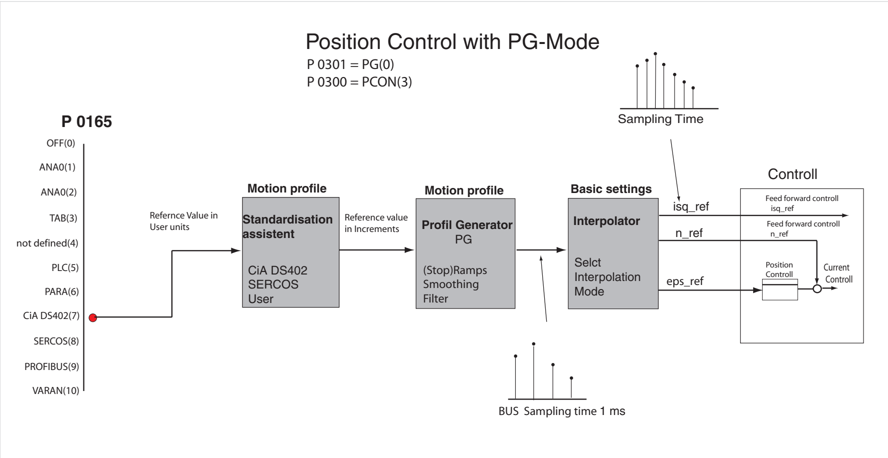
- Ref_Position: Ref_Position: Target position
- Ref_Speed: Maximum positioning speed
- Maximum acceleration
- Maximum deceleration

With the additional information on jerk **P 0166 MPRO_REF_JTIME** and an override factor **P 0167 MPRO_REF_OVR** for the positioning speed, the Profile Generator generates a time-optimized trajectory for the position reference, taking into account all limitations, in order to reach the target position.

The position reference values are then fine-interpolated in the interpolator.

The position references are used to generate pre-control values for speed and acceleration. These are scanned at the sampling time of the position controller (normally 125 µs) and switched to the control loops.
For information on how to generate positioning commands with bus systems, refer to the field bus documentation.

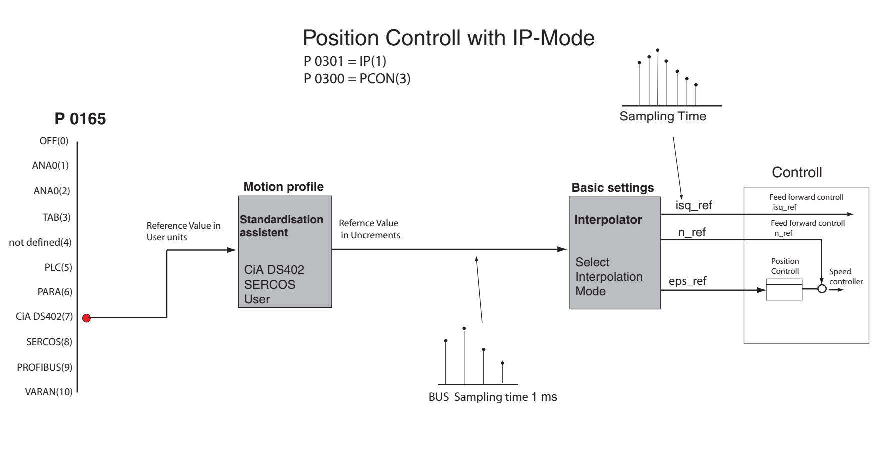
Illustration 110.1 Configuration of position control in PG mode



5.2.7 Position control via IP mode

In position control mode in IP mode, position references are set at a sampling time specified by the higher-level control. The drive controller sampling time can be matched to the sampling time of the PLC using parameter **P 0306 CON_Ip-RefTS**. For more information on the sampling time refer to the field bus documentation. The position references are then transferred to the fine interpolator. The resulting pre-control values for speed and acceleration are switched to the control loops.

Illustration 111.1 Position control in IP mode



5.2.8 "Smoothing" and "Speed offset"

Table 111.2

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P-0166	MPRO_REF_JTIME	Motion profile jerk time	Setting of smoothing time (jerk limitation)
P-0167	MPRO_REF_OVR	Motion profile speed override factor	The reference is weighted in percent dependent on the maximum specified reference value

Due to the jerk limitation the acceleration and deceleration times rise by the smoothing **P 0166**. The smoothing settings field appears on the screen only when JerkLin(3) = Jerk limited ramp is set in parameter **P 2243** "Profile type". With speed override **P 0167** the maximum preset speed reference can be scaled in percent.

Illustration 112.1 Without smoothing: Red = actual speed value; Grey = actual position

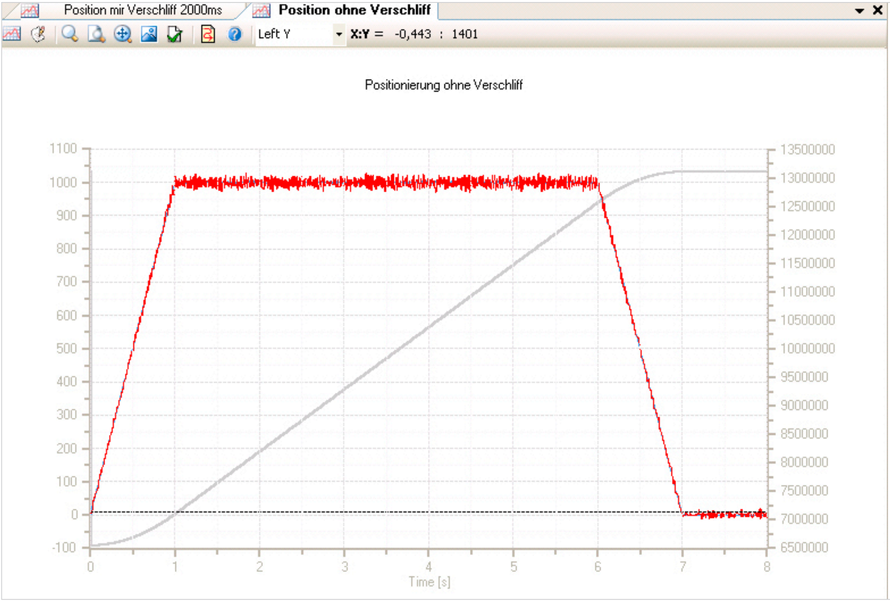
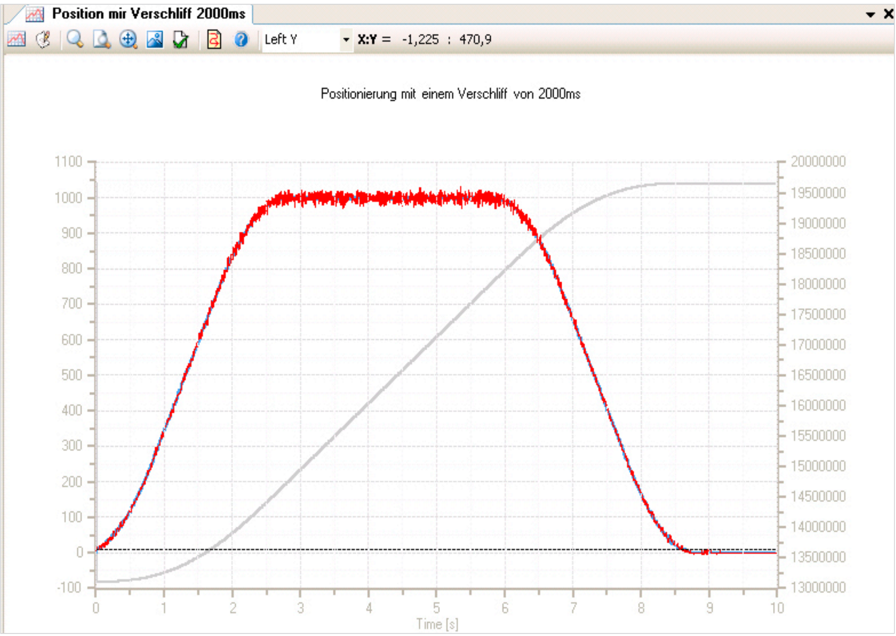


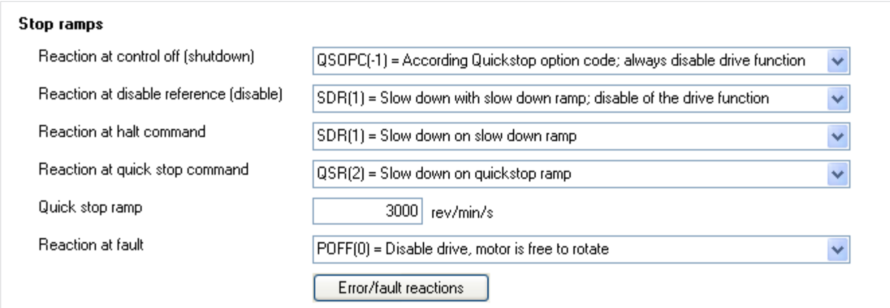
Illustration 112.2 With smoothing of 2000 ms; Red = actual speed value; Grey = actual position value



5.3 Stop ramps

Each reference source has its own acceleration and braking ramps. In addition to this there are the special deceleration ramps to the **CiA 402** standard listed below. The ramp functions are only effective in certain system states. The required settings can be selected from the screen. Clicking the „Error/fault reactions“ button directly accesses the screen for the error responses.

Illustration 113.1 Stop ramps screen



The following ramp options are available:

Table 113.2

P. no.	System state	Stop ramps	Preferred setting
P 2218	Quick stop	MP_QuickStopOC	(2)
P 2219	Control off	MP_ShutdownOC	SDR
P 2220	Transition from “Operation Enable” to “Switch on”	MC_DisabledOpOC	SDR
P 2221	Stop feed	HaltOC	SDR
P 2222	Error	MP_FaultReactionOC	QSR
P 2242	Braking ramp for quick stop	MPRO_402_QuickStopDec	

Reaction to "Quick stop"

The quick stop brakes a running movement. The drive controller is in the "Quick stop" system state. During braking, and depending on the response, acceleration is again possible in the old "Control active" state.

Table 114.1

P 2218	Designation in DM 5	Function
POFF(0)	0(0) = Disable power stage/drive function	Disable power stages; the drive coasts to a stop
SDR(1)	1(1) = Slow down on slow down ramp	The drive brakes with the programmed deceleration ramp, then the power stage is disabled
QSR(2)	2(2) = Slow down on slow quickstop ramp	Braking with quick-stop ramp, then the power stage is disabled. The factory setting QSR(2) incorporates use of a holding brake. If the settings differ from the factory setting, the possible use of a holding brake needs to be taken into account.
CLIM(3)	3(3) = Slow down on current limit	Braking with max. dynamism at the current limit. The speed reference value is set equal to 0, then the power stage is disabled.
Reserve(4)	Reserve	
SDR_QS(5)	5(5) = Slow down on slow down ramp and stay in quickstop	Braking with programmed deceleration ramp. The drive remains in the quick stop state, current is applied to the axis at zero speed. [1]
QSR_QS(6)	6(6) = Slow down on quickstop ramp and stay in quickstop	Braking with emergency stop ramp. The drive remains in the quick-stop state, current is applied to the axis at speed 0. [1]
CLIM_QS(7)	7(7) = Slow down on current limit and stay in quickstop	Braking with max. dynamism at the current limit. The speed reference is set equal to 0. The drive remains in the quick-stop state, current is applied to the axis at speed 0. [1]
Reserve(8)	Reserve	

[1] Transition to the state "Ready for switching on" is only possible by resetting the quick stop request. In the "Quick-stop" state cancelling the "Start closed-loop control/drive" signal has no effect as long as the quick-stop request is not reset as well.

Reaction to „Shutdown"

The condition transition „Control off" is passed through when the power stage is switched off. The control can be switched off via one of the various control channels (terminals, bus, PLC).

Table 114.2

P2219	Designation in DM 5	Function
QSOPC(-1)	According Quickstop option code	In the event of a Shutdown command the stop variant selected in "Response to quick stop" P 2218 is executed.
POFF(0)	Disable power stage/drive function	Disable power stages; the drive coasts to a stop
SDR(1)	Slow down with slow down ramp; disable of the drive function	The drive brakes with a programmed deceleration ramp. Then the holding brake – if fitted – engages according to its parameter setting.

Reaction to “Disable Operation”

The „disable operation option code“ parameter determines which action is to be executed at the transition from „Operation enable“ to „Switched on“ (4 and 5).

Table 115.1

P 2220	Designation in DM 5	Function
POFF(0)	0(0)= Disable power stage/drive function	Disable power stages; drive coasts to a stop
SDR(1)	1(1)= Slow down with slow down ramp; disable of the drive function	The drive brakes with the programmed deceleration ramp, then the power stage is disabled

Reaction to “Halt ”

The “Halt ” state brakes an ongoing movement for as long as the state is active. During braking the drive can be accelerated back to the previous state. When deactivated, the programmed acceleration ramp is again applied.

Table 115.2

P 2221	Designation in DM 5	Function
SDR(1)	1(1)= Slow down on slow down ramp	The drive brakes with a programmed deceleration ramp
QSR(2)	2(2)= Slow down on slow quickstop ramp	Braking with emergency stop ramp
CLIM(3)	3(3)= Slow down on current limit	Braking with max. dynamism at the current limit. The speed reference is set equal to 0.
Frei(4)	not implemented	

Reaction to “Fault Reaction”

Table 115.3

P 2222	Designation in DM 5	Function
POFF(0)	Disabled drive, motor is free to rotate	Disable power stages; the drive coasts to a stop
SDR(1)	Slow down on slow down ramp	The drive brakes with a programmed deceleration ramp
QSR(2)	Slow down on quickstop ramp	Braking with emergency stop ramp
CLIM(3)	Slow down on current limit	Braking with max. dynamism at the current limit. The speed reference is set equal to 0.
(4) -(4)	not implemented	

Braking ramp for “Quick stop”

Table 115.4

P 2242	Settings	MP_QuickStopDec:
(0)	3000	Setting of quick-stop ramp in rev / min / s

5.4 Homing

The drive-controlled homing runs are executed according to the CANopen drive profile DSP 402 as from V 2.0.

Note:
These drive-controlled homing runs with the corresponding parameters also used in the case of control via the SERCOS and PROFIBUS field buses and in conjunction with internal reference generation.

5.4.1 Drive-controlled homing via field bus

Since relative sensor systems are used, the drive must be homed, triggered by bit 11 in control word 1. As soon as this bit is set by the master, the drive performs a position-controlled homing run using an internal Profile Generator taking into account homing speed, homing acceleration and the strategy stored in the homing method.

Homing speed
The homing speed is preset via parameter **P 2262 MPRO_402_HomingSpeeds** in DriveManager. In this, the user has the possibility to specify two different homing speeds.

Table 116.1

P 2262	**MPRO_402_HomingSpeeds**	**Designation in DM 5**	**Function**
(0)	SpeedSwitch(0)	Speed during search for switch	Speed on the way to the limit switch
(1)	SpeedZero(1)	Speed during search for zero	Speed during travel to zero point

Homing acceleration
The homing acceleration is preset via **P 2263 MPRO_402_HomingAcc** in DriveManager.

Zeroing offset
Absolute encoders (e.g. SSI-Multiturn encoders) are a special feature in homing, because they establish the absolute position reference directly. Homing with these encoders therefore requires no movement and, under certain conditions, no current to the drive. Homing type -5 is recommended for the zero balancing. A zero offset can be set via parameter **P 0525 ENC_HomingOff**.

Zero pulse evaluation
If a reference motion is selected which requires an index pulse evaluation, this evaluation will automatically be started in the background and automatically stopped when homing is completed. It is possible to plot the zero pulse on the scope for diagnostic purposes (Scope channel: Encoder Position Channel 1/3 Np).

Reference cam, limit switch
The reference cam signal can be optionally linked to one of the digital inputs. Inputs ISD00 to ISD06 are available. In homing to a limit switch, the digital input must be selected with the available selection parameter LCW(5) for a positive or LCCW(6) negative limit switch. In homing to a cam, the selection parameter HOMSW(10) must be chosen (see parameters **P 0101–P 0107**).

Table 117.1

P. no.	Parameter name/ Setting	Designation in DM 5	Function
P 2261	P 0101 to P 0107 MPRO_INPUT_FSISDxx	MPRO_402_HomingMethod	Digital inputs
(-7)	–	Move positive direction, for distance coded encoder	Homing method for increment-coded encoder for positive direction
(-6)	–	Move negative direction, for distance coded encoder	Homing method for increment-coded encoder for negative direction
(-5)	–	Act. position + homing offset (multiturn-encoder)	Homing (absolute value encoder)
(-4)	–	Not defined	
(-3)	–	Not defined	
(-2)	–	No homing mode (act. position + homing offset)	No homing; only an offset adjustment is made
(-1)	–	Reference position = homing offset (parameter HOOFF)	Actual position=Zero
(0)	–	Not defined	No homing
(1)	LCCW	Neg. end switch, zero pulse	Homing negative limit switch and zero pulse
(2)	LCW	Pos. end switch, zero pulse	Homing positive limit switch and zero pulse
(3)	HOMSW	Pos. reference cams, zero pulse at RefNock=Low	Homing to cam negative edge, positive direction + zero pulse
(4)	HOMSW	Pos. reference cams, zero pulse at RefNock=High	Homing to cam positive edge, positive direction + zero pulse
(5)	HOMSW	Neg. reference cams, zero pulse at RefNock=Low	Homing to cam negative edge, negative direction + zero pulse
(6)	HOMSW	Neg. reference cams, zero pulse at RefNock=High	Homing to cam positive edge, negative direction + zero pulse
(7) bis (14)	HOMSW	Left reference cam polarity, zero pulse at RefNock=Low	Various homing runs to cam
(15), (16)	–	Not defined	Reserved
(17)	LCCW	Neg. end switch	Homing negative limit switch
(18)	LCW	Pos. end switch	Homing positive limit switch
(19)	HOMSW	Pos. reference cams, Stop at RefNock=Low	Homing to cam negative edge, positive direction
(20)	HOMSW	Pos. reference cams, Stop at RefNock=High	Homing to cam positive edge, positive direction
(21)	HOMSW	Neg. reference cams, Stop at RefNock=Low	Homing to cam negative edge, negative direction
(22)	HOMSW	Neg. reference cams, Stop at RefNock=High	Homing to cam positive edge, negative direction

Table 118.1

P. no.	Parameter name/ Setting	Designation in DM 5	Function
P 2261	P 0101 bis P 0107 MPRO_INPUT_FSISDxx	MPRO_402_HomingMethod	Digitale Eingänge
(23) bis (30)	HOMSW		Various homing runs to cam
(31), (32)	–	Not defined	Reserved
(33)	–	Next left zero pulse	Zero pulse in negative direction
(34)	–	Next right zero pulse	Zero pulse in positive direction
(35)	–	Actual position = Reference position	Zero is current position

Homing method
The homing method is selected via parameter **P 2261 MPRO_402_HomingMethod** (type (-5) to type (35)).

The following describes the different homing methods. The individual reference points corresponding to the zero are numbered in the diagrams. The different homing speeds (V1=SpeedSwitch, V2=SpeedZero) and the directions of movement are also shown.

Type (-5): Absolut Encoder:
This type is suitable for absolute encoders (e.g. SSI-Multiturn encoders). Homing is performed immediately after power-on. It can also be activated with the power disconnected.
The current position complies with the zero point. The zero position is calculated on basis of the absolute encoder position + zero offset.
According to this, homing with zero point offset = 0 supplies the absolute position of the SSI-encoder, e.g. in operation of a SSI-Multiturn-Encoder. Another homing run with unchanged setting of the zero offset does not cause a change in position.

Homing to block or zero balancing of the system is performed as follows:

1. Enter zero offset = 0
2. Homing (Start homing) delivers the absolute position of the encoder
3. Move drive to reference position (machine zero)
4. Then enter the zero offset (the value by which the position is to be changed
5. Repeat homing (Start homing)
6. Save setting (zero offset)
7. At power-on the system is automatically homed. Manual homing is no longer necessary.

Type (-4): Not defined.

Type (-3): Not defined.

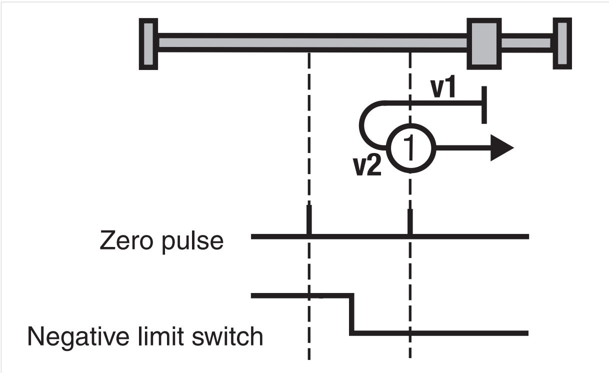
Type (-2): No homing is performed:
No homing is performed. The current position is added to the zero offset. The first time the power stage is switched on the „Homing completed“ status is set. This method is suitable for absolute encoders, as long as no zero balancing is required. For zero balancing please select type -5.

Type -1: Actual position = 0:
The actual position corresponds to the zero point, it is set to 0, i.e. the closed-loop control runs an actual position reset. The zero offset is added.

Type 0: Not defined.

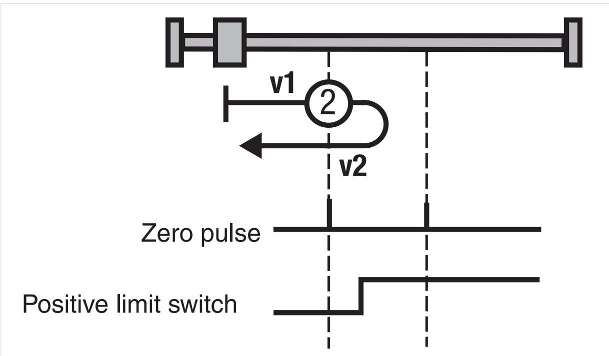
Type: 1, Negative limit switch and zero pulse:
The initial movement is as shown in illustration 119.1 towards the negative (left) hardware limit switch (which is inactive) and the direction of movement is reversed when the edge is active. The first zero pulse after the falling edge corresponds to the zero.

Illustration 119.1 Type 1: Negative limit switch and zero pulseFigure pulse



Type 2: Positive limit switch and zero pulse
The initial movement is as shown in illustration 119.2 towards the positive (right) hardware limit switch (which is inactive) and the direction of movement is reversed when the edge is active. The first zero pulse after the falling edge corresponds to the zero.

Illustration 119.2 Type 2: Positive limit switch and zero pulse



Type 3+4: Positive reference cam and zero pulse

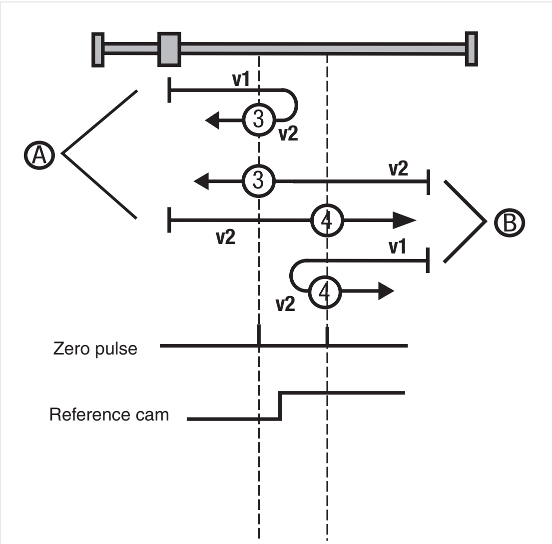
The initial movement is as shown in illustration 114.1 towards the positive (right) hardware limit switch, if the reference cam is inactive - see symbol A in illustration 114.1.

As soon as the reference cam is active, the type 3 direction is reversed. The first zero pulse after the falling edge corresponds to the zero.

For type 4 the first index pulse after the rising edge corresponds to the zero point. The initial movement is towards the negative (left) hardware limit switch and the reference cam is active - see symbol B in illustration 114.1

If the reference cam becomes inactive, the first index pulse of type 3 will correspond to the zero point. With type 4, the direction reverses as soon as the reference cam becomes inactive. The first zero pulse after the rising edge corresponds to the zero.

Illustration 120.1 Type 3+4: Positive reference cam and zero pulse



Type 5+6: Negative reference cam and zero pulse
The initial movement is towards the positive (right) hardware limit switch and the reference cam is active - see symbol A in figure 121.1.

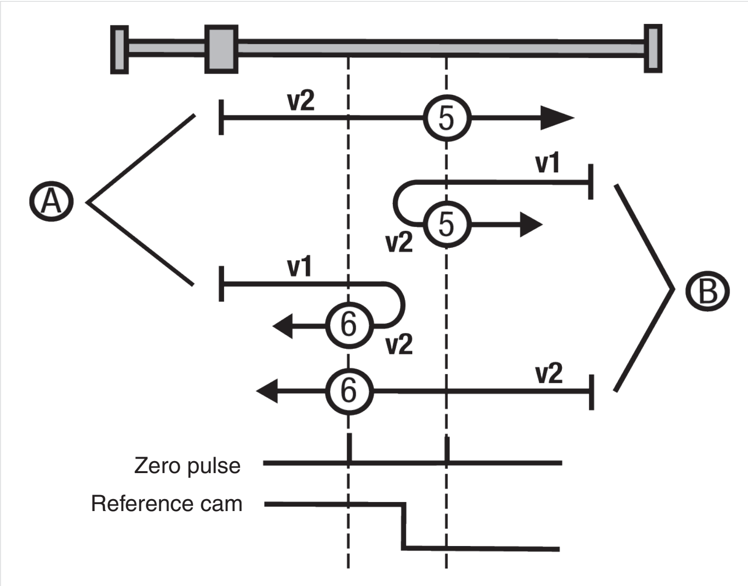
With type 5 the first zero pulse after the falling edge corresponds to the zero.

When the reference cam becomes inactive, the direction of movement with type 6 will be reversed and the first index pulse after the rising edge corresponds to the zero point. The initial movement is towards the negative (left) hardware limit switch and the reference cam is inactive - see symbol B in 121.1.

With type 5 the direction of movement is reversed as soon as the reference cam becomes active, and the first zero pulse after the falling edge corresponds to the zero.

For type 6 the first index pulse after the rising edge corresponds to the zero point.

Illustration 121.1 Type 5+6: Negative reference cam and zero pulse



Homing method for increment-coded encoders:

Type (-6): move negative direction for distance coded encoder-

Type (-7): move positive direction for distance coded encoder-

Type 7 to 10: Reference cam, zero pulse and positive limit switch
The initial movement is in direction of the positive (right) hardware limit switch. It and the reference cam are inactive (see symbol A in illustration 117.1). Type 7 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge. With type 8 the zero corresponds to the first zero pulse with an active reference cam. Type 9 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge. With type 10 the reference cam is overrun and the first zero pulse after that corresponds to the zero.

The initial movement is in direction of the negative (left) hardware limit switch. The positive limit switch is inactive and the reference cam is active - see symbol B in illustration 117.1.

With type 7 the zero point corresponds to the first index pulse after falling edge of the reference cam. Type 8 reverses the direction of movement after a falling edge of the reference cam. The zero point corresponds to the first index pulse after the rising edge of the reference cam.

The initial movement is in direction of the positive (right) hardware limit switch. It is inactive and the reference cam is active - see symbol C in illustration 117.1.

Type 9 changes the direction of movement, if the reference cam is inactive. The zero corresponds to the first zero pulse after the rising edge. With type 10 the first zero pulse after a falling edge of the reference cam is the zero point.

The initial movement is in direction of the positive (right) hardware limit switch. It and the reference cam are inactive. As soon as the positive limit switch becomes active, the direction of movement is reversed - see symbol D in illustration 117.1.

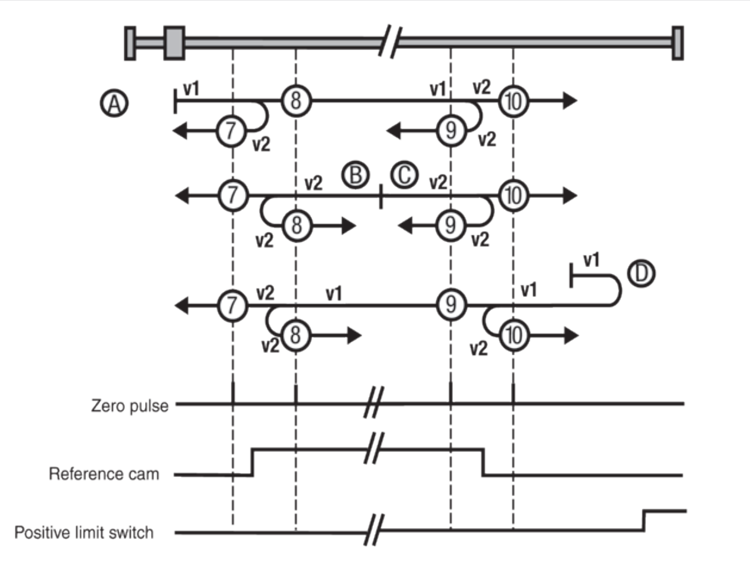
With type 7 the first zero pulse after overrunning the reference cam corresponds to the zero.

Type 8 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 9 the zero corresponds to the first zero pulse with an active reference cam.

Type 10 changes the direction of motion after the active reference cam. The zero corresponds to the first zero pulse after a falling edge.

Illustration 123.1 Type 7 to 10: Reference cam, zero pulse and positive limit switch



Type 11 to 14: Reference cam, zero pulse and negative limit switch
The initial movement is in direction of the negative (left) hardware limit switch. It and the reference cam are inactive - see symbol A in illustration 118.1.

Type 11 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge. With type 12 the zero corresponds to the first zero pulse with an active reference cam.

Type 13 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 14 the reference cam is overrun and the first zero pulse after that corresponds to the zero.
The initial movement is in direction of the negative (left) hardware limit switch. It is inactive and the reference cam is active - see symbol B in illustration 118.1.

Type 13 changes the direction of movement, if the reference cam is inactive. The zero corresponds to the first zero pulse after the rising edge. With type 14 the first zero pulse after a falling edge of the reference cam is the zero point.

The initial movement is in direction of the positive (right) hardware limit switch. The positive limit switch is inactive and the reference cam is active - see symbol C in illustration 118.1.

With type 11 the zero point corresponds to the first index pulse after falling edge of the reference cam. Type 12 reverses the direction of movement after a falling edge of the reference cam. The zero point corresponds to the first index pulse after the rising edge of the reference cam.

The initial movement is in direction of the negative (left) hardware limit switch. It and the reference cam are inactive. As soon as the negative limit switch becomes active, the direction of movement is reversed - see symbol D in illustration 118.1.

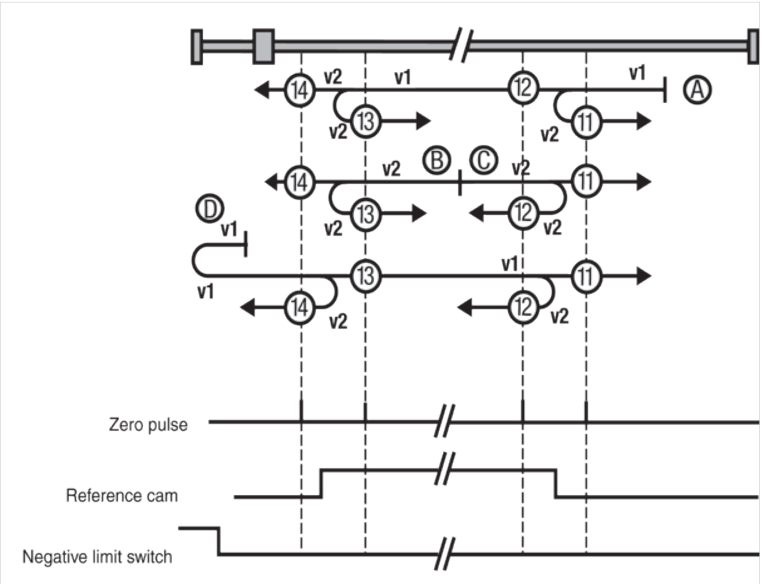
With type 11 the reference cam must be overrun, then the first zero pulse corresponds to the zero.

Type 12 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 13 the zero corresponds to the first zero pulse with an active reference cam.

Type 14 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge.

Illustration 124.1 Type 11 to 14: Reference cam, zero pulse and negative limit switch

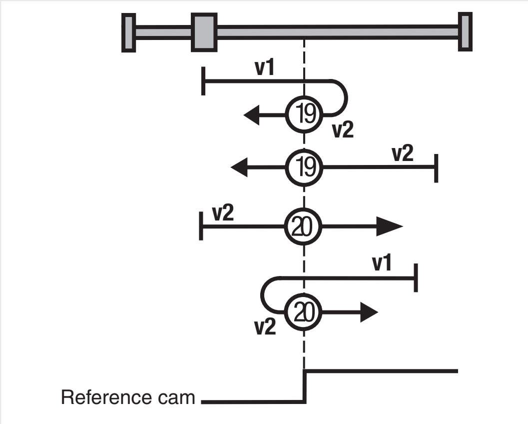


Type 15+16: These homing methods are not defined.

Type 17 to 30: reference cams

The homing method types 17 to 30 are similar to types 1 to 14. Determination of the zero point does not depend on the zero pulse, but solely on the reference cam or the limit switches.

Illustration 125.1 Type 17 to 30: Reference cam



Type comparison for the individual homing methods

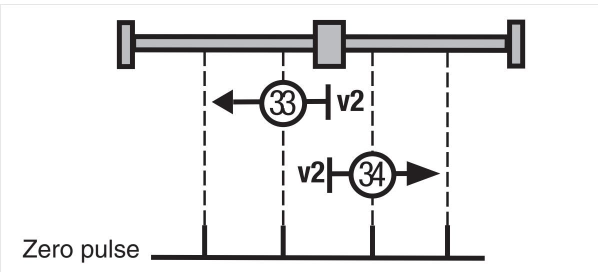
Table 125.2

Type 1 corresponds to type 17 + zero pulse	Type 12 corresponds to type 28 + zero pulse
Type 4 corresponds to type 20 + zero pulse	Type 14 corresponds to type 30 + zero pulse
Type 8 corresponds to type 24 + zero pulse	

Type 31+32: These homing methods are not defined.

Type 33+34: Zero pulse
The zero corresponds to the first zero pulse in the direction of movement.

Illustration 125.3 Type 33 + 34: Zero pulse

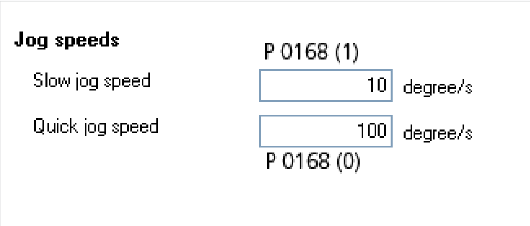


Type 35:
The current actual position corresponds to the zero.

5.5 Jog mode

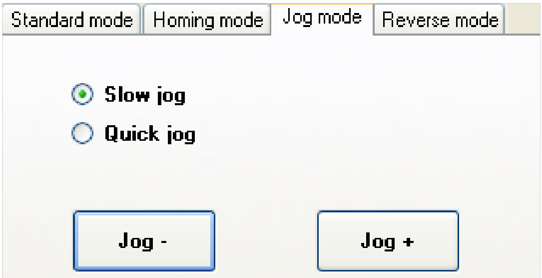
Jog mode enables the drive to be moved manually. A bus system or reference sourcing via terminal can be selected as the reference. The unit corresponds to the selected user unit. It is possible to select fast and slow jog speeds in both directions. For jogging in positive and negative direction two digital input parameters must be set to INCH_P(7) = Jog + and INCH_P(8) = Jog -. For jogging at different speeds, both switches must be activated. If the "Jog left" switch is activated first and then switch two, quick jog mode left is started. If the "Jog right" switch is activated first, quick jog mode right is started.

Illustration 126.1 Screen for jog mode settings



It is also possible to move the drive by way of the manual mode window in jog mode. The jog speeds in the manual mode window are oriented to the values of the upper screen: "Jog mode settings".

Illustration 126.2 Screen for jog mode in manual mode window

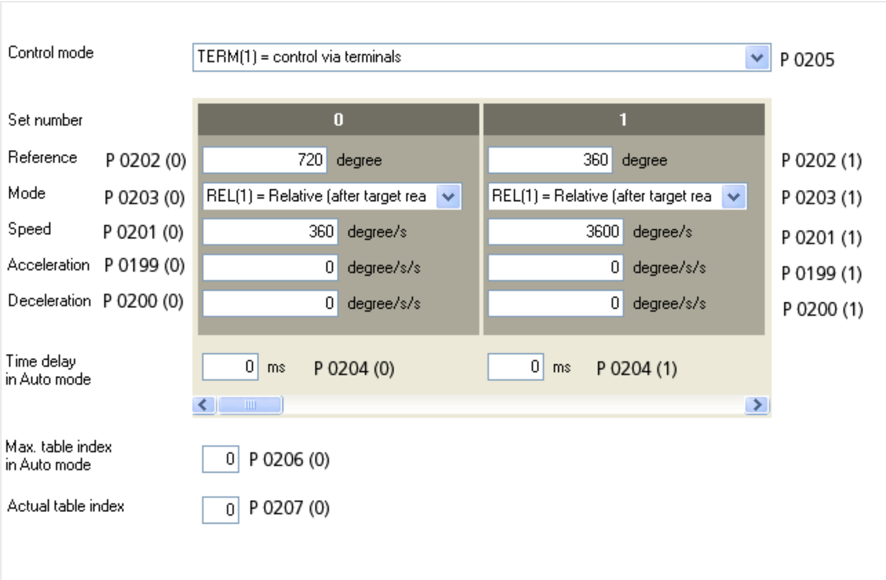


5.6 Setpoint table

Fixed speeds, fixed torques or fixed positions can be preset by way of a table. A travel profile is generated internally using the Profile Generator. The 16 table values can be selected using the on-screen slider.

Reference input for fixed positions:
Each position value is assigned a speed and acceleration and braking ramps.

Illustration 127.1 Reference table screen



There are 16 driving sets (0-15)

Table 127.2

P. no.	Index	Parameter name/ Settings	Designation in DM 5	Function
P 0199	0-15	MPRO_TAB_PAcc	Position mode acceleration	Acceleration ramp
P 0200	0-15	MPRO_TAB_PDec	Position mode deceleration	Braking ramp
P 0201	0-15	MPRO_TAB_PSpd	Position mode speed	Speed
P 0202	0-15	MPRO_TAB_PPos	Position mode reference position	Reference
P 0203	0-15	MPRO_TAB_PMode	Position mode	Positioning mode
(0)		ABS(0)	Absolut	Absolute positioning
(1)		REL(1)	Relative, after target reached	Relative positioning after target position reached
(2)		REL at once(2)	Relative at once	The current motion task is interrupted and a new pending task is directly accepted and executed.
(3)		SPEED(3)	Endless, Speed controlled	Infinite motion, SPD (infinite motion task): If a table value is set to SPD, an infinite motion task is transmitted. If a table value with the setting ABS or REL is additionally selected, the infinite task is quit and the newly selected table value is approached from the current position.

Table 128.1

P. no.	Index	Parameter name/ Settings	Designation in DM 5	Function
P 0204	0-15	MPRO_TAB_Wait time	Max time for position or speed control	With follow-up tasks: Wait time until execution of the next motion task
P 0205		MPRO_TAB_Mode	Operation mode	Selection of table values
(0)		PARA(0)	Control via parameter **P0207**	Selection of a table value via **P 0207**
(1)		TERM(1)	Control via terminals	Selection of a table value via terminal
(2)		AUTO(2)	Control via timer, **P 0204**	Selection of a table value via timerr **P 0204**
(3)		BUS(2)	Control via fieldbus	Selection of a table value via field bus system
P 0206		MPRO_TAB_MaxIdx	Max Index im AUTO Mode	Setting for number of table values to be worked through in sequence from top to bottom. Example: If this value is set to 6, the first six reference values from the table are worked through in sequence. This process is repeated until the table is disabled or the start contact is removed.
P 0207		MPRO_TAB_ActIdx	Actual Index	Display of the currently selected motion task

Note:
Before a driving set can be executed, the data set is first selected. Then it must be read-in. If the activation is via terminal, this is done with a digital input parameterized to "TBEN". A motion task is selected via field bus by setting the corresponding bits (see field bus user manual).

Note:
Before configuring the driving set parameters the units and scaling must first be checked.

Selection of driving sets:

Table 128.2

Activation	Setting	Description
Triggering via terminal _ I/O configuration	Input ISDxx = TBEN	Enabling a selected driving set. The selection of a new motion task always interrupts an ongoing positioning or follow-up task logic.
Triggering via terminal _ I/O configuration	Input ISDxx = TAB0 to TAB3	The binary significance (2^0, 2^1 , 2^2 , 2^3) results from the TABx assignment. The TAB0 setting has the lowest significance (2^0), and the TAB3 the highest (2^3). A Logical 1 level at the input activates the significance.
Triggering via field bus system	Cross-check "Execute motion task" bit with control word!!!	Enabling a selected driving set. The selection of a new motion task always interrupts an ongoing positioning or follow-up task logic.
Triggering via field bus system	"Activate follow-up task" bit Check adjustment with control word!!!	The binary significance (2^0, 2^1 , 2^2 , 2^3) results from the TABx assignment of the control word. The TAB0 setting has the lowest significance (2^0), and the TAB3 the highest (2^3).

Table settings dependent on control mode:

Table 129.1

Control mode	Table reference	Acceleration ramp	Braking ramp	Speed	Positioning mode
Torque	P 0195	P 0193	P 0194		
Speed	P 0198	P 0196	P 0197		
Position	P 0202	P 0199	P 0200	P 0201	P 0203

Reference setting:
Motion Control provides references in user-defined travel units. These values must be converted into internal units. This is done by way of the scaling block "Standardisation/units".
There are three options for scaling of the drive controller: The selection is made via **P 0283 MPRO_FG_Type** (for more information see "Scaling" section).

Speed:
The speed can be specified signed. A negative setting is only evaluated in case of infinite positioning. It is limited by parameter **P 0328 CON_SCON_SMax**.

Starting and braking
The acceleration values for starting and braking can be parameterized irrespective of each other. The input must not be zero. Accelerations are controlled by the limitations.

Follow-up task:
The positioning jobs from zero up to the "Number of follow-up tasks to be processed" set in **P 0206** are continuously processed. Once the driving set in **P 0206** is finished, the first data set is restarted. Processing is only stopped by removing the start contact. If a task has the setting REL at once, the driving set can be aborted and a new one can be started immediately.

Driving sets in speed control
Each driving set, either for speed or torque, has an acceleration and a braking ramp.

Table 129.2

P. no.	Index	Parameter name/Settings	Designation in DM 5	Function
P-0196	0-15	MPRO_TAB_SAcc	Speed mode acceleration	Acceleration ramp
P-0197	0-15	MPRO_TAB_SDec	Speed mode deceleration	Braking ramp
P 0198	0-15	MPRO_TAB_SRef	Speed mode reference value	Reference

Driving sets in torque control

Table 129.3

P. no.	Index	Parameter name/Settings	Designation in DM 5	Function
P-0193	0-15	MPRO_TAB_TAcc	Torque mode acceleration	Acceleration ramp
P-0194	0-15	MPRO_TAB_TDec	Torque mode deceleration	Braking ramp
P 0195	0-15	MPRO_TAB_TRef	Torque mode reference value	Reference

5.7 Measuring switch function/Touch probe

Using the two fast digital inputs ISD05/06, a position value can be recorded and processed during ongoing operation. A positive or negative switching edge optionally triggers recording of a measured value.
After enabling the relevant measuring switch, a value is only recorded on the first trigger. Prior to any further measurement the measuring switch must be enabled again – **P 2279** Bit 0 (one-time measurement).

Table 130.1

P. no.	CANopenObjekt no.	Setting	Function
P 2285	-	2	CiA DS402 motion profile (partial)
P 2279	60B8 control word	0101 hex	Digital input ISD05; triggering by a rising edge
		0202 hex	Digital input ISD05; triggering by a falling edge
		0304 hex	Digital input ISD06; triggering by a rising edge
		0408 hex	Digital input ISD06; triggering by a falling edge
P 2280	60B9 status word	0101 hex	Digital input ISD05; triggering by a rising edge
P 2280	60B9 status word	0202 hex	Digital input ISD05; triggering by a falling edge
		0304 hex	Digital input ISD06; triggering by a rising edge
		0408 hex	Digital input ISD05; triggering by a falling edge
P 2081	60BA	Position value in user units	The value is always written to this object. As there is no 100 percent match with DS402 here.

6.1 Digital Inputs

All digital inputs of the controller are set by way of a function selector. By this selector a unique function can be assigned to each input. Other settings can be made by clicking the **>Options** button.

Function selector for the digital inputs:

Illustration 131.1 Function selector

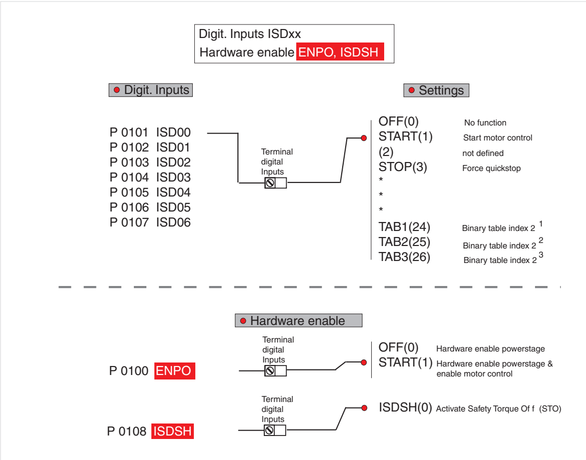


Illustration 131.2 Screen for the digital inputs

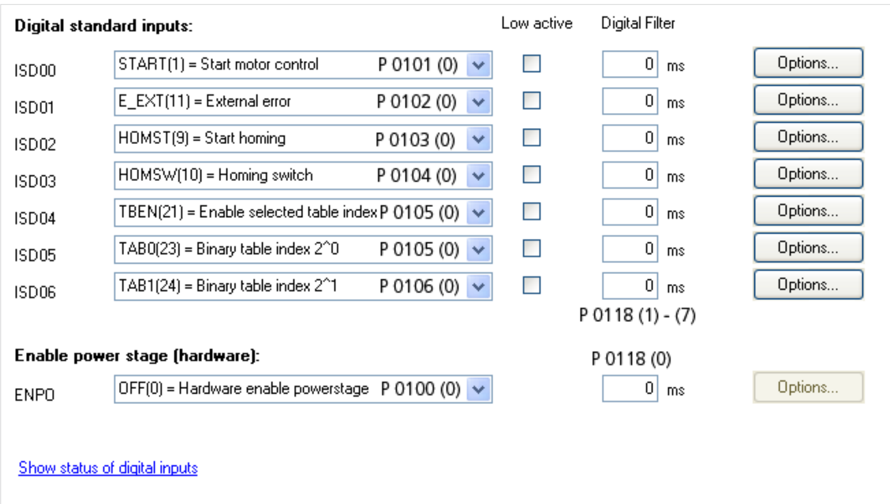
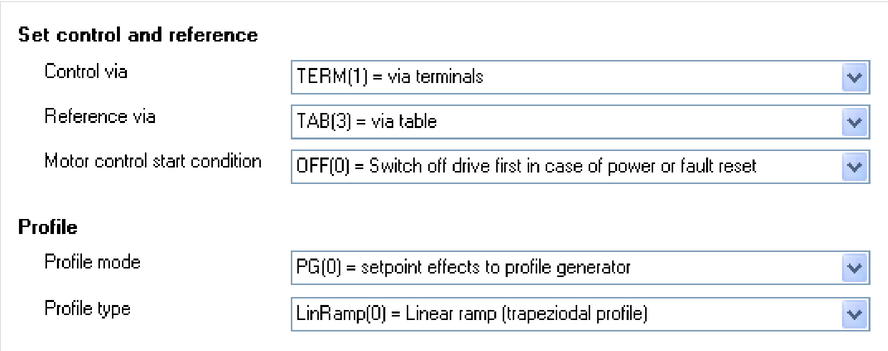


Illustration 132.1 Example for „Start“ function



Seven digital inputs (ISD00 to ISD06) can be assigned a wide variety of functions via parameters P 0101 to P 0107. The two inputs ISDSH STO „Safe Torque Off“ and ENPO „Enable Power“ are reserved for the hardware enable. For the touch probe function the two „fast“ inputs ISD05 and ISD06 are provided.

Table 132.2 Overview of function selectors:

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0100	MPRO_INPUT_FS_ENPO	Function of digital input ENPO	Setting of hardware input ENPO
	OFF(0)	Hardware enable powerstage	The digital input ENPO (terminal 10 on x4) is reserved for hardware enable. In its default setting “OFF” it only executes the “Hardware enable” function. Apart from this, it can also be assigned the “START” function. In combination with parameter P 0144 DRVCOM AUTO_START= “LEVEL” autostart mode is active. If STO is active, activation of the hardware enable ENPO via terminal 10 on X4 is sufficient to switch on the drive control (section 6.1.4)
	START(1)		
P 0101	MPRO_INPUT_FS_ISD00	Function of digital input ISD00	Settings for the digital inputs ISD00 - ISD06 are listed in the following table.
P 0102	MPRO_INPUT_FS_ISD01	Function of digital input ISD01	
P 0103	MPRO_INPUT_FS_ISD02	Function of digital input ISD02	
P 0104	MPRO_INPUT_FS_ISD03	Function of digital input ISD03	
P 0105	MPRO_INPUT_FS_ISD04	Function of digital input ISD04	Settings for the digital inputs ISD00 - ISD06 are listed in the following table.
P 0106	MPRO_INPUT_FS_ISD05	Function of digital input ISD05	
P 0107	MPRO_INPUT_FS_ISD06	Function of digital input ISD06	
P 0108	MPRO_INPUT_FS_ISDSH	Function of digital input ISDSH	Reserved for STO (Safe Torque Off), (see also Inputs/ outputs section)
P 0109	MPRO_INPUT_FS_ISA00	Function of analog input ISA00	Analog input ISA00 see Analog inputs section
P 0110	MPRO_INPUT_FS_ISA01	Function of analog input ISA01	Analog input ISA01 see Analog inputs section

6.1.1 Settings for digital inputs ISD00-ISD06

Table 133.1

P. no. P 0101-P 0107	Parameter name/ settings	Function
(0)	OFF	Input off
(1)	START	Start of closed-loop control - motor is energized. The direction of rotation depends on the reference.
(2)	(2)	Not defined
(3)	STOP	Quick stop according to quick stop reaction (Low active) see “Reaction to quick stop”
(4)	HALT	The running movement of the axis is interrupted according to the STOP reaction (see “Reaction to Halt Feed”) and continued when reset.
(5)	LCW	Limit switch evaluation without override protection. The response to limit switch activation and to interchange limit switches is programmable (see “Error reactions, alarms, warnings” section)
(6)	LCCW	Limit switch evaluation without override protection. The response to limit switch activation and to interchange limit switches is programmable (see “Error reactions, alarms, warnings” section)
(7)	INCH_P	In manual positioning the axis can be moved in creep speed or in rapid. positive motion, (jog mode).
(8)	INCH_N	In manual positioning the axis can be moved in creep speed or in rapid, negative motion, (jog mode).
(9)	HOMST	According to the homing method parameterized in P 02261 MPRO_402_Homing Method
(10)	HOMSW	Reference cam for zero point definition in positioning
(11)	E-Ext	Error messages from external devices cause an error message with the reaction determined in parameter P 0030 Error-Reaction Sub Index 11
(12)	WARN	External collective warning
(13)	RSERR	Error messages are reset with a rising edge, if the error is no longer present
(14)	MAN	In field bus operation switching of the reference source P 0165 CON_CfgCon and the control location P 0159 MPRO_CTRL to Term can be set via a digital switch.
(15)	PROBE	Only adjustable for the fast inputs ISD05 and ISD06
(16)	PLC	Input can be read by PLC program
(17)	PLC_IR	Interruption of the PLC program
(18)	(18)	Not defined
(19)	(19)	Not defined
(20)	(20)	Not defined
(21)	TBEN	Import and execution of selected table driving set
(22)	TBTBA	Teach in for position driving set table
(23)	TAB0	Binary driving set selection (Bit 0) , (significance 20) for speed
(24)	TAB1	Binary driving set selection (Bit 1) , (significance 21) for speed or positioning
(25)	TAB2	Binary driving set selection (Bit 2) , (significance 22) for speed or positioning
(26)	TAB3	Binary driving set selection (Bit 3) , (significance 23) for speed or positioning

6.1.2 Hardware enable ISDSH STO (Safe Torque Off)

For the function “Save Torque Off” STO according to EN 954-1 “Category 3”, under due consideration of the requirements specified in EN 61508 concerning the fulfilment of the systematic integrity for SIL 2, the drive controllers are equipped with an integrated circuit with feedback contact. The logic cuts the power supply to the pulse amplifiers to activate the power stage. Combined with the “ENPO” controller enable, a two-channel block is placed on the occurrence in the power circuit of a pulse pattern suitable to generate a rotating field in the motor.

Function testing: The STO function (protection against unexpected starting) must essentially be checked to ensure it is operative:

- During initial comissioning
- After any modification of the system wiring
- After replacing one or more items of system equipment

Cancelling one of the two signals „ISDSH“ or „ENPO“ disables the control and the motor runs down unregulated.

The drive controller has its own relay contact for feedback (terminal RSH on x4).

⚠

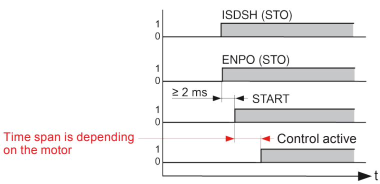
Attention!
The machine manufacturer is responsible for determining the safety category required for an application (minimizing risk).

6.1.3 Hardware enable and autostart

The digital input ENPO (terminal 10 on X4) is reserved for hardware enable. In its default setting „OFF“ it only executes the „Hardware enable“ function. Apart from this, it can also be assigned the „START“ function. In combination with parameter **P 0144 DRVCOM AUTO_START= „ON“** autostart mode is active.
If the „Safe Stop“ function is active, the activation of the hardware enable ENPO via terminal 10 on X4 suffices to switch on the drive control.
When the „ENPO“ is cancelled the drive runs down freely.

Power-up sequence
Regardless of which control mode was selected, the power-up sequence must be followed in order to start the drive.

Illustration 134.1 Power-up sequence for control



Power-up sequence	Command	System state
	STO ISDSH	(2) Starting lockout
	ENPO-Enable Power	(3) Ready for starting
	FS_ISDXX or Start.BIT= START(1)	(4) Switched on
	control active	(5) Control active

If the power-up sequence as shown in figure 100 is followed, the drive starts with a rising edge of the digital input parameterized to START or when the corresponding Start bit is set via a bus system. The reference polarity determines the direction of rotation.

6.1.4 Manual drive control via digital inputs

Setting a digital input to "MAN(14)" allows a change of control location to the reference source selected in **P 0164 MPRO_REF_SEL_MAN**. This enables fast switching to manual control for setup or emergency running mode for example.

Table 135.1

P. no.	Parameter name/settings	Designation in DM 5	Function
P 0164	MPRO_INPUT_FS_ISDx	Function of digital input	Function selection
(0)	OFF	No profile selected	No profile selected
(1)	ANA0	Profile via channel analog 0	Reference value of analog input ISA0
(2)	ANA1	Profile via channel analog 1	Reference value of analog input ISA1
(3)	TAB	Profile via table positioning	Reference from table
(4)	(4)	Not defined	Not defined
(5)	PLC	Profile via PLC definition	Reference from PLC
(6)	PARA	Profile via parameter definition	Reference via parameter
(7)	DS402	Profile via DS402 definition	Reference via CIA402 IE1131
(8)	SERCOS	Profile via SERCOS definition	Reference via SERCOS
(9)	PROFI	Profil via PROFIBUS definition	Reference via PROFIBUS

Table 135.2 Required parameters

P. no.	Parameter name/settings	Designation in DM 5	Function
P 0101 - P 0107	MPRO_INPUT_FS_ISD00 - ISD06	Function of digital input	Set digital input to MAN(14)
P 0159	MPRO_CTRL_SEL	Motion control selection	The control mode must not be changed when switching reference source.
P 0164	MPRO_REF_SEL_MAN	Motion profile selection	Target reference source
P 0165	MPRO_REF_SEL	Motion profile selction	Reference source
P 0300	CON_CfgCon	Select control mode	Control mode must not be changed

When a digital input set to "MAN(14)" is activated, the control location **P 0159 MPRO_REF_SEL** is set to **"TERM"** (switch to TERM is not displayed in DM5). In parallel, the reference source is set to the reference selected via paramater **P 0164-MPRO_REF_SEL_MAN**.
Additionally, the start signal must be connected to a digital input (ISDxx = Start).

The control mode **P 0300_CON_CfgCon** cannot be switched.
„MAN(14)" mode is displayed in the remote bit in the CIA 402.

Note:

- It is not possible to switch to "MAN" mode when the power stage is activated (system states 1,2,3) or when the drive in the DM5 is operated via the Control window.
- A level-triggered START **(P 0144 MPRO_DRVCOM_AUTO_START=LEVEL (1))** is ignored in „MAN" mode. After activation of „MAN" mode, the START input must be reset.
- When "MAN" mode is ended the motor control also stops.

6.2 Digital Output

The digital standard outputs OSD00 to OSD02 can also be assigned corresponding functions via selectors **P 0122** to **P 0124**. The relay output **P 0125 MPRO RELOUT1** is intended for the motor brake. It can also be assigned other functions via function selectors P 0122 to P 0124 if necessary.
The digital output RELOUT2 is set to the „STO SH_H" function and its setting cannot be changed. Additional information on the STO function can be found in the documentation „Description of the safety function STO".

Illustration 136.1 Function block for adaptation of the digital outputs

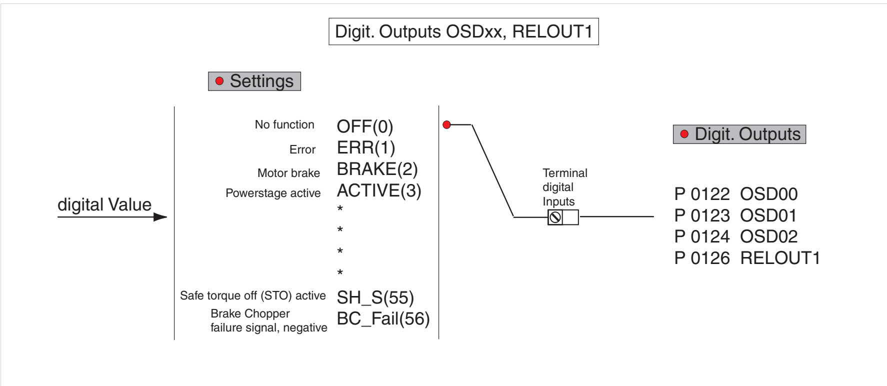


Illustration 136.2 Screen for digital outputs

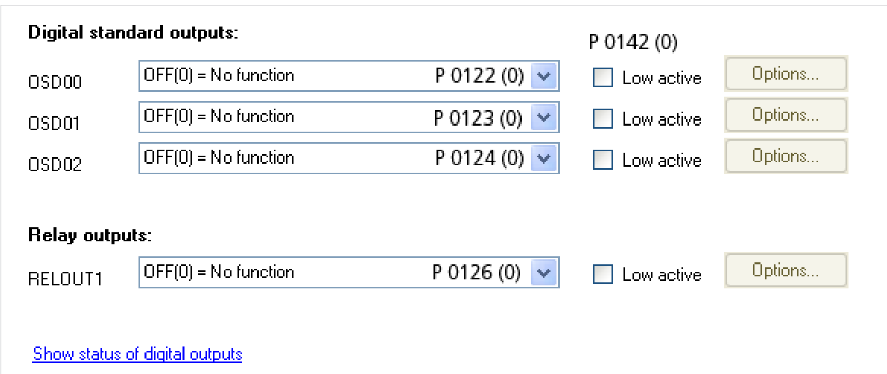


Table 137.1

P. no.	Parameter name/settings	Designation in DM 5	Description
P 0122 - P 0127	MPRO_OUTPUT_FS_OSD0x	Function of digital output	Function selection
(0)	OFF(0)	No function	Output off
(1)	ERR(1)	Error	Collective error message
(2)	BRAKE(2)	Motor brake	Output becomes active in accordance with the holding brake function, see section 4.6, Motor brake.
(3)	ACTV(3)	Power activ	Power stage active and closed-loop/open-loop control in function
(4)	S_RDY(4)	Device initialized	Output is activated when the device is initialized after power-on
(5)	C_RDY(5)	Control initialized	Output is activated when the device is "Ready to switch on" based on setting of the ENPO signal and no error message has occurred. Device ready - ReadyToSwitchOn flag in DriveCom status word set (in states 3, 4, 5, 6, 7)
(6)	REF	Target reached,	The preset reference has been reached (dependent on control mode)
(7)	HOMATD	Homing attained	Homing complete
(8)	E_FLW	Following error	Tracking error
(9)	ROT_R	Rotation right	Motor in standstill window when running clockwise
(10)	ROT_L	Rotation left	Motor in standstill window when running anti-clockwise
(11)	ROT_0	Motor stand still	Motor in standstill window, depending on actual value
(12)	STOP	Drive in „Quickstop"	The drive is in the "quick-stop" state
(13)	HALT	Drive in „halt"	The display system is in HALT state (activated via DS 402 profile, input or PROFIBUS IntermediateStop, SERCOS from V 2.0). Reaction according to HALT Option Code (P 2221 MPRO_402_HaltOC)
(14)	LIMIT	Reference limitation	The output function LIMIT(14) detects when a reference reaches its limitation. In this case the output is set.
(15)	N_GT_Nx	Speed greater than Nx	Nact greater than Nx where Nx = value in **P 0740 MON_SpeedThresh**
(16)	N_LT_Nx	Speed less than Nx	Nact less than Nx where Nx = value in **P 0740 MON_SpeedThresh**
(17)	P_LIM_activ	Position setpoint limited	Position reference limited (e.g. with parameterized software limit switches from V 2.0)
(18)	N_LIM_activ	Speed setpoint limited	Speed reference limitation active
Warnings/warning thresholds are set via **P 0730 MON_WarningLevel**			

Table 138.1

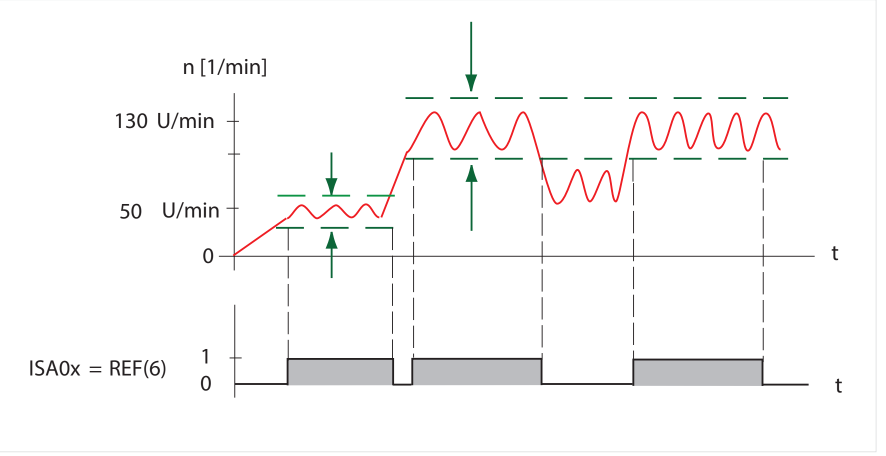
P. no.	Parameter name/ Settings	Designation in DM 5	Description
P 0122 - P 0127	MPRO_OUTPUT_FS_ OSD0x	Function of digital output	Function selection
(19)	I_LIM_activ	Current setpoint limited	Current reference active.
(20)	COM	Set via communication profile	Set output via COM option (from V 2.0)
(21)	ENMO	Motor contactor output	Activate motor contactor (wiring of motor via contactor)
(22)	PLC	PLC sets output	Use output via PLC program
(23)	WARN	Warning	Collective warning message
(24)	WUV	Warning undervoltage	Warning: undervoltage in DC link
(25)	WOV	Warning overvoltage	Warning: voltage overload in DC link
(26)	WIT	Warning I^2xt power stage	Warning I^2xt power stage protection threshold reached
(27)	WOTM	Warning overtemperatur motor	Warning motor temperature
(28)	WOTI	Warning overtemperatur drive	Warning heat sink temperature of inverter
(29)	WOTD	Warning overtemperatur motor	Warning internal temperature in inverter
(30)	WLIS	Warning current threshold reaction	Warning apparent current limit value exceeded
(31)	WLS	Warning speed threshold reaction	Warning speed limit value exceeded
(32)	WIT	Warning I^2xt motor protection	Warning I^2xt motor protection threshold
(33)	WLTQ	Warning torque/force threshold	Warning torque limit value exceeded
(34)	TBACT	Table positioning active	Table positioning in AUTO and activated state
(35)	TB0	Actual table index 2^0	Significance 2^0
(36)	TB1	Actual table index 2^1	Significance 2^1
(37)	TB2	Actual table index 2^2	Significance 2^2
(38)	TB3	Actual table index 2^3	Significance 2^3
(39)-(54)	CM1 – CM16	Cam switch 1 to 16	Cam group (as from V 2.0)
(55)	SH_S	Safe Standstill activ	STO function activated
(56)	BC:Fail	Brake chopper failure signet	Braking chopper error

Warnings/warning thresholds are set via **P 0730 MON_WarningLevel**

Output function „Reference reached REF(6)“ P 0122 to P 0127 OSDxx = REF(6)

For torque and speed control as well as positioning the setting REF(6) can be used to define a range in which the actual value may deviate from the reference without the „Reference reached“ (REF) message becoming inactive. Reference fluctuations caused by reference input, e.g. via analog inputs, can thus be taken into account.

Illustration 139.1 REF setting: "Reference reached" window for speed control via analog input



Output function „LIMIT(14)"
The output function LIMIT(14) detects when a reference value reaches its setpoint (reference) limit. In this case the output is set.

The limit values for maximum torque and maximum speed depend on the control system. A detailed description is given in the Limits section.

Torque control:
Limit value monitoring becomes active when the torque reference exceeds the max. torque.

Speed control:
Limit value monitoring becomes active when the speed reference exceeds the max. speed.

Positioning:
Limit value monitoring becomes active when the speed reference exceeds the max. speed or the torque reference exceeds the max. torque.

Infinite positioning/speed mode:
Monitoring is activated in infinite positioning (speed mode) when the speed reference has been reached.

If an ongoing positioning operation is interrupted with „HALT", the „Reference reached" message is not sent in this phase. The message only appears after the actual target position has been reached.

Output function „Switch motor contactor“ OSDxx = ENMO(21)
The motor cable must always be switched with the power cut, otherwise problems such as burnt-out contactor contacts, overvoltage or overcurrent shut-off may occur.

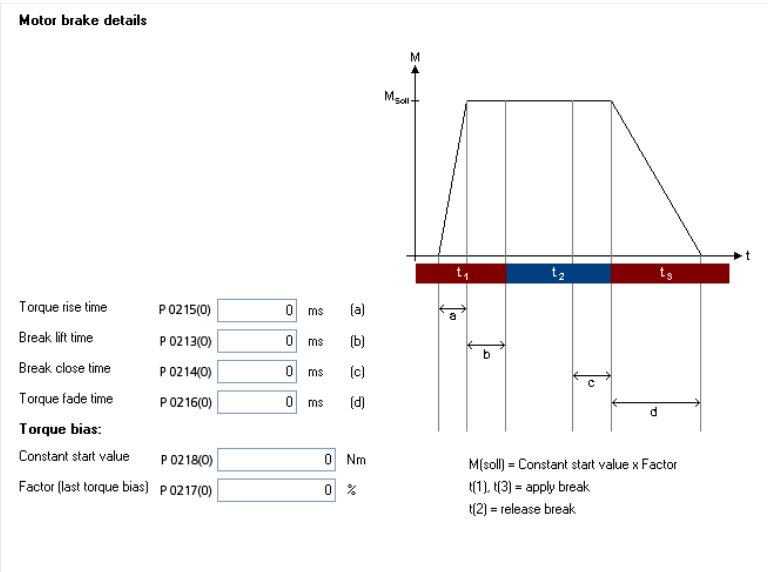
In order to assure de-energized switching, the contacts of the motor contactor must be closed before the power stage is enabled. In the opposite case the contacts must remain closed until the power stage has been switched off. This can be achieved by implementing the corresponding safety periods for switching of the motor contactor into the control sequence of the machine or by using the special ENMO software function of the drive controller.

A power contactor in the motor supply line can be directly controlled by the drive controller via parameter **P 0125 MPRO_OUTPUT_FS_MOTO = ENMO**. By way of the timer **P 0148 MPRO_DRVCOM_ENMO_Ti** the on-and-off delay of the power contactor can be taken into account. This ensures that the reference will only be applied after the start enable when the contactor is closed, or if the motor is isolated from the position controller via contactor when the power stage is inactive.

Note:
The **MPRO_DRVCOM_ENMO_Ti** timer time should allow additional times for typical contactor bounce. They may be several hundred ms, depending on contactor

Motor brake output RELOUT1:
Output **P 0125 MPRO_OUTPUT_FS_Motor_Brake** should be used in conjunction with a brake. If the output is set to BRAKE(2), the brake can be configured by way of the option field.

Illustration 140.1 Brake output



An optional holding brake built in to the motor provides protection against unwanted motion when the power is cut and in case of error.
If the brake is mounted on the axle mechanism and not directly on the shaft, undesirably severe torsional forces may occur on sudden engagement of the brake.

Attention!
Please check the settings of the stop ramps if use of a holding brake is specified (Motion profile section, Stop ramps).

The brake response can be adapted to the requirements of the application as shown in the following illustration and using the parameters listed. This function can be used in both speed as well as position controlled operation.

Illustration 142.1 Brake response: Brake output RELOUT1

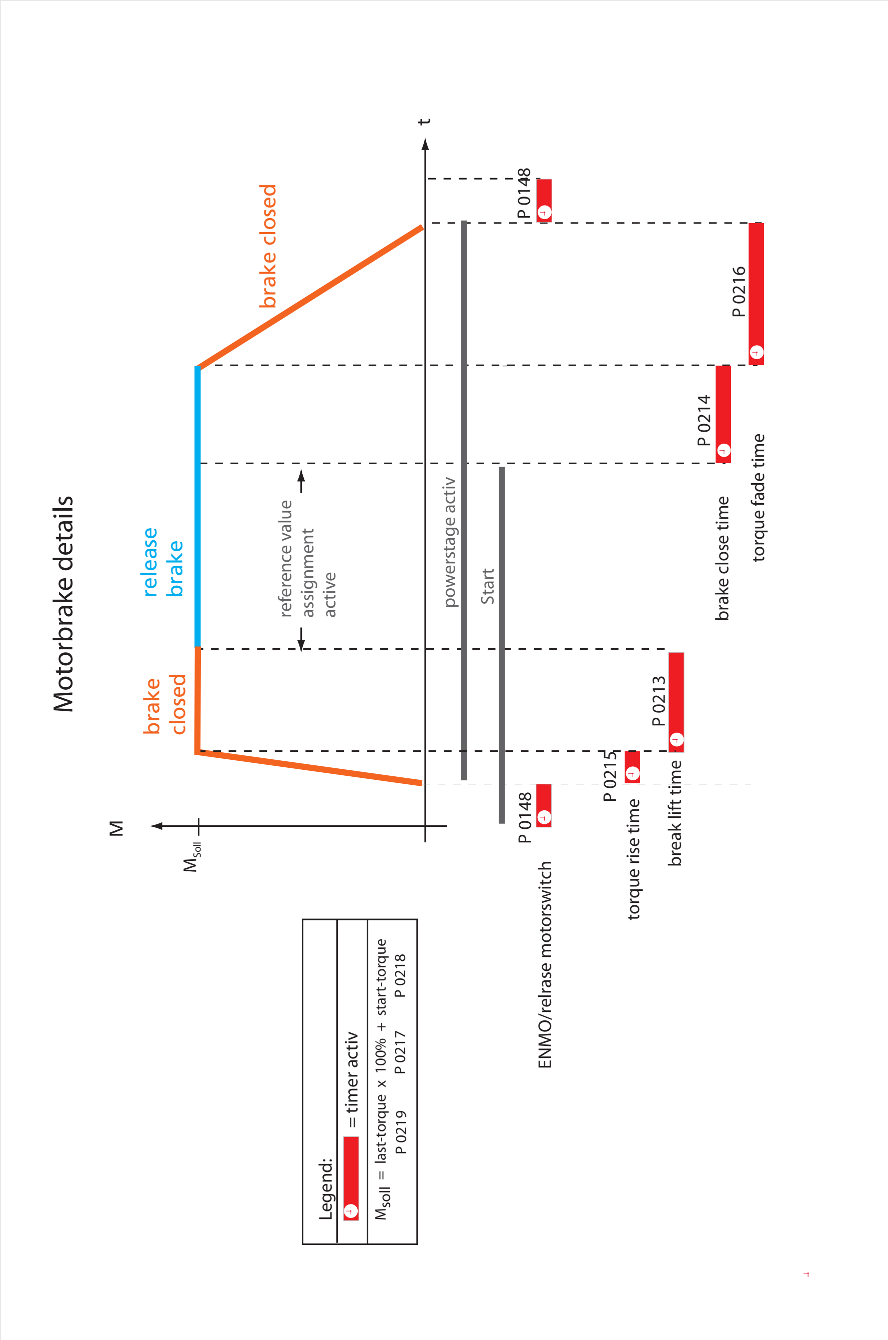


Table 143.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0125	MPRO_OUTPUT_FS_MO-TOR_BREAKE	Setting of analog output from OFF(0) to BC_Fail(56)	Output for use of a motor holding brake. If no brake is used, the output can be used for a wide variety of other functions (section 6.2).
P 0147	MPRO_DRVCOM_EPCHK	CHECK EnablePower	Power-up condition
(0)	OFF	NO CHECK = ENPO is set via ENMO-function	Hardware enable "ENPO" is switched via the motor contactor.
(1)	ON	CHECK = ENPO is set via terminals	ENPO must be switched via a digital input.
P 0148	MPRO_DRVCOM_ENMO	Time out in „Ready/to switch On; to enable motor switch	The timer "ENMO" (Enable Motor Contactor) generates an On/Off-delay of the motor contactor and thus of the power stage. The effect is active when setting and resetting the START command and in case of error.
P 0213	MPRO_BRK_LiftTime	Motor brake lift time	The "lift time" takes account of the mechanically dictated opening time of the brake. An applied reference will only be activated when this timer has elapsed.
P 0214	MPRO_CloseTime	Motor brake close time	The "Closetime" starts after removing the start condition or in case of a fault. It is the mechanically dictated time which a brake takes to close.
P 0215	MPRO_RiseTime	Motor brake torque rise time	The "rise time" is the rise of the ramp to build up the reference torque "Mref".
P 0216	MPRO_FadeTime	Motor brake torque fade time	The "fade time" is the descending ramp to reduce the reference torque Mref to 0.
P 0217	MPRO_BRK_LastTorqFact:	Motor brake factor for application of last torque	If the loads change on restarting, a restart with the Last-Torque (torque on shutdown) is recommended. In this case the actual value parameter is applied with a factor 1-100 %. (0 % = off). Note: On the very first power-up a StartTorque **P 0218** must be set.
P 0218	MPRO_BRK_StartTorq	Motor brake contstant initial torque	If the moving load always remains constant, M_{ref} is set by way of parameter P 0218 "StartTorque". M_{soll} = lasttorque * lasttorque-factor+ starttorque When following the formula and setting the LastTorq-factor = 0, one only uses the StartTorque setting. If StartTorque = 0 is set, the Last Torque is also used. On the very first operation there is no LastTorque though. In this case StartTorque is set = 0 and LastTorque factor unequal to 0 and then the control is started. The last torque applied is adopted.
P 0219	MPRO_BRK_LastTorq	Motor brake torque samples at last closing time	This parameter is only a display parameter. In it, the last torque applied is entered on shutdown and the scale factor **P 0217** is applied to it as a percentage where necessary.
P 0220	MPRO_BRK Lock	Lock brake	Only for testing. By setting this parameter the brake can be applied during operation.

6.3 Analog inputs

6.3.1 Analog channel ISA0x

To be able to specify reference setpoints for the control via the two analog inputs ISA0 and ISA1, the following function selectors must be set accordingly.

Setting of analog input ISA0/1:
P 0109, P 0110 must each be set to REV(-2). The functions usable in analog mode are indicated by a (-) mark (see „I/O configuration“ section)..

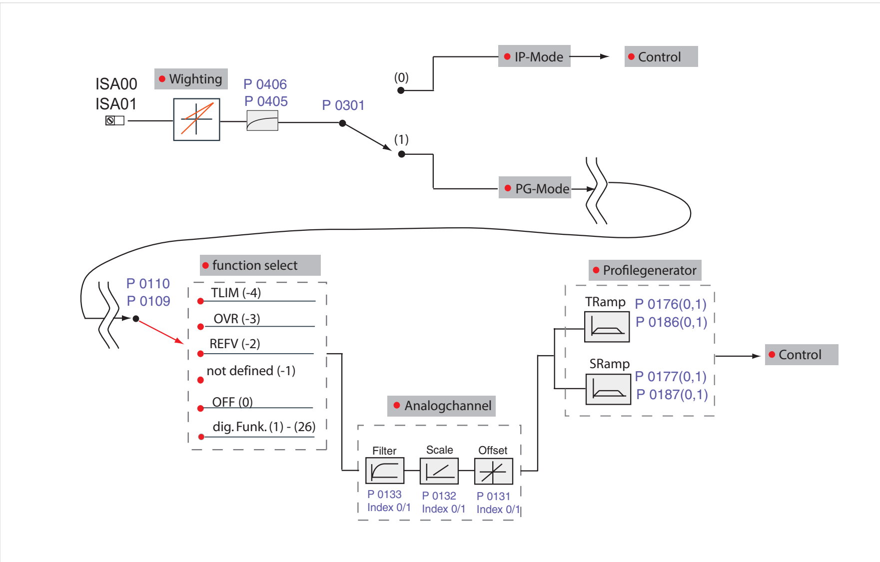
Table 144.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0109 P 0110	MPRO_INPUT_FS_ISA00/01	Function of analog input ISA00/01	Function of the analog input
	REFV(-2)	Analog command	The analog reference can be passed on to the control
P 0165	MPRO_REF_SEL	Motion profile selection	Reference selector
	(1) ANA1(2)	Via analog channel ISA01	Selection of the analog reference source

Depending on the parameterized control mode **(P 0300 CON_CfgCon)**, a speed or a torque can be set as the reference.

Structure diagram:

Illustration 144.2 References via analog input (analog channel ISA00 and ISA01)



Parameters for reference processing are available for all control modes (torque, speed and position control). The scaling, weighting, an offset and a threshold (dead travel) are programmable. The parameters are described in the following sections. The reference can also be filtered via parameters **P 0405 CON_ANA_Filt0** and **P 0406 CON_ANA_Filt1**.

Note:
For additional information on PG and IP modes refer to the Motion control section, 5.2.3/Profile generator/Interpolated mode.

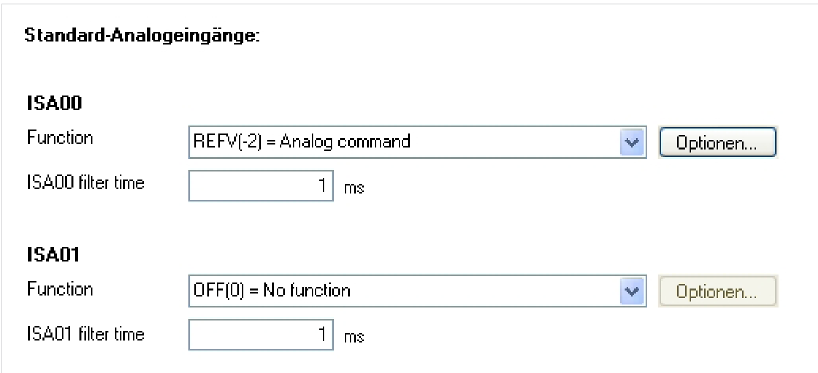
6.3.2 Reference input via analog inputs (IP/PG mode)

Parameter **P 0301 CON_REF_Mode** is used to determine whether the analog references are specified via the ramp generator (setting PG(0)) or directly (setting IP(1)).

If direct input via IP mode is selected, only the input filters are active. The analog values are in this case scanned and filtered in the current control cycle and then directly transferred as references for the speed or torque control. This is the operation mode to be set, for example, if the position controller (or speed controller) is implemented in a higherlevel control and transfers the speed references (or torque references) to the drive controller via the analog input.

With the two analog inputs ISA00 and ISA01 the analog references (input signals) are processed and filtered. Four analog functions are available.

Illustration 145.1 Setting the analog inputs



Scale/offset/dead travel function, ramps

At start of configuration the +/- 10 V is assigned (Scale) to the maximum reference value (e.g. 3000 rpm). Component spread is compensated by way of the offset function and the Dead travel setting defines a dead travel range. The setting for specifying torque references is made via the analog channel, as in speed control. The braking and acceleration ramp corresponds to the ramp for torque rise and fall.

Illustration 146.1 Options

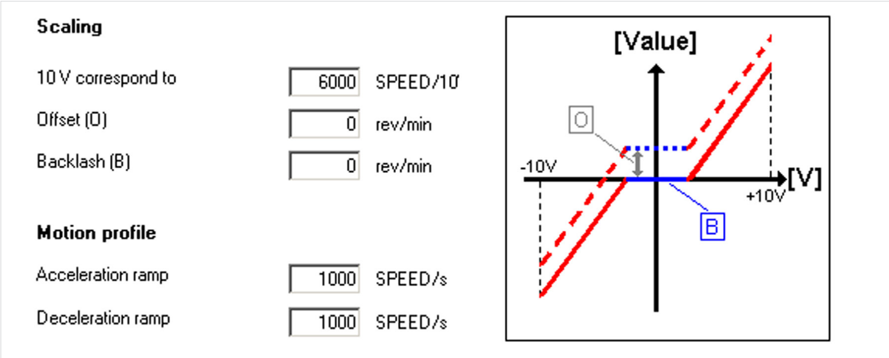


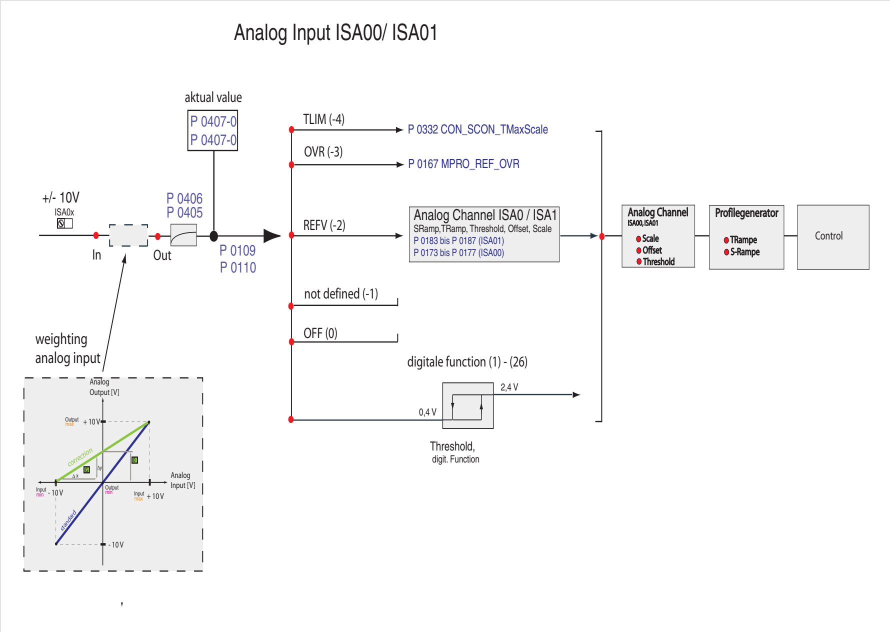
Table 146.2

P. no.	Parameter name/ settings	Designation in DM 5	Function
P 0173 P 0183	MPRO_ANA0_Scale	Scale factors	Scaling/weighting:
(0)	TScale	Scale factor for torque reference	Scaling for the torque reference (Nm/10 V)
(1)	SScale	Scale factor for speed reference	Scaling for the speed reference (rpm / 10 V)
(2)	PScale	Scale factor for position reference	Scaling for the position reference (user unit/10 V)
P 0174 P 0184	MPRO_ANA1_OFF	Offset	Reference offset (Nm)
(0)	TOffset	Offset for torque reference	Offset for the torque reference [Nm]
(1)	SOffset	Offset for Speed reference	Offset for the speed reference [rpm]
(2)	POffset	Offset for position reference	Offset for the position reference [user unit]
P 0175 P 0185	MPRO_ANA1_Thresh	Threshold	Dead travel
(0)	TThreshold	Threshold for torque reference	Dead travel for the torque reference [Nm]
(1)	SThreshold	Threshold for speed reference	Dead travel for the speed reference [rpm]
(2)	PThreshold	Threshold for position reference	Dead travel for the position reference [user unit]
P 0176 P 0186	MPRO_ANA0_TRamp	Acceleration ramp(0) and deceleration ramp (1)	Acceleration ramp (0), braking ramp (1)
(0)	TRamp	Torque acceleration ramp	Torque acceleration ramp
(1)	TRamp	Torque deceleration ramp	Torque braking ramp
P 0177 P 0187	MPRO_ANA0_SRamp	Speed mode acceleration (0) and deceleration (1)	Acceleration and braking ramp
(0)	SRamp	Speed acceleration ramp	Speed acceleration ramp
(1)	SRamp	Speed deceleration ramp	Speed braking ramp
P 0405 P 0406	CON_ANA_Filt0	Filter time	Filter time for the analog input (0-100 ms)

The reference can be filtered via parameter **P 0405 CON_ANA_Filt0**.

Switching PG/IP, Analog channel and weighting

Illustration 147.1 Analog inputs function block, PG/IP switching, Analog channel and Weighting



Analog setting options (-4) to (-1)

Table 148.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0109 P 0110	MPRO_INPUT_FS_ISA00/ ISA01	Function of anlalog input ISA0x	Function selection
(-4)	TLIM(-4)	Analog Torque limit 0-100%	Online torque scaling: 0 to 10 V corresponds to 0-100 % of the maximum set torque. The torque scaling is recorded directly after the analog filter and before the dead travel (threshold, offset). The analog input describes the parameter P 0332 SCON TMaxScale torque limitation. The dead travel is therefore not effective for these functions.
(-3)	OVR(-3)	Speed Override 0 - 100 % at positioning	0 to 10 V corresponds to 0 – 100 % Scaling of the configured speed during positioning. The override is tapped directly after the analog filter and before the dead travel. At this point the system branches off to parameter P 0167 Profile Speed override factor. The dead band (threshold, offset) is thus without any effect for these functions!
(-2)	RERFV(-2)	Analog command	Reference input +/-10 V. Observe the scaling and adapt the reference structure by means of the reference selector.
(-1)	Not defined(-1)	Not defined	Not assigned
(0)	OFF(0)	No function	No function
(1)-(26)	START - REFANAEN (1) - (26)	Corresponds to the settings for digital inputs ISD00 to ISD06	The settings (1)-(26) can be used as digital inputs.

Attention!
By switching parameter P 0301 from PG(0) to IP(1) mode, an analog input can be used as a “fast input”. The sampling-time set in parameter P 0306 for the interpolation, takes effect.

Note:
The two analog inputs ISA00 and ISA01 can also be used as digital inputs (function (1) - (28)). The switching thresholds for reliable High Level and Low Level are:

high: > 2,4 V, low: < 0,4 V

6.3.4 Weighting of analog inputs

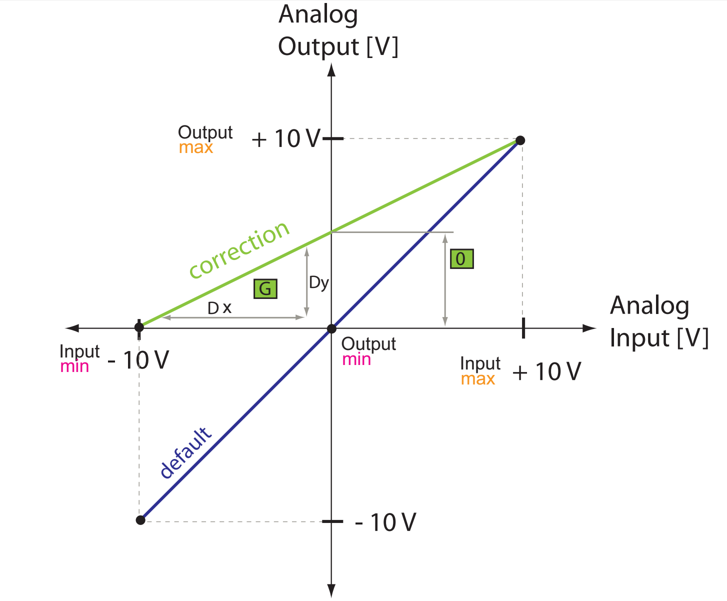
It is possible to change the weighting of the two inputs. With the two parameters P 0428 and P 0439 the input gain and input offset can be changed.

Reasons for changing the weighting:

- Change to input voltage range of analog torque scaling
- Change to input voltage range of speed override function
- Change to switching threshold of a digital input function

The illustration shows how the weighting function works. With the specified formulas, the gain and offset can be defined.

Illustration 149.1 Weighting of analog inputs



Gain
P 0428 (0, 1)

$$G = \frac{(OUT_{max}[V]) - (OUT_{min}[V])}{(IN_{max}[V]) - (IN_{min}[V])}$$

Offset
P 0429 (0, 1)

$$0 = [(OUT_{min}[V]) - (IN_{min}[V])] \times G$$

Output

$$OUT_{min}[V] = [0 + IN_{min}] \times G$$

$$OUT_{max}[V] = [0 + IN_{max}] \times G$$

Example: Analog torque weighting:

Default setting (standard controller function):
An input voltage range of the torque scaling from
0 V to +10 V corresponds to 0% - 100%;
-10 V to 0 V corresponds to -100% to 0%

Correction of input and offset gain:
The entire +/-10 V input voltage range is to be used.
-10 V corresponds to 0%
+10 V corresponds to 100% of the torque scaling
The following settings are required for this:
-10 V input voltage (In_{min} = -10 V) corresponds to 0 V output voltage (Out_{min} = 0 V) corresponds to 0% torque scaling

+10 V input voltage (In_{max} = +10 V) corresponds to +10 V output voltage (OUT_{max} = 0 V) corresponds to 100% torque scaling

Based on the formula, this results in:
Gain G = 0,5
Offset O = 5 V

7. Limits

7.1 Control limitation

To protect the device, motor and machine plant, it is necessary to limit some variables. The different limitations are described in the following. They take effect independently of other limitations within the motion profile. In addition, the servocontroller offers the possibility to set the limits for positive and negative values asymmetrically and/or to change the limits online. **The limits are specified as percentages of the rated quantities** (current, torque, speed,...), so that following calculation logical default settings are available. The default settings refer to 100% of the rated values and the parameters must thus be adapted to application and motor.

7.1.1 Torque limitation (torque/force limits)

To protect against overspeed, a speed controller becomes activated when the maximum speed defined in P0329 is reached and speed is limited to this max. value. It is possible to limit negative (P0330) as well as the positive (P0331) torque online, independent from each other.

Illustration 151.1 Torque limitation without field-weakening

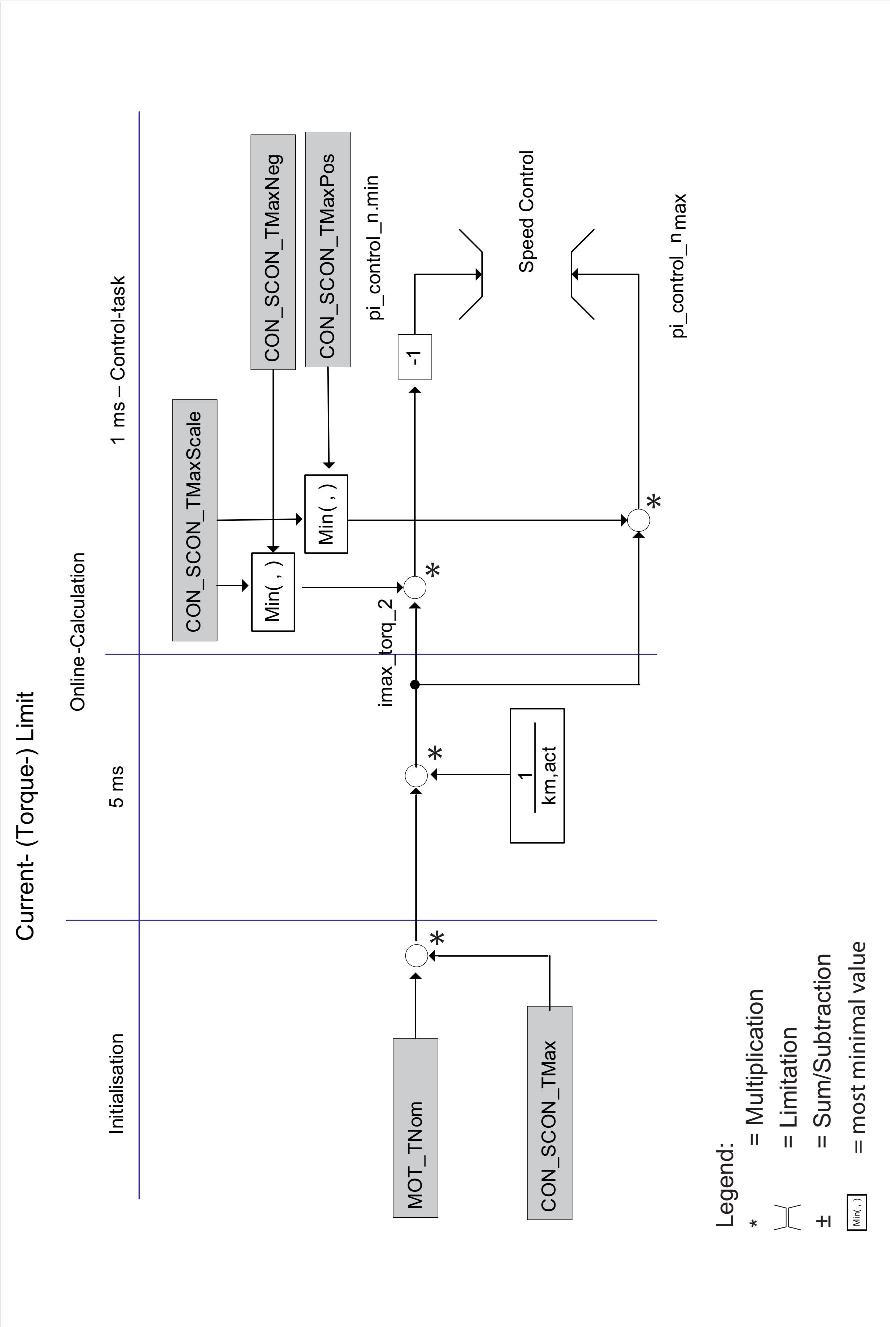
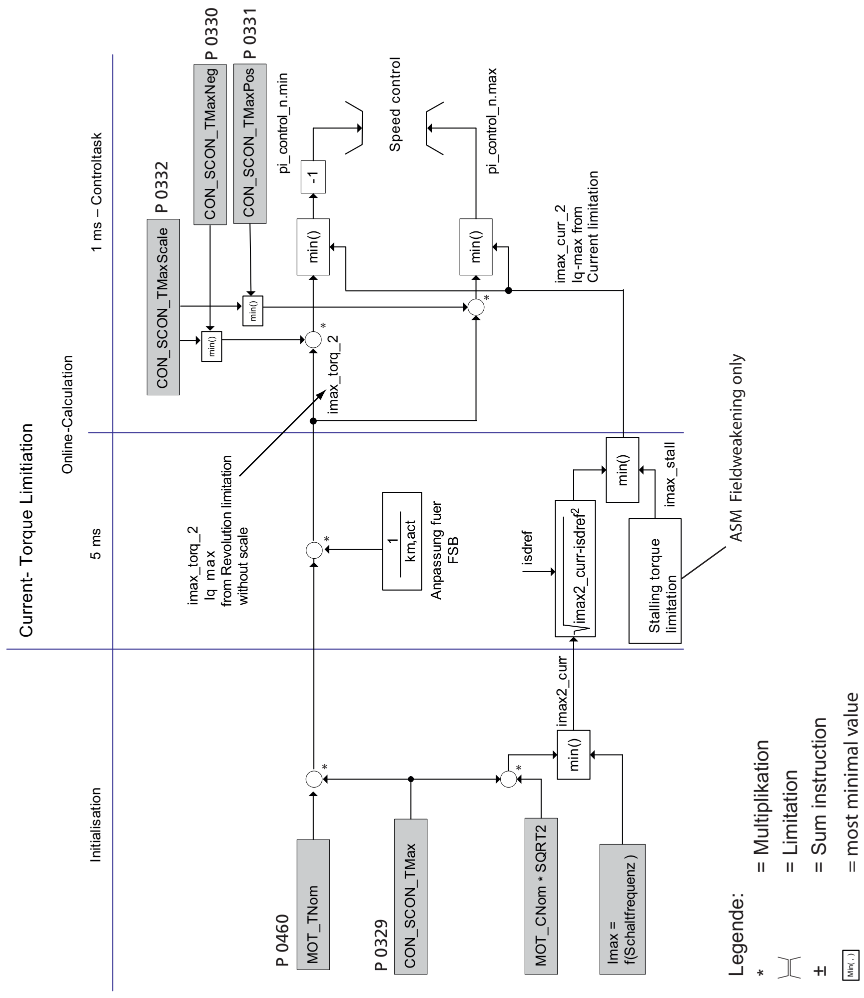


Table 152.1 Parameters:

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 0329	CON_SCON_TMax	Motor torque scaling of limits	Scaling of the maximum torque, referred to the rated torque P 0460 MOT_TNom (not changeable online)..
P 0330	CON_SCON_TMaxNeg	Motor torque scaling of nega-tive limit	Torque limitation in negative direction (not changeable online)
P 0331	CON_SCON_TMaxPos	Motor torque scaling of posi-tive limit	Torque limitation in positive direction (not changeable online)
P 0332	CON_SCON_TMax-Scale	Motor torque scaling (online factor)	Percentage torque weighting (de-fault 100%) (changeable online)
P 0460	MOT_TNom	Motor rated torque	Rated motor torque
P 0741	MON_TorqueThres	Monitoring torque/force threshold	Setting of limit for torque threshold (exp. digital input).

The torque reference is limited symmetrically by parameter P 0332 . If the limitation is to be directional, the setting can be made via P 0330 (negative direction) and P 0331 (positive direction).
The limitation of the torque reference always corresponds to the parameter with the lowest value.

Illustration 153.1 Dependence in case of field-weakening and/or limitation by power stage



In the following cases additional limitations of the torque may occur, so that the parameterized limit torque is not reached:

Possible parameterization error:

Ratio of rated current to rated torque incorrect:
The torque constant of the motor (parameterized by way of the flux for a synchronous machine or the magnetizing current for an asynchronous machine) does not match the ratio of rated current and rated torque. If the torque constant is less than this ratio, the motor current is limited in order to prevent excessively high motor current. These parameterization error is avoided by using an original motor data set or by generating the motor data using the servocontroller's calculation wizard.

Maximum power stage current too low:
The maximum current resulting from the torque limitation is greater than the maximum current of the power stage.

The field-forming d-current is not equal to zero:
In the field-weakening range the field-forming current isd becomes unequal to 0 for the synchronous machine. The q-current component isq_{max} remaining for the torque is reduced correspondingly, so that the maximum current is_{max} is not exceeded.
In the upper field-weakening range for asynchronous machines (the speed is then more than 3 to 5 times the rated speed) the slip is limited to the pull-out slip by reducing the torque limit.

7.1.2 Speed limitation Speed/Velocity

The following illustration shows the structure of speed limitation. The speed can be symmetrically limited in relation to the rated speed by the scaling parameter **P 0328 CON_SCON_SMax**. Asymmetric limiting is possible via parameters **P 0333 CON_SCON_SMaxNeg** and **P 0334 CON_SCON_SMaxPos**.
An activated reversing lock **P 0337 CON_SCON_DirLock** also has an effect on the limitations with respect to the reference speeds for the control. The setting POS locks the positive references and NEG the negative references.
With **P 0745 MON_RefWindow** the standstill window is set for the speed.

Note:
Parameters **P 0337 CON_SCON_SMaxScale, P 0328 CON_SCON_SMax** and **P 0335 CON_SCON_DirLock** are not changeable online. Parameters **P 0333 SCON_SCON_SMaxNeg, P 0334 CON_SCON_SMaxPo**s are changeable online.

Illustration 155.1 Speed limitation

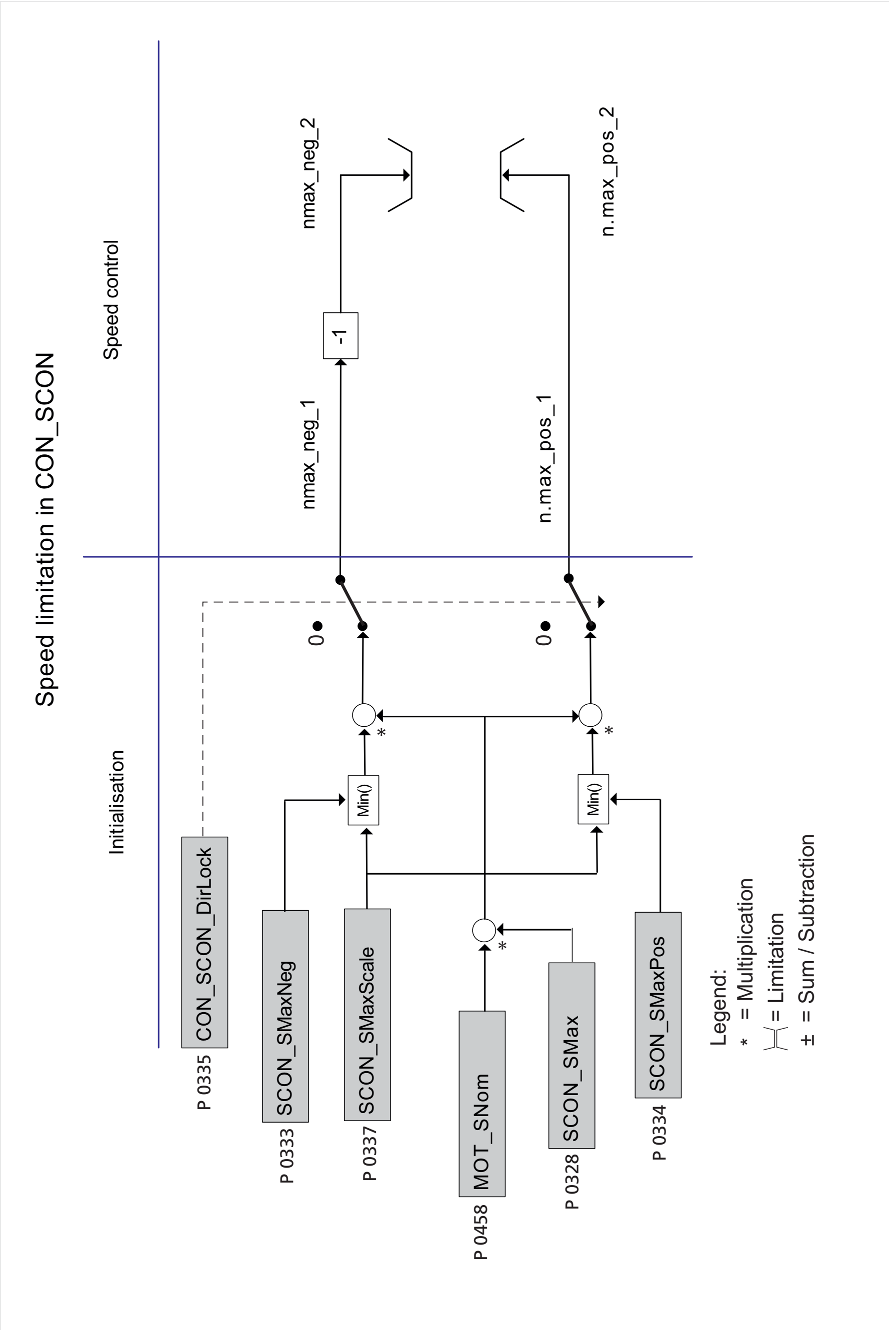


Table 156.1 Parameters:

P. no.	Parameter name/ settings	Designation in DM 5	Function
P 0335	CON_SCON_DirLock	Direction lock for speed reference value	Directional lock, left and right
P 0328	CON_SCON_Max	Speed control maximum speed	Scaling to the rated speed in **P 0458 Motor rated speed**
P 0333	CON_SCON_S_MaxNeg	Motor speed scaling of negative limit	Speed limitation in negative direction
P 0334	CON_SCON_S_MaxPos	Motor speed scaling of positive limit	Speed limitation in positive direction
P 0337	CONSCON_S_MaxScale	Motor speed scaling	Percentage speed weighting (default 100%)
P 0740	MON_SpeedThresh	Monitoring speed threshold	Setting of threshold for maximum speed
P 0744	MON_SDiffMax	Monitoring speed difference threshold	Setting of threshold for maximum tracking error.
P 0167	MPRO_REF_OVR	Motionprofile speed override factor	Setting of override factor

7.1.3 Position limitation (position limit)

Table 156.2

P. no.	Parameter name/ settings	Designation in DM 5	Function
P 0743	MON_UsrPosDiffMax	Monitoring position difference threshold	Limit value for the maximum permissible tracking error in USER units
P 0746	MON_UsrPosWindow	Position window, for „target reached" status	Standstill window for position reached

7.1.4 Powerstage

Table 156.3

P. no.	Parameter name/ settings	Designation in DM 5	Function
P 0747	MON_PF_ONLimit	Voltage limit for power fail reaction	Voltage threshold for power failure response
P 0749	MON_Def_OverVoltage	Overvoltage DC Link	Voltage treshold for DC bus overvoltage

Limitation of rated motor current

Note:
Information on motor temperature and current limitation is given in the Motor and Encoder sections (I^2xt).

DC failure reaction

If the value of the DC link voltage drops below the value set in parameter P 0747 MON_PF_OnLimit , the error ERR-34 „Power failure detected“ is reported and the parameterized error reaction is triggered.
By parameterizing a quick stop as the error reaction with a sufficiently steep deceleration ramp, the DC link voltage can be maintained above the undervoltage threshold (power failure bridging). This reaction lasts until the drive has been braked to a low speed.
The default setting is 0 V (function disabled).

7.1.5 Software limit switches

The software limit switches are only applicable in positioning mode, and are only activated once homing has been completed successfully.

Table 157.1

P. no.	Parameter name/ Settings	Designation in DM 5	Function
P 2235	MPRO_402_SoftwarePosLimit	607DH **DS 402** Software Position Limit	Positive and negative software limit switch
(0)	Software Position Limit	Min position lim	Negative limit switch
(1)	Software Position Limit	Max position lim	Positive limit switch

The response to reaching a SW limit switch depends on the preset error response (see parameter **P 0030 Error reaction**).

Table 157.2

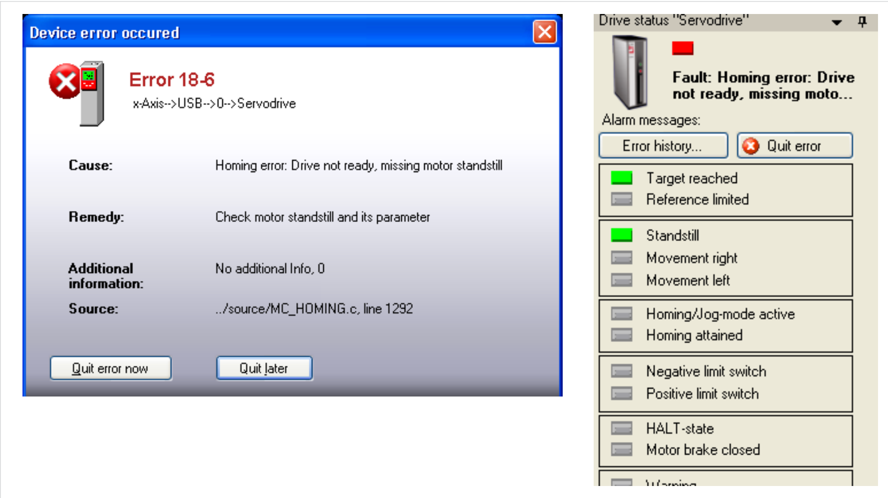
Positioning mode	Reaction
Absolut Relativ	Before enabling an absolute motion task, a check is made whether the target is in the valid range – that is, within the software limit switches. If the target is outside, no motion task is signalled and the programmed error response as per P 0030 is executed.
Infinite (speed controlled))	The drive travels until a software limit switch is detected. Then the programmed error response as per P 0030 is executed..

8. Diagnostics

8.1 Error status/Warning status

Errors are shown on the drive controller display (for D1/2 display see Operation Manual) and in parallel in the DriveManager. When a new error occurs, the window below opens, indicating the error name, location and cause. In addition, the green rectangle in the „Drive Status“ switches to red.

Illustration 158.1 Current error display



Clicking the “Error history” button in the “Drive Status” window calls up a buffer memory log listing the last 20 errors. When the 21st error occurs, the oldest error in the list is overwritten.

Illustration 158.2 Error history; storage of last 20 errors

Fehlerprotokoll Servodrive (Servodrive-->USB-->0-->Servodrive)

Nr.	Eintrag	Zeitstempel	Ursache	Abhilfe
1	Fehler 16-1	2755:9:8	Max. speed difference detected	Check your parameter data set
2	Fehler 3-1	2749:6:14	Es wurde Unterspannung ermittelt	
3	Fehler 0-0	0:0:0		

8.1.1 Error reactions

Each of the errors listed in parameter **P 0033** (sub-ID 0-47) can be assigned one of the error reactions listed below. However, not every error has every selection option.

Table 159.1

P. no.	Parameter name/ Settings	Description in DM 5	Error reactions
P 0030 Sub Id 0-8	Error Reactions	Programmable reaction in case of failure	Error response
(0)	Ignore	Ignore error	The error is ignored
(1)	Specific1	Notify error, reaction is forced by internal PLC function block	A specific error reaction can be programmed via PLC
(2)	Specific2	Notify error, reaction is forced by external control unit	Error reaction external
(3)	FaultReaction OptionCode	Notify error, reaction as given by fault reaction option codes	The error reaction is based on the value set in object 605Eh "Fault reaction" option code.
(4)	ServoStop	Notify error, execute quick stop and wait for restart of control	Quick stop, waiting for restart of control
(5)	ServoStopAndLock	Notify error, execute quick stop, disable power stage, protect against restart	Quick stop, block power stage, secure against switching on
(6)	ServoHalt	Notify error, disable power stage	Block power stage
(7)	ServoHaltAndLock	Notify error, block power stage, protect against restart	Block power stage, block enable
(8)	WaitERSAndReset	Notify error, block power stage and reset only via switching off/on control voltage (24 V)	Block power stage, reset only by switching the 24 V control voltage off and back on

8.1.2 Error details/Alarm & warning details

Table 159.2

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
(0))	**(0) no error**	No error	0xFF00	1	0x 000
(1)	(1) RunTimeError	Runtime error	0x6010	1	0x1
	(2) RunTimeError_ DynamicModules	Internal error in device initialization	0x6010	1	0x1
	(3) RunTimeEr-ror_Flashmemory	Error in flash initialization	0x6010	1	0x1
	(4) RunTimeError_PLC	PLC runtime error	0x6010	1	0x1
(2)	**ParaList**				
	(1) ParameterInit	Error in parameter initialization	0x6320	1	0x1
	(2) Parameter-VirginInit	Basic parameter initialization (factory setting)	0x6320	1	0x1

Table 160.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
	(3) ParameterSave	Parameter data backup	0x5530	1	0x1
	(4) ParameterAdd	Registration of a parameter	0x6320	1	0x1
	(5) ParameterCheck	Check of current parameter list values	0x5530	1	0x1
	(6) ParameterLis-tAdmin	Management of parameter list	0x6320	1	0x1
	(7) ParaList_PST	Non-resetable errors from PowerStage : EEPROM data error	0x5400	1	0x1
	(8) ParaList_PST_VL	Error in power stage initialization; selected device voltage not supported	0x6320	1	0x1
(3)	**OFF**				
	(1) Off_MON_Device	Undervoltage	0x3120	1	0x200
(4)	**OverVoltage**				
	(1) OverVoltage_ MON_Device	Overvoltage	0x3110	1	0x100
(5)	**OverCurrent**				
	(1) OverCurrent_Hard-wareTrap	Overcurrent shut-off by hardware	0x2250	1	0x80
	(2) OverCurrent_ Soft	Overcurrent shut-off (fast) by software	0x2350	1	0x80
	(3) OverCurrent_ ADC	Measuring range of AD converter exceeded	0x2350	1	0x80
	(4) OverCurrent_ WireTest	Short-circuit test on initialization	0x2350	1	0x80
	(5) OverCurrent_DC	(Fast) Overcurrent shut-off “below 5 Hz“	0x2350	1	0x80
	(6) OverCurrent_ Zero,	Total current monitoring	0x2350	1	0x80
	(7) OverCurrent_ I2TS	Fast I^2xt at high overload	0x2350	1	0x80
(6)	**OvertempMotor**				
	(1) OvertempMotor_ MON_MotTemp	Calculated motor temperature above threshold value	0x4310	1	0x4
	(2) OvertempMotor_ MON_Device_DIN1	PTC to DIN1	0x4310	1	0x4
	(3) OvertempMotor_ MON_Device_DIN2	PTC to DIN2	0x4310	1	0x4
	(4) OvertempMotor_ MON_Device_DIN3	PTC to DIN3	0x4310	1	0x4
(7)	**OvertempInverter**				
	(1) OvertempInverter _MON_Device	Heat sink temperature too high	0x4210	1	0x2

Table 161.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
(8)	**OvertempDevice**				
	(1) OvertempDevice_MON_Device	Interior temperature evaluation	0x4210	1	0x40
(9)	**I2tMotor**				
	(1) I^2tMotor_MON_I2t	I^2xt integrator has exceeded motor protection limit value (permissible current/time area)	0x2350	1	0x1
(10)	**PowerAmplifier**				
	(1) I^2tPowerAmplifier_MON_Device	I^2xt power stage protection limit value exceeded	0x2350	1	0x1
(11)	**External**				
	(1) External_MPRO_INPUT	External error message	0xFF0	1	0x8000
(12)	**CAN**				
	(1) ComOptCan_BusOff	CAN option: BusOff error	0x8140	1	0x8000
	(2) ComOptCan_Guarding	CAN option: Guarding error	0x8130	1	0x8000
	(3) ComOptCan_MsgTransmit	CAN option: Unable to send message	0x8100	1	0x8000
	(4) ComOptCan_HeartBeat	CAN option: Heartbeat error	0x8130	1	0x8000
	(5) ComOptCan_Addr	CAN option: Invalid address	0x8110	1	0x8000
	(6) ComOptCan_PdoMappingError	Mapping error	0x8200	1	0x8000
	(7) ComOptCan_SyncTimeoutError	CAN option: Synchronization error	0x8140	1	0x8000
(13)	**SERCOS**				
	(1) ComOptSercos_HardwareInit	SERCOS: Hardware initialization	0xFF00	1	0x1000
	(2) ComOptSercos_IllegalPhase	SERCOS: Invalid communication phase	0xFF00	1	0x1000
	(3) ComOptSercos_CableBreak	SERCOS: Cable break	0xFF00	1	0x1000
	(4) ComOptSercos_DataDisturbed	SERCOS: Disturbed data transmission	0xFF00	1	0x1000
	(5) ComOptSercos_MasterSync	SERCOS: Faulty synchronization	0xFF00	1	0x1000
	(6) ComOptSercos_MasterData	SERCOS: Data telegrams missing	0xFF00	1	0x1000
	(7) ComOptSercos_Address-Double	SERCOS: Duplicate address	0xFF00	1	0xFF00
	(8) ComOptSercos_PhaseSwitchUp	SERCOS: Faulty phase switching (Up shift)	0xFF00	1	0xFF00

Table 162.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Errorreg-ister DS 402	Error code SERCOS
	(9) ComOptSercos_PhaseSwitchDown	SERCOS: Faulty phase switching (Down shift)	0xFF00	1	0x1000
	(10) ComOptSercos_PhaseSwitchAck	SERCOS: Faulty phase switching (missing acknowledgement)	0xFF00	1	0x1000
	(11) ComOptSercos_InitParaList	SERCOS: Faulty initialization of SERCOS parameter lists	0xFF00	1	0x1000
	(12) ComOptSercos RunTimeError	SERCOS: Various runtime errors	0xFF00	1	0x1000
	(13) ComOptSercos_Watchdog	SERCOS: Hardware watchdog	0xFF00	1	0x1000
	(14) ComOptSercos_Para	SERCOS: Error in parameterization (selection of OP mode, IP times, etc...)	0xFF00	1	0x1000
(14)	**EtherCat**				
	(1) ComOptEtherCat_Sm_Watchdog0	EtherCat: Sync-Manager0 - Watchdog	0x8130	1	0x8000
	(2) ComOptEtherCat_Wrong EepData	EtherCat: Parameter error, parameter data implausible	0x8130	1	0x8000
	(3) ComOptEtherCat_RamError	EtherCat: Internal RAM error‘	0x8130	1	0x8000
(15)	**Parameter**				
	(1) Parameter_MON_Device_Current	Error in current monitoring initialization	0x2350	1	0x8000
	(2) Parameter_MON_I2t	Motor protection	0x2350	1	0x8000
	(3) Parameter_CON_ICOM	Autocommutation: Plausibility tolerance exceeded	0xFF00	1	0x8000
	(4) Parameter_CON_FM	Field model	0xFF00	1	0x8000
	(5) Parameter_CON_Timing	Basic initialization of control	0xFF00	1	0x8000
	(6) Parameter_MPRO_FG	Error calculating user units	0x6320	1	0x8000
	(7) Parameter_ENC_RATIO	Error initializing encoder gearing	0x6320	1	0x8000
	(8) Parameter_Nerf	Speed detection / observer	0x8400	1	0x8000
	(9) Parameter_ObsLib	Error in matrix library	0xFF00	1	0x8000
	(10) Parameter_CON_CCON	Current control	0x8300	1	0x8000
	(11) Parameter_reserved1	Not used/reserved	0xFF00	1	0x8000
	(12) Parameter_Inertia	Moment of inertia is zero	0xFF00	1	0x8000
	(13) Parameter_MPRO	PARA_WatchDog in open-loop control via DM5	0xFF00	1	0x8000
	(14) Parameter_DV_INIT	DV_INIT: Error in system initialization	0xFF00	1	0x8000

Table 163.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Errorreg-ister DS 402	Error code SERCOS
(16)	**SpeedDiff**				
	(1) SpeedDiff_MON_SDiff	Speed tracking error above threshold value	0x8400	1	0x8000
	(2) SpeedDiff_MON_NAct	Current speed above maxi-mum speed of motor	0x8400	1	0x8000
(17)	**PositionDiff**				
	(1) PositionDiff_MON_ActDelta	Position tracking error too large	0x8611		0x8000
(18)	**Motion control**				
	(1) MotionControl_MC_HOMING_Lim-itSwitchInterchanged	Homing: Limit switches interchanged	0x8612	1	0x8000
	(2) MotionControl: MC_HOMING: Unexpected home switch event	Homing: Limit switch tripped unexpectedly	0x8612	1	0x8000
	(3) MotionControl_MC_HOMING_Er-rorLimitSwitch	Homing: Limit switch error	0x8612	1	0x8000
	(4) MotionControl_MC_HOMING_Un-knownMethod	Homing: Wrong homing method, homing method not available	0x8612	1	0x8000
	(5) MotionControl_MC_HOMING_Meth-odUndefined	Homing: Homing method available but not defined	0xFF00	1	0x8000
	(6) MotionControl_MC_HOMING_Drive-NotReadyHoming	Homing: Drive not ready for homing	0xFF00	1	0x8000
	(7) MotionControl_MC_HOMING_Drive-NotReadyJogging	Homing: Drive not ready for jog mode	0xFF00	1	0x8000
	(8) MotionControl_MC_HOMING_ WrongConMode	Homing: Control mode does not match homing method	0xFF00	1	0x8000
	(9) MotionControl_MC_HOMING_Enco-derInitFailed	Homing: Encoder initializa-tion error	0xFF00	1	0x8000
	(10) MotionControl_MC_HOMING_ MaxDistanceOverrun	Homing: Homing travel exceeded	0xFF00	1	0x8000
	(11) MotionControl_MPRO_REF_Enable-dOperationFailed	Max. permissible tracking error on “Start control” exceeded	0xFF00	1	0x8000
	(12) MotionControl_MPRO_REF_SSP_ StackOverflow	Memory overflow for table values	0xFF00	1	0x8000
	(13) MotionControl_MC_HOMING_ RestoreBackupPos,	Error initializing last actual position after restart.	0xFF00	1	0x8000

Table 164.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
(19)	**FatalError**	Non-resettable error			
	(1) FatalError_PowerStage_ Limit_Idx	PST: Data index too large	0x5400	1	0x8000
	(2) FatalError_PowerStage_ SwitchFreq	PST: Error in switching frequencyde-pendent data	0x5400	1	0x8000
	(3) FatalError_PowerStage_ DataInvalid	PST: Invalid EEPROM data	0x5400	1	0x8000
	(4) FatalError_PowerStage_CRC	PST: CRC error	0x5400	1	0x8000
	(5) FatalError_PowerStage_ ErrorReadAccess	PST: Error reading power stage data	0x5400	1	0x8000
	(6) FatalError_PowerStage_ ErrorWriteAccess	PST: Error writing power stage data	0x5400	1	0x8000
	(7) FatalError_MON_Chopper	Current in braking resistor even though transistor switched off	0x5420	1	0x8000
	(8) FatalError_HW_ Identification	Hardware identification error	0x5300	1	0x8000
	(9) FatalError_FlashMemory	Error in flash memory	0x5300	1	0x8000
(20)	**HardwareLimitSwitch**				
	(1) HardwareLimitSwitch_ Interchanged	Limit switches interchanged	0x8612	1	0x8000
	(2) HardwareLimitSwitch_LCW	Hardware limit switch LCW	0x8612	1	0x8000
	(3) HardwareLimitSwitch_ LCCW	Hardware limit switch LCCW	0x8612	1	0x8000
(21)	**EncoderInit**	**General encoder initialization (loca-tions which cannot be assigned to a channel))**			
	(1) EncoderInit_CON_ICOM_ EpsDelta	Encoder general initialization: Exces-sive motion	0x7300	1	0x20
	(2) EncoderInit_CON_ICOM_ Tolerance	Encoder general initialization: Exces-sive tolerance	0x7300	1	0x20
(22)	**Encoder CH1Init**	**Encoder channel 1 initialization**			
	(1) EncCH1Init_Sincos_Lines	Encoder channel 1 initialization, Sincos: Plausibility check ‚Lines' from PRam_ENC_CH1_Lines	0x7305	1	0x20
	(2) EncCH1Init_Sincos_ABS-quareSum	Encoder channel 1 initialization, Sin-cos: Getting AB-SquareSum, Timeout	0x7305	1	0x20
	(3) EncCH1Init_Sincos_EncObs	Encoder channel 1 initialization, SinCos: Encoder monitoring Sincos	0x7305	1	0x20
	(4) EncCH1Init_EnDat2.1_ NoEnDat2.1	Encoder channel 1 initialization, EnDat2.1: No EnDat2.1 encoder (encoder may be SSI)	0x7305	1	0x20

Table 165.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
	(5) EncCH1Init_EnDat2.1_Line5	Encoder channel 1 initialization, EnDat2.1: Plausibility check ‚Lines' from encoder	0x7305	1	0x20
	(6) EncCH1Init_EnDat2.1_Multiturn	Encoder channel 1 initialization, EnDat2.1: Plausibility check ‚Multiturn' from encoder	0x7305	1	0x20
	(7) EncCH1Init_EnDat2.1_Singleturn	Encoder channel 1 initialization, EnDat2.1: Plausibility check ‚Singleturn' from encoder	0x7305	1	0x20
	(8) EncCH1Init_EnDat2.1_CrcPos	Encoder channel 1 initialization, EnDat2.1: CRC error position transfer	0x7305	1	0x20
	(9) EncCH1Init_EnDat2.1_CrcData	Encoder channel 1 initialization, EnDat2.1: CRC error data transfer	0x7305	1	0x20
	(10) EncCH1Init_EnDat2.1_WriteToProt	Encoder channel 1 initialization, EnDat2.1: An attempt was made to write to the protection cells in the encoder!	0x7305	1	0x20
	(11) EncCH1Init_EnDat2.1_SscTimeout	Encoder channel 1 initialization, EnDat2.1: Timeout on SSC transfer	0x7305	1	0x20
	(12) EncCH1Init_EnDat2.1_StartbitTimeout	Encoder channel 1 initialization, EnDat2.1: Timeout, no start bit from encoder	0x7305	1	0x20
	(13) EncCH1Init_EnDat2.1_PosConvert	Encoder channel 1 initialization, EnDat2.1: Position data not consistent	0x7305v	1	0x20
	(14) EncCH1Init_SSI_Lines	Encoder channel 1 initialization, SSI: Plausibility check ‚Lines' from encoder	0x7305	1	0x20
	(15) EncCH1Init_SSI_Multiturn	Encoder channel 1 initialization, SSI: Plausibility check ‚Multiturn' from encoder	0x7305	1	0x20
	(16) EncCH1Init_SSI_Singleturn	Encoder channel 1 initialization, SSI: Plausibility check ‚Singleturn' from encoder	0x7305	1	0x20
	(17) EncCH1Init_SSI_ParityPos	Encoder channel 1 initialization, SSI: Parity error position transfer	0x7305	1	0x20
	(18) EncCH1Init_SSI_SscTimeout	Encoder channel 1 initialization, SSI: Timeout on SSC transfer	0x7305	1	0x20
	(19) EncCH1Init_SSI_PosConvert	Encoder channel 1 initialization, SSI: Position data not consistent	0x7305	1	0x20
	(20) EncCH1Init_SSI_EncObs	Encoder channel 1 initialization, SSI: Encoder monitoring bit	0x7305	1	0x20
	(21) EncCH1Init_Hiperface_NoHiperface	Encoder channel 1 error initializing Hiperface interface	0x7305	1	0x20
	(22) EncCH1Init_Hiperface_Common	Encoder channel 1 initialization, Hiperface: Interface, gen. Error	0x7305	1	0x20
	(23) EncCH1Init_Hiperface_Timeout	Encoder channel 1 initialization, Hiperface: Interface, Timeout	0x7305	1	0x20
	(24) EncCH1Init_Hiperface_CommandMismatch	Encoder channel 1 initialization, Hiperface: Encoder, impossible COMMAND in response	0x7305	1	0x20
	(25) EncCH1Init_Hiperface_EStatResp_Crc	Encoder channel 1 initialization, Hiperface: CRC error in error status response	0x7305	1	0x20

Table 166.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
	(26) EncCH1Init_Hiperface_ EStatResp_Com	Encoder channel 1 initialization, Hiperface: Error status response returns communication error	0x7305	1	0x20
	(27) EncCH1Init_Hiperface_ EStatResp_Tec	Encoder channel 1 initialization, Hiperface: Error status response returns technology or process error	0x7305	1	0x20
	(28) EncCH1Init_Hiperface_ EStatResp_None	Encoder channel 1 initialization, Hiperface: Error status response returns no error(!)	0x7305	1	0x20
	(29) EncCH1Init_Hiperface_ Response_Crc	Encoder channel 1 initialization, Hiperface: CRC error in response	0x7305	1	0x20
	(30) EncCH1Init_Hiperface_ Response_Com	Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns communication error	0x7305	1	0x20
	(31) EncCH1Init_Hiperface_Response_Tec	Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns technology or process error	0x7305	1	0x20
	(32) EncCH1Init_Hiperface_ Response_None	Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns no error	0x7305	1	0x20
	(33) EncCH1Init_Hiperface_ Status_Com	Encoder channel 1 initialization, Hiperface: Status telegram reports communication error	0x7305	1	0x20
	(34) EncCH1Init_Hiperface_ Status_Tec	Encoder channel 1 initialization, Hiperface: Status telegram returns technology or process error	0x7305	1	0x20
	(35) EncCH1Init_Hiperface_TypeKey	Encoder channel 1 initialization, Hiperface: Type identification of encoder unknown	0x7305	1	0x20
	(36) EncCH1Init_Hiperface_ WriteToProt	Encoder channel 1 initialization, Hiperface: An attempt was made to write to the protection cells in the encoder!	0x7305	1	0x20
	(37) EncCH1Init_TTL_ IncompatibleHardware	Encoder channel 1 initialization, TTL: Control pcb does not support TTL evaluation	0x7305	1	0x20
	(38) EncCH1Init_EnDat2.1_PositionBits	Encoder channel 1 initialization, EnDat2.1: Plausibility check ‚Position Bits' from encoder	0x7305	1	0x20
	(39) EncCH1Init_EnDat2.1_ TransferBits	Encoder channel 1 initialization, EnDat2.1: Plausibility check ‚Transfer Bits' of transfer	0x7305	1	0x20
	(40) EncCH1Init_Np_ NominalIncrement	Encoder channel 1 initialization, NP: Plausibility check ‚Lines' and "Nominal-Increment"	0x7305	1	0x20
	(41) EncCh1Init_Endat21_Common	Encoder channel 1 initialization, Endat21: Interface gen. error	0x7305	1	0x20
	42) EncCh1Init_SSI_Common	Encoder channel 1 initialization, SSI: Interface gen. error	0x7305	1	0x20
	43) EncCh1Init_Sincos_ Common	Encoder channel 1 initialization, Sincos: Interface gen. error	0x7305	1	0x20

Table 167.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Errorreg-ister DS 402	Error code SERCOS
(23)	**EncChannel2Init**				
	(1) EncCH2Init_Res_Lines	Encoder channel 2 initialization, Res: Plausibility check ‚Lines' from PRam_ENC_CH1_Lines	0x7306	1	0x20
	(2) EncCH2Init_Res_ABS-quareSum_TimeOut	Encoder channel 2 initialization, Res: Get-ting AB-SquareSum, Timeout	0x7306	1	0x20
	(3) EncCH2Init_Res_EncObs	Encoder channel 2 initialization, Res: Encoder monitoring resolver	0x7306	1	0x20
(24)	**EncCH3Init**				
	(1) EncCH3Init_Module IdentificationFailed	Encoder channel 3 initialization: No module inserted or wrong module	0x7307	1	0x20
	(2) EncCH3Init_Com-mon_EO_Error	Encoder channel 3 initialization: General EO error (encoder option)	0x7307	1	0x20
	(3) EncCH3Init_SSI_ EncObs_20c	Encoder channel 3 initialization: Encoder monitoring	0x7307	1	0x20
	(4) EncCH3Init_EnDat2.1_ NoEnDat2.1	Encoder channel 3 initialization, EnDat2.1: No EnDat2.1 encoder (encoder may be SSI)	0x7307 0x7307	1	0x20
	(5) EncCH3Init_ EnDat2.1_Lines	Encoder channel 3 initialization, EnDat2.1: Plausibility check ‚Lines' from encoder	0x7307	1	0x20
	(6) EncCH3Init_ EnDat2.1_Multiturn	Encoder channel 3 initialization, EnDat2.1: Plausibility check ‚Multiturn' from encoder	0x7307	1	0x20
	(7) EncCH3Init_ EnDat2.1_Singleturn	Encoder channel 3 initialization, EnDat2.1: Plausibility check ‚Singleturn' from encoder	0x7307	1	0x20
	(8) EncCH3Init_ EnDat2.1_CrcPos	Encoder channel 3 initialization, EnDat2.1: CRC error position transfer	0x7307	1	0x20
	(9) EncCH3Init_ EnDat2.1_CrcData	Encoder channel 3 initialization, EnDat2.1: CRC error data transfer	0x7307	1	0x20
	(10) EncCH3Init_EnDat2.1_ WriteToProt	Encoder channel 3 initialization, EnDat2.1: An attempt was made to write to the protection cells in the encoder!	0x7307	1	0x20
	(11) EncCH3Init_ EnDat2.1_SscTimeout	Encoder channel 3 initialization, EnDat2.1: Timeout on SSC transfer	0x7307	1	0x20
	(12) EncCH3Init_EnDat2.1_ StartbitTimeout	Encoder channel 3 initialization, EnDat2.1: Timeout, no start bit from encoder	0x7307	1	0x20
	(13) EncCH3Init_EnDat2.1_ PosConvert	Encoder channel 3 initialization, EnDat2.1: Position data not consistent	0x7307	1	0x20
	(14) EncCH3Init_SSI_Lines	Encoder channel 3 initialization, SSi: Error initializing SSI interface	0x7307	1	0x20
	(15) EncCH3Init_SSI_Mul-titurn	Encoder channel 3 initialization, SSi: Plausi-bility check ‚Multiturn' from encoder	0x7307	1	0x20
	(16) EncCH3Init_SSI_Sin-gleturn	Encoder channel 3 initialization, SSi: Plausi-bility check ‚Singleturn' from encoder	0x7307	1	0x20
	(17) EncCH3Init_SSI_Pari-tyPos	Encoder channel 3 initialization, SSi: Parity error position transfer	0x7307	1	0x20

Table 168.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Error-register DS 402	Error code SERCOS
	(18) EncCH3Init_SSI_ SscTimeout	Encoder channel 3 initialization, SSi: Timeout on SSC transfer	0x7307	1	0x20
	(19) EncCH3Init_SSI_ PosConvert	Encoder channel 3 initialization, SSi: Position data not consistent	0x7307	1	0x20
	(20) EncCH3Init_SSI_ EncObs	Encoder channel 3 initialization, SSi: Encoder monitoring bit	0x7307	1	0x20
	(38) EncCH3Init_ EnDat2.1_PositionBits	Encoder channel 3 initialization, EnDat2.1: Plausibility check ‚Position Bits' from encoder	0x7307	1	0x20
	(39) EncCH3Init_ EnDat2.1_TransferBits	Encoder channel 3 initialization, EnDat2.1: Plausibility check ‚Transfer Bits' of transfer	0x7307	1	0x20
	(40) EncCH3Init_Np_ NominalIncrement	Encoder channel 3 initialization, NP: Plausibility check ‚Lines' and "Nominal-Increment"	0x7307	1	0x20
	(41) EncCH3Init_Endat21_ Common	Encoder channel 3 initialization, EnDat21: Interface, gen. error	0x7307	1	0x20
	(42) EncCH3Init_SSI_Com-mon	Encoder channel 3 initialization, SSi: Interface, gen. error	0x7307	1	0x20
	(43) EncCH3Init_ Sincos_Common	Encoder channel 3 initialization, Sincos: Interface, gen. error	0x7307	1	0x20
	(50) EncCH3Init_TOPT_cfg	Encoder channel 3 initialization, interface, gen. error	0x7307		0x20
(25)	**EncoderCycl**	EncoderCycl			
	(1) EncoderCycl_CON_ ICOM_Epsdelta	Encoder general cyclic: Autocommuta-tion: Excessive motion	0xFF00	1	0x20
	(2) EncoderCycl_CON_ ICOM_Tolerance	Encoder general cyclic: Autocommuta-tion: Excessive tolerance	0xFF00	1	0x20
(26)	**EncCh1Cycl**				
	(1) EncCH1Cycl_Np_ Distance	Encoder channel 1 cyclic, NP: Plausibil-ity, CounterDistance'	0x7305	1	0x20
	(2) EncCH1Cycl_Np_ DeltaCorrection	Encoder channel 1 cyclic, NP: Delta correction not possible	0x7305	1	0x20
	(3) EncCH1Cycl_Np_Delta	Encoder channel 1 cyclic, NP: Plausibility ‚CounterDelta'	0x7305		0x20
(27)	**EncCh2Cycl**				
	(1) EncCH2Cycl_NoLo-cation	Not used	0x7306	1	0x20
(28)	**EncCh3Cycl**				
	(1) EncCH3Cycl_NoLo-cation	Not used	0x7307	1	0x20
(29)	**TC (TriCore)**				
	(1) TC_ASC	TriCore ASC	0x5300	1	0x8000
	(2) TC_ASC2	TriCore ASC2	0x5300	1	0x8000

Table 169.1

P. no. P 0030	Error name/Error location	Description of error	Emergency code DS 402	Errorregister DS 402	Error code SERCOS
	(3) TC_FPU	TriCore floating point error	0x5300	**1**	0x8000
	(4) TC_FPU_NO_RET_ ADDR	TriCore floating point error, no return address available	0x5300	**1**	0x8000
(30)	**InitCon**				
	(1) InitCon_AnaInput	Initialization error analog input	0x5300	**1**	0x8000
	(2) InitCon_FM_GetKM	Initialization error calculating motor torque constant	0x5300	**1**	0x8000
	(3) InitCon_FM_ASM	Initialization error asynchronous motor	0x5300	**1**	0x8000
	(4) InitCon_FM_ASM_ FW	Initialization error asynchronous motor in field-weakening	0x5300	**1**	0x8000
(31)	**PLC**				
	(1) PLC_Location 0...65536	User-specific: Errors generated in PLC program	0xFF00	1	0x8000
(32)	**Profibus**				
	(1) ComOptDp_Timeout	PROFIBUS DP: Process data Timeout	0xFF00	1	0x8000
(33)	**Timing**	**Task overflow**			
	(1) Timing_ADCTask_ ReEntry	ADC task automatically interrupted	0x5300	1	0x8000
	(2) Timin_ControlTask	Control task exceeded scan time	0x5300	1	0x8000
(34)	**PowerFail**	**Power failure detection**			
	PowerFail	Power failure detection; supply voltage error	0x3220	1	0x8000
(35)	**EncObs**	**Encoder cable break**			
	(1) EncObs_CH1_Sincos	Cable break: Encoder channel 1	0xFF00	1	0x20
	(2) EncObs_CH2_ Resolver	Cable break: Encoder channel 2	0xFF00	1	0x20
	(3) EncObs_CH3_Sincos	Cable break: Encoder channel 3	0xFF00	1	0x20
	(4) EncObs_CH1_SSI	Cable break: Encoder channel 1	0xFF00	1	0x20
(36)	**VARAN**				
	(1) ComOptVARAN_ InitHError	Error in hardware initialization: VARAN option	0x5300	1	0x8000
	(2) ComOptVARAN_ BusOffError	"Bus off" error; no bus communication: VARAN option	0x5300	1	0x8000
(37)	**Syncronization controller**				
	(1) RatioError	The ratios between interpolation, synchronization and/or speed control time do not match	0x6100	1	0x8000

Table 170.1

P. no. P 0030	**Error name/Error location**	**Description of error**	**Emergency code DS 402**	**Errorregister DS 402**	**Error code SERCOS**
(38)	**Brake chopper monitoring**				
	(1) BC_Overload	Braking chopper overload	0x4210	**1**	0x0000
(39)	**TwinWindow**	**Monitoring of speed and torque**			
	(1) TwinWindow_Speed	Speed deviation between Master and Slave			
	(2) TwinWindow_Torque	Torque deviation between Master and Slave			
(40)	**Twin-Sync-Module**	**Communication fault TECH option**			
	(1) TOPT_TWIN_CommLost	Error in "Twin Sync" technology option	0x7300	**1**	0x8000
	(2) TOPT_TWIN_SwitchFreq		0x7300	**1**	0x8000
	(3) TOPT_TWIN_ModeConflict		0x7300	**1**	0x8000
	(4) TOPT_TWIN_RemoteError		0x7300	**1**	0x8000
(41)	**fast discharge DC bus**	**Maximum period for fast discharge**			
	(1) FastDischarge_Timeout	Maximum period for fast discharge exceeded (35s)	0x7300	1	0x8000
(42)	**EtherCAT Master Implementation**	**Error EtherCat Master**			
	(1) Location can't specified CommError	Communication error EtherCat Master	0x6100	1	0x8000
(43)	**Ethernet interface**	**Error in Ethernet configuration**			
	(1) Ethernet_Init	Initialization error TCP/IP communication	0x6100	1	0x8000
(44)	**wire break detected**				
	(1) WireBreak_MotorBrake	No consumer on output X13 (motor holding brake)	0x6100	1	0x8000
(45)	LERR_LockViolate				
	(1)	Movement requested which was limited by reversing lock, limit switch or reference setpoint limitation	0x8612	1	0x8000
	(2)	Movement requested which was limited by reversing lock, limit switch or reference setpoint limitation. Lock active in both directions	0x8612	1	0x8000
46	LERR_positionLimit				
	(1) Position Limit_neg.	Negative software limit switch approached	0x8612	1	0x2000
	(2) Position Limit_pos	Positive software limit switch approached	0x8612	1	0x2000
	(3) Position Limit_Overtravel	Reference setpoint outside software limit switches	0x8612	1	0x2000
47	LERR_FSAFE	Reserved			

8.1.3 Warnings

In order to get timely information on excessive or inadequate values via an external controller or the drive's internal PLC, warning thresholds can be freely parameterized with P 0730 . Each warning is assigned on and off thresholds. This enables parameterization of a hysteresis.

When a warning is triggered, the corresponding bit is entered in parameter P 0034-ERR_WRN_State . The binary value enables a status interrogation. Warnings can also be programmed onto digital outputs (see section 6, I/O's). The following warning thresholds are supported by the parameter:

Table 171.1

P 0034	**Warning thresholds**
BIT number	
0	I^2xt integrator (motor) warning threshold exceeded
1	Heat sink temperature
2	Motor temperature
3	Interior temperature
4	Reserved for SERCOS
P 0034	**Overspeed**
5	Overspeed
6	Reserved for SERCOS
7	Reserved for SERCOS
8	Reserved for SERCOS
9	Undervoltage
10	Reserved for SERCOS
11	Reserved for SERCOS
12	Reserved for SERCOS
13	Reserved for SERCOS
14	Reserved for SERCOS
15	Reserved for SERCOS
16	I^2xt integrator (device) exceeded
17	Monitoring of apparent current
18	Overvoltage
19	Protection of braking chopper, warning threshold exceeded
20	Overtorque
21	Reserve
22	Reserve
23	Reserve
24	Speed reference limitation active
25	Current reference limitation
26	Right limit switch active
27	Left limit switch active
28	External warning via input
29	Reserve
30	Reserve
31	Reserve

The ON and OFF options enable suitable on and off thresholds (switching hysteresis) to be defined for the following warnings.

Table 172.1

P 0730 Index	Parameter name MON Warning Level	Meaning of Warning Level	Warnings
0	UnderVoltage_ON	DC link undervoltage	Undervoltage
1	UnderVoltage_OFF	DC link undervoltage	
2	OverVColtage_ON	DC link overvoltage	Undervoltage
3	OverVoltage_OFF	DC link overvoltage	
4	Current_ON	Motor current	Motor current
5	Current_OFF	Motor current	
6	Device I2t_ON	I^2t internal device protection	I^2xt device protection
7	Device I2t_OFF	I^2t internal device protection	
8	Motor I2t _ON	I^2t Motor protection	I^2xt motor protection
9	Motor I2t _OFF	I^2t Motor protection	
10	Torque ON	Motor torque	Torque limit reached
11	Torque OFF	Motor torque	
12	Speed ON	Motor actual speed	Speed limit reached
13	Speed OFF	Motor actual speed	
14	TC ON	Cooler (power electronics) temperature	Heat sink temperature reached
15	TC OFF	Cooler (power electronics) temperature	
16	Tint ON	Internal (control electronics) temperature	Housing internal temperature reached
17	Tint OFF	Internal (control electronics) temperature	
18	MotorTemp ON	Motor temperatur	Motor temperature reached
19	MotorTemp OFF	Motor temperatur	

9. Field bus systems

Note:
For a detailed description of the field bus system refer to the separate documentation for the field bus.

9.1 CANopen

CANopen functionality of the YukonDrive®
The CANopen Communication Profile is documented in the CiA DS-301, and regulates „how“ communication is executed. It differentiates between Process Data Objects (PDOs) and Service Data Objects (SDOs). The communication profile additionally defines a simplified network management system. Based on the communication services of DS-301 (Rev. 4.01) the device profile for variable-speed drives DSP402 was created. It describes the operation modes and device parameters supported.

9.2 EtherCAT®

EtherCAT® is featured by outstanding performance, easy cabling and its openness for other protocols. EtherCAT® sets new standards, where conventional field bus systems comes to their limits.

9.3 PROFIBUS-DP

Short description of the YukonDrive® PROFIBUS DP interface
Reference to PROFIdrive specification
The implementation in the YukonDrive® is based on the PROFIdrive profile

Key features

- Data transfer using two-wire twisted pair cable (RS 485)
- Optionally 9.6 K, 19.2 K, 45.45 K, 93.75 K, 187.5 K, 500 K, 1.5 M, 3 M, 6 M or 12 MBaud
- Automatic baud rate detection
- PROFIBUS address can be set using the rotary coding switches or alternatively using the addressing parameters
- Cyclic data exchange reference and actual values using DPV0
- Acyclic data exchange using DPV1
- Synchronization of all connected drives using freeze mode and sync mode
- Reading and writing drive parameters using the PKW channel or DPV1

Note:
For a detailed description of the PROFIBUS field bus system refer to the separate „Profibus User Manual“.

9.4 SERCOS

Short description of the YukonDrive® SERCOS interface

The basis for implementing SERCOS in the YukonDrive® is the document titled „Specification SERCOS Interface Version 2.2“

Key features

- Data transfer by fibre-optic cable
- Optionally 2, 4, 8 or 16 MBaud
- Automatic baud rate detection
- Transmission power adjustable by DIP switches
- SERCOS address programmable via buttons and display
- Cyclic data exchange of references and actual values with exact time equidistance
- SERCOS sampling time of 125 µs to 65 ms (multiples of 125 µs programmable)
- Multi-axis synchronization between reference action times and actual value measurement times of all drives in the loop
- Full synchronization of all connected drives with the master control system
- Free configuration of telegram content
- Maximum configurable data volume in MDT: 20 bytes
- Maximum configurable data volume in DT: 20 bytes
- Programmable parameter weighting and polarity for position, speed, acceleration and torque
- Modulo weighting
- Additive speed and torque references
- Fine-interpolation (linear or cubic) inside the drive
- Optionally master control-side (external) or in-drive generation of rotation speed and acceleration pre-control
- Service channel for parameter setting and diagnosis
- Support for touch probes 1 and 2
- Support for configurable real-time status and control bits
- Support for configurable signal status and control word
- Supported commands:
- S-0-0099 Reset state class 1
- S-0-0127 Preparation for switch to phase 3
- S-0-0128 Prepare switch to phase 4
- S-0-0148 Drive-controlled homing
- S-0-0152 „Position spindle“ command
- S-0-0170 „Touchprobe“ command
- S-0-0262 „Parameter initialization to defaults“ command
- S-0-0263 „Parameter initialization to backup values“ command
- S-0-0264 „Save current parameter values“ command

Note:

For a detailed description of the SERCOS field bus system refer to the separate „SERCOS User Manual“.

10. Technology option

10.1 General:

It is possible to use one of the following encoder types by way of option slot 3.

- High resolution sine / cosine with or without absolute interface
- TTL-encoders
- TTL encoder with commutation signals

For more information on the technology options, please refer to the corresponding manuals

10.2 SinCos module

The SinCos module enables evaluation of high-resolution encoders. A track signal period is interpolated at a 12-bit resolution (fine interpolation).

10.3 TTL module

With the TTL module the following operation modes are possible:

- Evaluation of a TTL encoder
- Simulation of a TTL encoder (signals from other encoders are converted into TTL signals and made available as output signals [for a slave axis])
- TTL repeater (evaluation and transmission of incoming TTL signals for additional axes)

10.4 TTL encoder with commutation signals

With this module, the evaluation of incremental encoders providing rectangular position signals and additional rectangular commutation signals is possible

11. Process controller

11.1 Function, controller structure, setup

The process controller function enables a measured process variable to be controlled to a reference (setpoint) value. Examples of applications are print/dancer controls etc.

- Process controller calculation in speed controller cycle
- Process controller as PI controller with Kp adptation
- Process controller actual value selectable via selector
- Filtering and offset correct of reference and actual values
- Process controller output can be connected to different points in the general control structure
- Process controller is usable in all control modes

Illustration 176.1 Control structure of the process controller

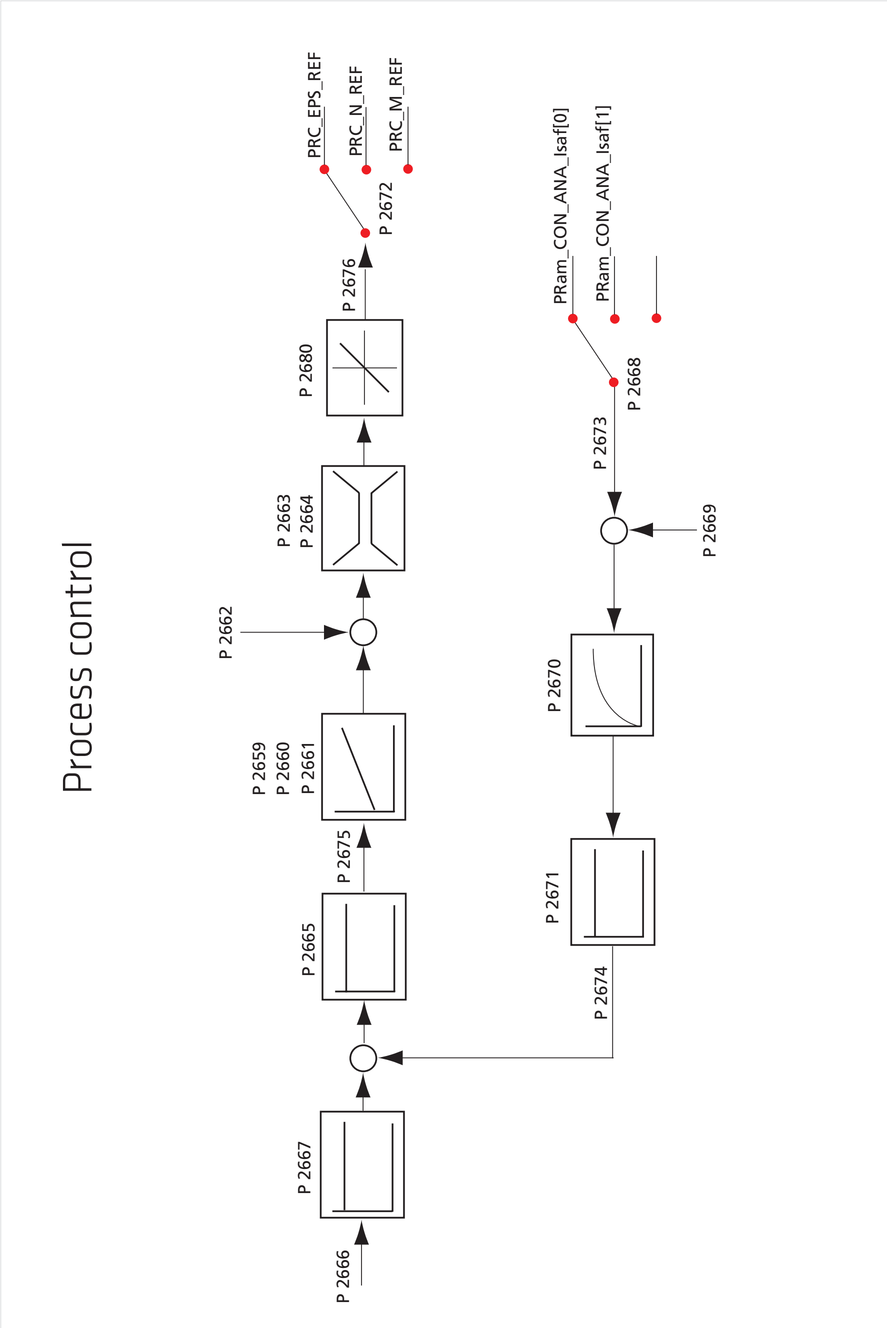


Table 177.1

P. no.	Parameter name/ Settings	Function
P 2658	CON_PRC_ENABLE	Starting the process controller
P 2659	CON_PRC_Kp	P-gain of the process controller
P 2660	CON_PRC_KP_SCALE	Adaptation of the P-gain
P 2661	CON_PRC_Tn	Process controller integral-action time
P 2662	CON_PRC_REFOFFSET	Offset for the process controller output
P 2663	CON_PRC_LIMPOS	Positive process controller limitation
P 2664	CON_PRC_LIMNEG	Negative process controller limitation
P 2665	CON_PRC_CDIFFSIGN	Adaptation of control difference sign
P 2666	CON_PRC_REFVAL	Process control reference value
P 2667	CON_PRC_REFSCALE	Scaling factor for the process controller reference
P 2668	CON_PRC_ACTSEL	Selection of the actual value source
(0)	ISA00(0)	Analog input 0
(1)	ISA01(1)	Analog input 1
(2)	FIELDBUS(2)	Field bus parameter CON PRC_ACTVAL_Fieldbus-ID 2677
(3)	REFSPEED(3)	Actual speed [rpm]
(4)	REFPOS(4)	Actual position [increments]
(5)	ISQREF(5)	Reference value from speed control
P 2669	CON_PRC_ACTOFFSET	Offset for actual value calibration
P 2670	CON_PRC_ACTTF	Filter time for actual value filter
P 2671	CON_PRC_ACTSCALE	Scaling for the filtered process actual value
P 2672	CON_PRC_OUTSEL	Selection parameter for the process controller output
(0)	OFF(0)	Off
(1)	REFTORQUE(1)	Additive torque reference
(2)	REFSPEED(2)	Additive speed reference
(3)	REFPOS(3)	Additive position reference
(4)	MOPRO(4)	Value for MotionProfile (CON_PRC_OUTSEL_MOPRO – ID 2678)
P 2673	CON_PRC_RAW_ACTVAL	Actual value of the selected actual value source
P 2674	CON_PRC_ACTVAL	Momentary actual value of the process controller after filtering and scaling
P 2675	CON_PRC_CDIFF	Control difference of the process control loop
P 2676	CON_PRC_OUTVAL	Process controller control variable
P 2677	CON_PRC_ACTVAL_FIELDBUS	Parameter to which an actual value can be written from the field bus
P 2678	CON_PRC_OUTSEL_MOPRO	Parameter to which the control variable can be written in order to be subsequently used in the motion profile
P 2680	CON_PRC_RateLimiter	Steepness limitation of the control variable
(0)	RateLimiter	Steepness limitation in standard process controller operation; unit [X/ms]
(1)	RateLimiter	Steepness limitation to reduce the process controller I-component; unit [X/ms]

Table 178.1

P. no.	Parameter name/ Settings	Function
P 2681	CON_PRC_CtrlWord	Control word of the process controller
(0)	PRC_CTRL_ON	Switch on process controller
(1)	PRC_CTRL_ResetIReady	Reset I-component via ramp after parameter 2680 / subindex 1
(2) bis (7)	PRC_CTRL_FREE	Reserve
P 2882	CON_PRC_StatWord	Status word of the process controller
(0)	PRC_STAT_On	PSwitch on process controller
(1)	PRC_STAT_ResetIReady	I-component of the process controller is reduced
(2) - (7)	PRC_STAT_FREE	Reserve
P 2683	CON_PRC_REFSEL	Selection of reference source
P 2684	CON_PRC_REFVAL_User	User input of process control reference

Procedure:

- **Set process controller reference:**
  P 2666 CON_PRC_REFVAL: Reference input in user units (this parameter can be written cyclically over a field bus).
- **Scaling of the process controller reference:**
  P 2667 CON_PRC_REFSCALE; The reference P2666 can be scaled (taking into account the user units, see Application Manual, "Scaling"**.**
- **Select actual value sources:**
  P 2668 CON_PRC_ACTSEL: The actual value source must be set to the desired reference source (e.g. field bus). The field bus writes the actual value to parameter **P 2677 CON_PRC_ACTVAL_Fieldbus.**
- **Select offset (optional)**
  P 2669 CON_PRC_ACTOFFSET: Setting of an offset for actual value calibration
- **Scaling of the process controller actual value:**
  P 2670 CON_PRC_ACTSCALE: filter time for the actual value filter [ms]. The actual value is smoothed via the integral-action time P 2670 > 0 ms of the PT-1 filter. (Taking into account the user units)
- **Inversion of the control difference**
  P 2665 CON_PRC_CDIFFSIGN: Adaptation of control difference sign
- **Activate process controller:**
  P 2681 CON_PRC_CtrlWord: Control word Bit 0 = 1 (process controller active)
- **Optimization of controller setup:**
  P 2659 CON_PRC_Kp: Controller gain
  P 2660 CON_PRC_KP_SCALE: Scaling of gain
  P 2661 CON_PRC_Tn: TN integral-action time: If the integral-action time is set to the permissible maximum value, the I-component of the controller is inactive (10000 ms = off).
- **Offset for the process controller output**
  P 2662 CON_PRC_REFOFFSET: Then the totalled variable is connected via a limitation to the output of the process control loop. The user can parameterize the limitation via parameter **P 2663 CON_PRC_LIMPOS** for the positive limit and **P 2664 CON_PRC_LIMNEG** for the negative limit.

RateLimiter:
Downstream of the control variable limiter there is another limitation which limits the changes to the control variable per sampling segment. By way of field parameter P 2680 CON_PRC_RateLimiter the limitation of the control variable steepness per millisecond can be parameterized. The subindex zero is for limitation in standard process controller operation. Selecting subindex 1 activates reduction of the I-component.

Table 179.1

P. no.	Parameter name/ Settings	Function
P 2680	CON_PRC_RateLimiter	Steepness limitation of the control variable
(0)	RateLimiter	Steepness limitation in standard process controller operation; unit [X/ms]
(1)	RateLimiter	Steepness limitation to reduce the process controller I-component; unit [X/ms]
P 0270	MPRO_FG_PosNorm	Internal position resolution [incr/rev]

The process controller is to deliver an additive position reference **P 2672 CON_PRC_OUTSEL = 3**. Then the possible change in the control variable is to be limited by way of the rate limiter
The control variable change each time interval by the process controller results in a speed change on the motor shaft.
Example: The amount of the process controller to change the speed on the motor shaft should not be higher than 100 revolutions per minute.
To achieve this, the value of parameter **CON_PRC_RateLimiter (ID 2680) subindex 0** must be parameterized with a value corresponding to the user unit.
The unit of this parameter is x/ms. The x stands for the respective unit of the process controller output variable.
In this example the control variable (additive position reference) has the unit Increments (see also parameter **P 270 MPRO_FG_PosNorm**). This parameter indicates how many increments correspond to one motor revolution.

In the following the conversion of revolutions per minute into increments per millisecond is calculated:

Example:
CON_PRC_RateLimiter(0)
P 2680 [inc/ms] = 100 [rpm] * P 0270 [inc/rev] * 1/60 [min/s] * 1/1000 [s/ms]

To reduce the I-component, the same procedure is applicable (**CON_PRC_RateLimiter(1) [Inc/ms]**).

If a change in control variable is not desired, **CON_PRC_RateLimiter** must be parameterized with the value zero.

Table 179.2

P. no.	Parameter name/ Settings	Function
P 2672	CON_PRC_OUTSEL	Selector for the additive reference values
(0)	OFF (0)	No reference selected
(1)	Additive torque reference (1)	Additive torque reference must be given in [Nm]
(2)	Additive speed reference (2)	Additive speed reference must be given in [rpm]
(4)	Additive position reference (3)	Additive position reference must be given in [increments]
(5)	Value for MotionProfile **P 2678 CON_PRC_OUTSEL_MOPRO**	**P 2678** is the parameter to which the control variable can be written in order to be subsequently used in the motion profile.

Note:
The scaling of internal units to user-specific units is set out in section 6, “Motion profile”.

Scope signals for visualization of the process control loop:

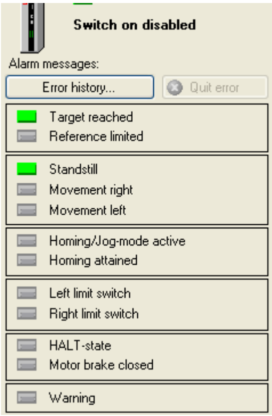
Table 180.1

Number	Scope variable	Description
2666	Ref_prc	Process controller reference **(P 2666 CON_PRC_REFVAL)**
78	Cdiff_prc	Control difference of the process controller (**P 2675 CON_PRC_CDIFF**)
2676	Actuating_var_prc	Control variable of the process controller (**P 2676 CON_PRC_OUTVAL**)
2673	Raw_actual_prc	Actual value of the selected actual value source (**P 2673 CON_PRC_RAW_ACTVAL**)
2674	Actval_prc	Momentary actual value of the process controller after filtering and scaling (**P 2674 CON_PRC_ACTVAL**)

Drive status

The “Drive status” window displays the current device status. In an error state the green rectangle at the top turns red. The rectangles at the bottom turn from transparent to green as soon as a condition (high) is met..

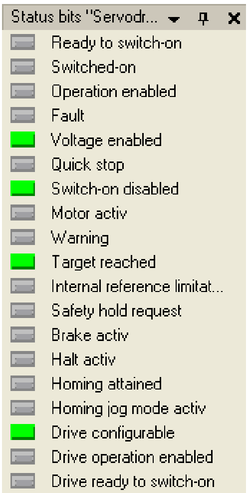
Illustration 181.1 Drive status-window



As soon as an error is detected, the status indicator at the top of the window turns red. Detailed information on the error and on previous errors can be viewed by clicking the “Error history” button.
At the bottom of the window the current states are displayed. A green light signifies active.

Status bits

Illustration 181.2 Status bits-windoe

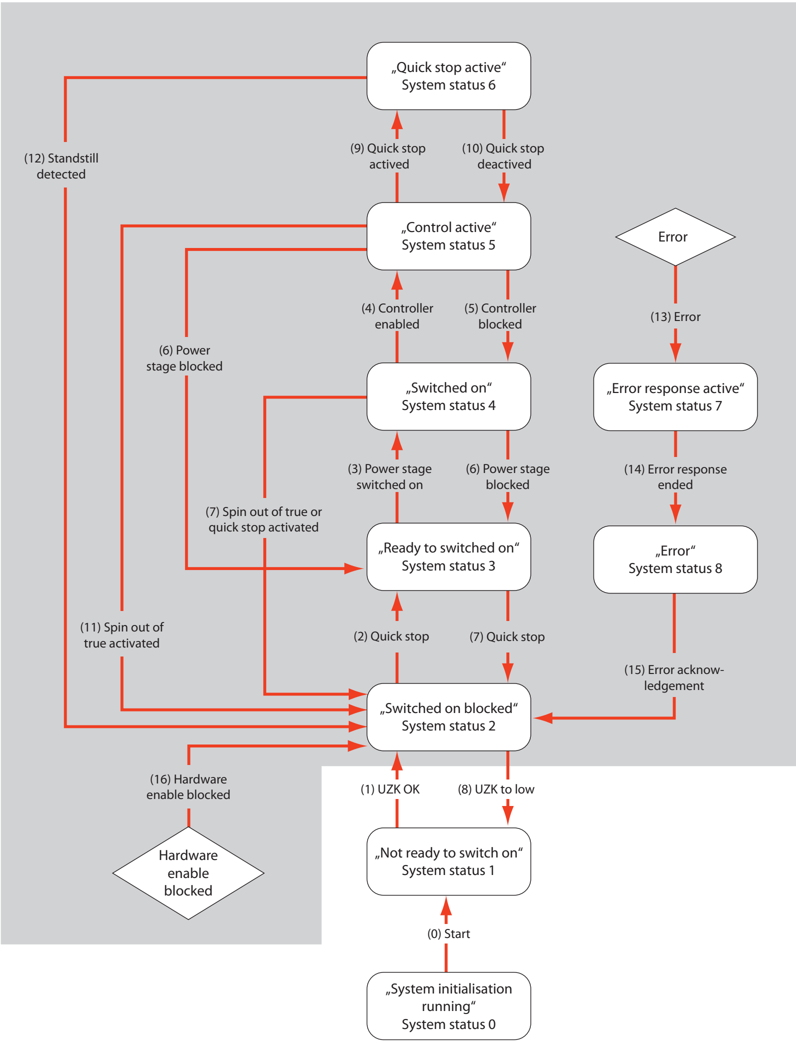


The “Status bits” window displays the current system states. The basis of those states is the DriveCom state machine. The active states are displayed in green. A schematic view is presented in figure A 3 and in figure 5.36 in the “Motion profile” section.

State machine

State machine of the drive controller:
The system states of the controller are recorded in the bordered boxes. Red arrows designate the individual state transitions, oriented to **CiA 402**. Changeable state transitions are bordered in grey.

Illustration 182.1 State machine of the drive controller



Manual mode
Manual mode enables a controller to be controlled in different modes regardless of whether a higher-level control system is pre-installed or not. All that is required is for the hardware to be enabled first (STO and ENPO)
When the manual mode window is closed, all the original settings are restored.
The drive motion can be plotted with the scope function, permitting analysis of the control performance for example.

⚠

Attention!
Before this function is started, a controller must first have been commissioned into operation as specified in the Operation Manual. When the Control window is opened the parameter settings in the connected device are automatically changed and are then restored when the window is closed. Communication should not be interrupted (such as by a power failure, unplugging the connecting cable or suchlike) while the Control window is active.

DANGER:
Manual mode causes the axis to execute movements. The connected control system is not active, and cannot intervene in the movement. It must be ensured that no hazard is posed to people or machinery.
In an emergency, the drive can be stopped at any time by cancelling the hardware enable (ENPO, STO). In the case of lifting applications, it must be ensured that a mechanical brake is installed.

Note:
If a drive cannot be moved by way of the Control window, check the following points:

- Controller system state
- Motor data
- Possibly safety switch
- Quick stop active
- Hardware enable via STO and ENPO

Monitoring functions

Actual values:

Table 183.1

P. no.	Parameter name/Setting	Designation in DM 5	Function
P 0276	MPRO_FG_UsrActPos	Actual position in user units	Current position in user units
P 0277	MPRO_FG_UsrRefPos	Reference position in user units	Reference position in user units
P 0278	MPRO_FG_UsrCmdPos	Position command in user units	Position command in user units
P 0279	MPRO_FG_UsrPosDiff	Tracking error in user units	Tracking error in user units

Table 184.1

P. no.	Parameter name/Setting	Designation in DM 5	Function
P 0280	MPRO_FG_UsrRefSpeed	Reference speed in user units	Speed reference in user unit
P 0281	MPRO_FG_UsrActSpeed	Actual speed in user units	Actual value in user units
P 0282	MPRO_FG_UsrCmdSpeed	Speed command in user units	Speed command in user units
P 0312	CON_CCON_VMot	Actual motor voltage (rms, phase to phase)	Actual motor voltage
P 0410	CON_ACT_VDC	Actual DC link voltage	Actual DC link voltage
P 0412	CON_PCON_ActPosition	Actual position in increments	Actual position value in increments
P 0413	CON_PCON_RefPosition	Reference position in increments	Position reference in increments
P 0414	CON_PCON_PosDiff	Actual position difference (RefPosition-ActPosition)	Difference between actual and reference position
P 0415	CON_SCALC_ActSpeed	Actual speed	Actual speed
P 0416	CON_SCON_RefSpeed	Reference speed	Reference speed
P 0417	CON_SCON_SDiff	Speed difference (RefSpeed-ActSpeed)	Difference between actual and reference speed
P 0418	CON_SCON_RefTorque	Reference torque	Torque reference
P 0419	CON_SCON_ActTorque	Actual torque	Actual torque
P 0700	MON_CurrentRMS	Actual current (r.m.s)	Actual current (mean value)
P 0702	MON_State	Device status word	Status word
P 0703	MON_PowerStage_TKK	Power stage temperature of cooling block	Heat sink temperature
P 0704	MON_Device_Tint	Power stage temperature of interior	Interior temperature
P 0734	MON_MotorTemp	Motor temperature	Motor temperature
P 0742	MON_UsrPosDiffHistory	Monitoring maximum position difference	Position tracking error in user units

Further actual values can be found in field parameter P 0701

Table 184.2

P. no.	Parameter name/Setting	Designation in DM 5	Function
P 0701	MON_ActValues	Monitoring, actual values of motor and inverter	Display of motor and controller actual values
(0)	I^2xt_Motor	Actual values of I^2xt integrator for motor protection	Actual value of the I^2xt integrator for motor protection
(1)	I^2xt_Inverter	Actual values of I^2xt integrator for inverter protection	Actual value of the I^2xt integrator for controller protection
(2)	Phasor	Actual motor current amplitude	Actual value of motor current amplitude
(3)	Imag	Actual magnetization (d-)current amplitude	Actual amplitude value of magnetizing current
(4)	Km	Actual torque constant	Torque constant

Interpolation method

Table 185.1

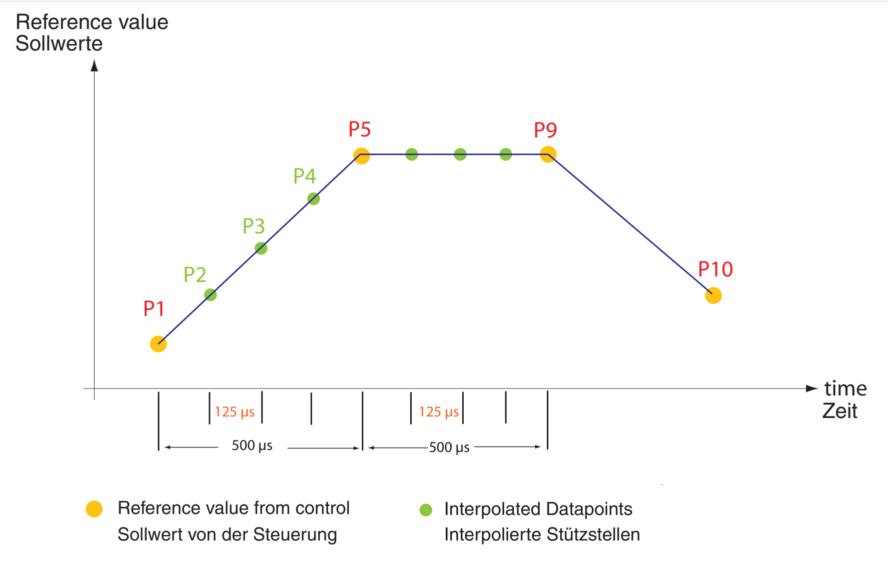
P 0370	CON_IP	Interpolation method in IP mode
(0)	NOIp(0)	No interpolation
(1)	Lin(1)	Linear interpolation
(2)	Spline_Ext_FF(2)	Interpolation with external pre-control
(3)	SplineII(3)	Cubic spline Interpolation
(4)	NonIPSpline(4)	Cubic spline approximation

NoIP(0): No interpolation

The values are transferred 1:1 to reference processing in 1 ms cycles.

LIN(1): Linear interpolation

Illustration 185.2 Linear interpolation



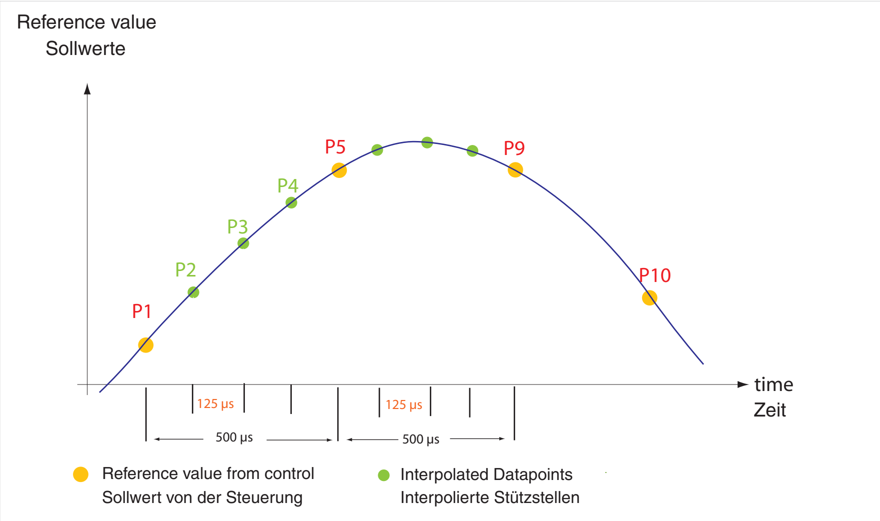
With the linear interpolation method the acceleration between two points is generally zero. Pre-control of the acceleration values is thus not possible and speed jumps are always caused.
Application:
This method is used mainly for test purposes and for initial commissioning.

SplineExtFF(2): Cubic spline interpolation with ext. pre-control value:

This method enables highly accurate adaptation of the position profile. The expected result should exhibit high contouring accuracy and low reference/actual value deviation.

SplineII(3): Cubic Spline Interpolation:

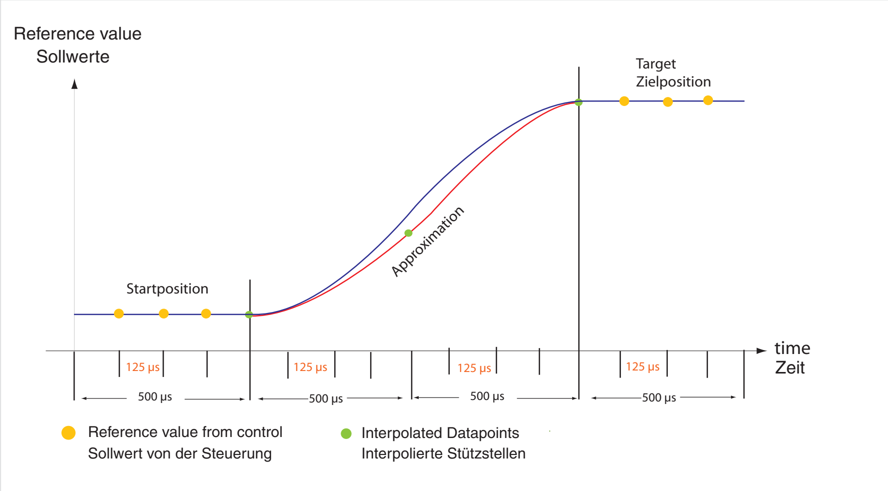
Illustration 186.1 Cubic Spline interpolation; P 0305=125 µs cycle



In this method interpolation is effected between the interpolation points of the control (P1, P5, P9, P10) by means of cubic splines. The trajectory is guided precisely by the control based on the specified points. This may cause a slight jerk at those points, noticeable in the form of "noise".
Application:
High contouring accuracy, slight "noise" is possible. "Noise" refers to mathematical anomalies which cannot be entirely eliminated by the computing methods applied.

NonIPSpline(4): Cubic Spline Approximation:

Illustration 187.1 Cubic Spline Approximation: P 0305=125 µs cycle



With this method the interpolation points are approximated by means of B-Splines. The trajectory normally does not run exactly through the points specified by the control. The deviation is normally negligibly small. In the interpolation points the transitions are continuous with regard to acceleration, which becomes apparent by minor “noise”.

In start and target position the interpolation points always match the trajectory.

Application:
Minimizing noise, smoother motion, restrictions on contouring

Note:
Further information on how to generate motion commands using the field buses or internal possibilities can be found in the field bus documentation.

Quick commissioning

Rotary motor system

Table 188.1

Instruction	Action	P. no.
Selection of motor (section 2.1.3 “Motor”)	Decision whether to use a synchronous motor (PSM) or an asynchronous motor (ASM)	**P 0450**
Selection of motor motion (section 2.1.3 “Motor”)	Decision whether to use a rotary or linear motion system.	**P 0490**
Motor identification (section 2.1.3 “Motor”)	The identification only needs to be carried out if the motor’s electrical data is missing. **Identification sequence:** Measurement of stator/rotor resistance, stray (leakage) inductanc Current controller tuning Calculation of nominal flux	**P 0470, P 0476, P 0471, P 0474, P 0462, P 0340**
Motor protection (section 2.2.3)	Setting of I^2xt monitoring, selection of temperature sensor, characteristic setting	**P 0731 P 0732 (0),(1) P 0733 (0)-(6)**
Encoder setup (section 3, Encoder)	The desired encoders and their channels must be selected.	
System test via manual mode (DM5 Online Help/ Manual mode window)	Open manual mode window - Control mode Vfc (open loop) mode - Move motor at low speed - Check direction	
Control setup	Optimize current controller (test signal generator, section 4.2) The current of the test signal generator is automatically set when the motor data is entered.	**P 1503 (0), (1)**
	Optimize speed controller (step responses, section 4.4)	**P 0320 P 0321 P 0322**
	Determine mass inertia [J] Section 4.1.1 “Basic settings”	**P 1517**
	Adjust speed filter: P 0351 = FS (0.6 ms) Recommended: SinCos encoder 0.2 ms - 0.6 ms Resolver 0.6 ms - 1.5 ms	**P 0351**
	Adjust rigidity Section 4.1.1 “Basic settings”	**P 1515 P 1516**
Optional settings	Scaling, IO‘s, field buses, etc.	

Linear motor system

Table 189.1

Instruction	Action	P. no.
Selection of motor (section 2.2 "Motor")	The parameter is automatically set to PSM if parameter P 0490 = LIN(1) is set.	**P 0450**
Selection of motor motion (section 2.2 "PS linear motor")	Selection for a linear motion system with P 0490 = LIN(1).	**P 0490**
Motor data set calculation (section 2.2 "PS linear motor")	Data set calculation: Fill out "Calculation of control setup for linear PS motors" screen form and start calculation. (See calculated values, section 2.2)	see parameter table, section 2.2
Motor protection (section 2.2.3)	Setting of I^2xt monitoring, selection of temperature sensor, characteristic setting	**P 0731** **P 0732 (0), (1)** **P 0733 (0)-(6)**
Encoder setup (section 3, Encoder)	The desired encoders and their channels must be selected.	
System test via manual mode (DM5 Online Help/Manual mode window)	Open manual mode window - Control mode VFC (open loop) mode (section 4.7) - Move motor at low speed **Motor will jerk, as it is in "open-loop" mode!** - Check direction!	
Control setup	Optimize current controller (test signal generator, section 4.2) The current of the test signal generator is automatically set when the motor data is entered.	**P 1503 (0), (1)**
	Optimize speed controller (step responses, section 4.4)	**P 0320** **P 0321** **P 0322**
	Determine mass inertia [J] Section 4.1.1 "Basic settings"	**P 1517**
	Adjust speed filter: P 0351 = FS (0.6 ms) Recommended: SinCos encoder 0.2 ms - 0.6 ms Resolver 0.6 ms - 1.5 ms	**P 0351**
	Adjust rigidity Section 4.1.1 "Basic settings"	**P 1515** **P 1516**
Optional settings	Scaling, IO's, field buses, etc.	

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