

# Communication / Function Manual

Motion Control

MCLM 300x RS

## RS232

## Imprint

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## About this document

# 1 About this document

## 1.1 Validity of this document

This document describes:

- Quick start:
  - Initial commissioning and operation of the device with serial interface
- Communication:
  - Communication with the drive via RS232
  - Basic services provided by the Communication structure
  - Methods for accessing the parameters
  - Drive from the viewpoint of the communication system
- Function:
  - Principle of the device controller
  - Commissioning and configuring the device
  - Operating modes and functions

This manual is related to the product series of the FAULHABER Motion Controllers and the FAULHABER Motion Control Systems. In the following these product series are termed "Motion Controller". The term "Motion Control System" will be used, only if the distinction is necessary.

This document is intended for following persons:

- Users who are commissioning a motor on the FAULHABER Motion Controller for the first time
- Software developers and project engineers with experience of interfaces
- Technicians and engineers in the application of controlled electrical drives and industrial communications systems

All data in this document relate to the standard versions of the drives. Changes relating to customer-specific versions can be found in the attached sheet.

## 1.2 Associated documents

For certain actions during commissioning and operation of FAULHABER products additional information from the following manuals is useful:

| Manual           | Description                                                              |
|------------------|--------------------------------------------------------------------------|
| Motion Manager 6 | Operating instructions for FAULHABER Motion Manager PC software          |
| Technical manual | Instructions for installation and use of the FAULHABER Motion Controller |

These manuals can be downloaded in PDF format from the Internet page [www.faulhaber.com/manuals/](http://www.faulhaber.com/manuals/).

## About this document

### 1.3 Using this document

- ▶ Read the document carefully before undertaking configuration.
- ▶ Retain the document throughout the entire working life of the product.
- ▶ Keep the document accessible to the operating personnel at all times.
- ▶ Pass the document on to any subsequent owner or user of the product.

### 1.4 List of abbreviations

| Abbreviation | Meaning                                             |
|--------------|-----------------------------------------------------|
| EEPROM       | Electrically Erasable Programmable Read-Only Memory |
| MOSFET       | Metal-Oxide Semiconductor Field-Effect Transistor   |
| PWM          | Pulse Width Modulation                              |
| PLC          | Programmable Logic Controller                       |
| TTL          | Transistor Transistor Logic                         |

### 1.5 Symbols and markers



#### CAUTION!

Hazards to persons. Disregard may lead to minor injuries.

- ▶ Measures for avoidance



#### NOTICE!

Risk of damage.

- ▶ Measures for avoidance



Instructions for understanding or optimising the operational procedures

- ✓ Pre-requirement for a requested action

1. First step for a requested action

↳ Result of a step

2. Second step of a requested action

↳ Result of an action

- ▶ Request for a single-step action

## Quick start

## 2 Quick start

To facilitate introduction, this chapter highlights the initial steps for commissioning and operation of FAULHABER Motion Controllers with serial interface. Additionally, the detailed documentation must be read and taken into account, particularly chap. 5.2.4, p. 60.

### 2.1 Commissioning using the default configuration

The following steps are necessary for commissioning using the default configuration:

1. Connect the drive unit to a 12 V – 24 V voltage source.  
For the connection cable assignment, see technical manual.
2. Connect drive unit to a serial interface of the PC (e.g. COM1) and switch on..  
For the interface assignment, see technical manual.
3. Execute configuration and motion commands via suitable software, e.g. FAULHABER Motion Manager.



Use of a USB serial adapter is recommended if the PC used does not have a serial port.

### 2.2 Setting node number and baud rate

The units are delivered as standard with node address 0 (NODEADR0) and with a transfer rate of 9 600 baud. The settings can be changed via the interface, e.g. with the FAULHABER Motion Manager.

Procedure when using the FAULHABER Motion Manager:

- ✓ Connection exists (see chap. 2.1, p. 9).
1. Select the **Configuration - Connection Parameters...** menu.
  2. Select the required transfer rate and node number.
  3. Press **Send** button.
    - ✚ The settings are transferred and are permanently stored in the controller. The Motion Manager then calls up the Scan function again and the node should now be displayed with the correct node number in the Node Explorer. After switching off and on again, the drive will operate with the set configuration.

## Quick start

### 2.3 Operation via FAULHABER Motion Manager

The FAULHABER Motion Manager offers easy access to the Motion Controller's command set. The desired node must have been activated beforehand by double clicking in Node Explorer in the case of network operation.

The FAULHABER commands described below can be entered directly in the command input line or selected from the commands menu.

In order to drive a motor via the Motion Manager, follow the procedure below:

- ✓ Connection exists (see chap. 2.1, p. 9).
- 1. Start FAULHABER Motion Manager.
- 2. Configure drive functions:
  - Motion Controllers with an externally connected motor must be equipped with current limitation values suitable for the motor and suitable controller parameters before being started up.

The Motor Wizard is available in Motion Manager for selection of the motor and basic parameters suitable for the motor.

Other settings, e.g. for the function of the fault output, can be made under the **Configuration – Drive Function** menu item, where a convenient dialog is provided (see chap. 5.2, p. 57). The configuration dialog is also available for direct access in the quick access bar of the Motion Manager.



#### NOTICE!

**Damage to the controller and / or drive by incorrect values in the Motion Controller's settings.**

- ▶ Check basic settings (see chap. 5.2.4, p. 60).
- 3. To operate the drive via the PC, set value presetting to digital (SOR0).
- 4. If the settings are to be permanently stored, press the **EEPSAV** button.
- 5. Activate the drive using the **EN** command.
  - Select **Motion Control - Enable Drive (EN)** via the context menu of the node explorer or via the **Commands** menu
  - or -
  - enter the **EN** command in the command input field of the terminal window
  - or -
  - press **Output stage enable** button in the symbol bar.
- 6. Drive the motor (e.g. with 100 mm/s, relative by 10 000 increments):
  - Enter **SP100** command.
  - Load the target position using the **LR10000** command.
  - Move to the loaded target position using the **M** command.
- 7. Stop the drive using the **V0** command.

## Quick start

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8. Move the motor (e.g. relative by 10 000 increments):

- Select **Motion Control - Load relative target position (LR)** via the context menu of the node explorer or via the **Commands** menu and enter the required value in the dialogue box

- or -

enter the `LR10000` command in the command input field of the terminal window.

- Select **Motion Control - Initiate Motion (M)** via the context menu of the node explorer or via the **Commands** menu

- or -

enter the `M` command in the command input field of the terminal window.

9. Deactivate the drive:

Press **Output stage disable** button in the symbol bar

- or -

press F5 key

- or -

select the **Motion Control - Disable Drive (DI)** menu item or execute the `DI` command.

### Adjusting the controller parameters using the Tool Controller tuning

Motion Manager provides the **Tool Controller tuning**, with which the controller parameters of the velocity and positioning controller can be adjusted to the application.



#### NOTICE!

**Material damage due to collisions.**

During operation with the **Tool Controller tuning** the motor is alternately run at different speeds. Obstacles within the movement range can lead to collisions and material damage.

- ▶ Make sure that during parameter search the drive is free to move within the values that were input.

## Functional description

### 3 Functional description

#### 3.1 Drive data

For the motor monitoring models the following parameters are required:

- Speed constant (derived from the generator voltage constants  $k_E$ )
- Connection resistance
- Magnetic pole pitch

These values are suitably preassigned by selecting a motor type in the Motion Manager's Motor Wizard.

| Command | Argument     | Function                | Description                                                                                                |
|---------|--------------|-------------------------|------------------------------------------------------------------------------------------------------------|
| KN      | 0...16 383   | Load Speed Constant     | Load speed constant $K_N$ in accordance with information in the data sheet [ $\text{min}^{-1}/\text{V}$ ]. |
| RM      | 10...320 000 | Load Motor Resistance   | Load motor resistance RM according to specification in data sheet [ $\text{m}\Omega$ ].                    |
| TM      | 8...60       | Load Magnetic Pitch     | Load magnetic pitch [mm].                                                                                  |
| ENCRES  | 8...65 535   | Load Encoder Resolution | Load resolution of external encoder [4 times pulse/mm].                                                    |

$K_N$  can be calculated using the following relationship from the data sheet values of the generator voltage constant  $k_E$  and the magnetic pole pitch  $\tau_m$ :

$$K_N = \frac{60\,000}{k_E \cdot \tau_m}$$

- Sensor Type:

The following combinations are supported as position encoder systems:

- Analogue Hall sensors (3 000 increments/ $\tau_m$ , fixed)
- Analogue Hall sensors + incremental encoder (resolution depends on the incremental encoder)

- Resolution external encoder (ENCRES):

If using an external incremental encoder its resolution must be given for 4 edge evaluation (4 times the pulse rate).

- Resolution internal encoder:

If using the analogue Hall sensors as position encoders a fixed 3 000 pulses are supplied per magnetic pole pitch  $\tau_m$ .

## Functional description

### 3.2 Configuration of the operating modes

The Motion Controllers can be configured for different operating modes. As standard the drive unit is delivered as a servomotor with set value presetting via the serial interface. The drive can be reconfigured by means of the corresponding FAULHABER commands.

| Command   | Argument | Function                     | Description                                                                                                                                                                                                                                                                                                                                          |
|-----------|----------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SOR       | 0...4    | Source For Velocity          | Source for velocity presetting. <ul style="list-style-type: none"> <li>0: Interface (Default)</li> <li>1: Voltage at analogue input</li> <li>2: PWM signal at analogue input</li> <li>3: Current target value via analogue input</li> <li>4: Target current value via analogue input with pre-setting of the direction via input polarity</li> </ul> |
| CONTMOD   | –        | Continuous Mode              | Switch back to normal mode from an enhanced mode.                                                                                                                                                                                                                                                                                                    |
| STEPMOD   | –        | Stepper Motor Mode           | Change to stepper motor mode.                                                                                                                                                                                                                                                                                                                        |
| APCMOD    | –        | Analog Position Control Mode | Position control with target value via analogue voltage.                                                                                                                                                                                                                                                                                             |
| ENCMOD    | –        | Encoder Mode                 | Change to encoder mode. An external encoder serves as position detector (the current position value is set to 0).                                                                                                                                                                                                                                    |
| HALLSPEED | –        | Hall Sensor As Speed Sensor  | Speed via Hall sensors in encoder mode.                                                                                                                                                                                                                                                                                                              |
| ENCSPEED  | –        | Encoder As Speed Sensor      | Speed via encoder signals in encoder mode.                                                                                                                                                                                                                                                                                                           |
| GEARMOD   | –        | Gearing Mode                 | Change to gearing mode                                                                                                                                                                                                                                                                                                                               |
| VOLTMOD   | –        | Set Voltage Mode             | Activate Voltage Regulator Mode.                                                                                                                                                                                                                                                                                                                     |

If the settings are to be permanently stored, the `SAVE` command must be executed after the configuration. This saves the current settings in the Flash data memory. From there they are reloaded when the unit is next switched on.

**i** Alternatively, the `EEPSAV` command can also be executed. Both commands are identical, therefore `SAVE` only is used in the following.

The power stage must be activated (`EN`) for the drive to operate.

All commands listed further below are summarised and explained again in chap. 7, p. 76.

## Functional description

### 3.3 Position control

#### 3.3.1 Set value presetting via the serial interface

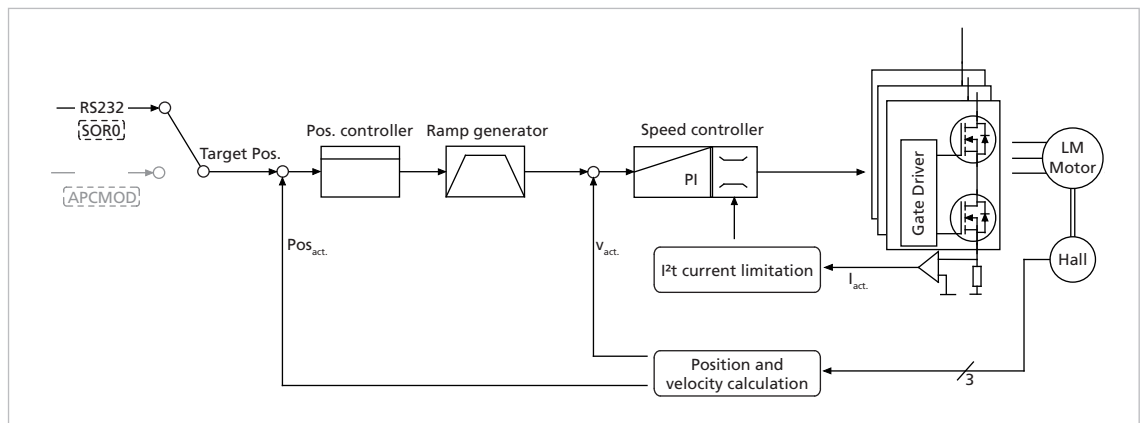


Fig. 1: Controller structure for set value presetting via the serial interface or via a sequence program

In this operating mode, target positions can be preset via the serial interface or a sequence program.

##### 3.3.1.1 Basic settings

Operating mode `CONTMOD` and `SOR0`.

The positioning range limits can be set via the command `LL` and activated via `APL`. The proportional amplification `PP` and a differential term `PD` can be set for the position controller.

| Command | Argument                               | Function                              | Description                                                                                                                                                                                                                                                                  |
|---------|----------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PP      | 1...255                                | Load Position Proportional Term       | Load position controller amplification.                                                                                                                                                                                                                                      |
| PD      | 1...255                                | Load Position Differential Term       | Load position controller D-term.                                                                                                                                                                                                                                             |
| LL      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$ | Load Position Range Limits            | Load limit positions (the drive cannot be moved out of these limits). <ul style="list-style-type: none"> <li>Positive values specify the upper limit.</li> <li>Negative values specify the lower limit.</li> </ul> The range limits are only active if <code>APL</code> = 1. |
| APL     | 0...1                                  | Activate / Deactivate Position Limits | Activate range limits ( <code>LL</code> ) (valid for all operating modes except <code>VOLTMOD</code> ). <ul style="list-style-type: none"> <li>1: Position limits activated</li> <li>0: Position limits deactivated</li> </ul>                                               |

## Functional description

### 3.3.1.2 Additional settings

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

See chap. 3.8.1, p. 40.

#### Velocity controller / current limitation

The controller parameters `POR` and `I` of the velocity controller can be adjusted. In addition, the current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

See chap. 3.4, p. 20.

### 3.3.1.3 Motion control commands

The positioning is executed via the FAULHABER motion control commands (see chap. 7.4, p. 85).

| Command | Argument                                 | Function               | Description                                                                                                                                                                                                        |
|---------|------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EN      | –                                        | Enable Drive           | Activate drive.                                                                                                                                                                                                    |
| DI      | –                                        | Disable Drive          | Deactivate drive.                                                                                                                                                                                                  |
| LA      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Load Absolute Position | Load new absolute target position.                                                                                                                                                                                 |
| LR      | $-2,14 \cdot 10^9 \dots 2,14 \cdot 10^9$ | Load Relative Position | Load new relative target position, in relation to last started target position. The resulting absolute target position must lie between the values given as argument.                                              |
| M       | –                                        | Initiate Motion        | Activate position control and start positioning.                                                                                                                                                                   |
| HO      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Define Home Position   | <ul style="list-style-type: none"> <li>Without argument: Set actual position to 0.</li> <li>With argument: Set actual position to specified value.</li> </ul>                                                      |
| NP      | –                                        | Notify Position        | <ul style="list-style-type: none"> <li>Without argument: A "p" is returned when the target position is attained.</li> <li>With argument: A "p" is returned if the specified position is over-travelled.</li> </ul> |
| NPOFF   | –                                        | Notify Position Off    | Notify Position command that has not yet been triggered is deactivated again.                                                                                                                                      |

Example:

- Load target position: `LA40000`
- Start positioning: `M`

Attainment of the target position or any intermediate position is indicated by a "p" on the serial interface if "Notify Position" is set before the start of positioning, provided that `ANSW1` or `ANSW2` is set.

#### Position resolution

The `TM` parameter represents the magnetic pitch ( $\tau_m$ ) of the linear motor. If the linear Hall sensors of the motors are used as position transducers, 3 000 pulses per magnetic pitch ( $\tau_m$ ) are supplied.

## Functional description

### Complex motion profiles

More complex motion profiles can be generated through appropriate presetting of new values (maximum speed, acceleration, end position) during positioning. After a value change, simply execute a new motion start command (M). The commands NP and NV can be used to control the sequence.

Further information on complex motion profiles is given in chap. 3.8.1, p. 40.

### Digital signal target position

The entry into the target corridor can be displayed via the fault output as a digital output signal in the POSOUT function. The signal is not reset until a further Motion start command (M).

Further information on configuration is given in chap. 3.7, p. 38.

## 3.3.2 Analogue positioning mode (APCMOD)

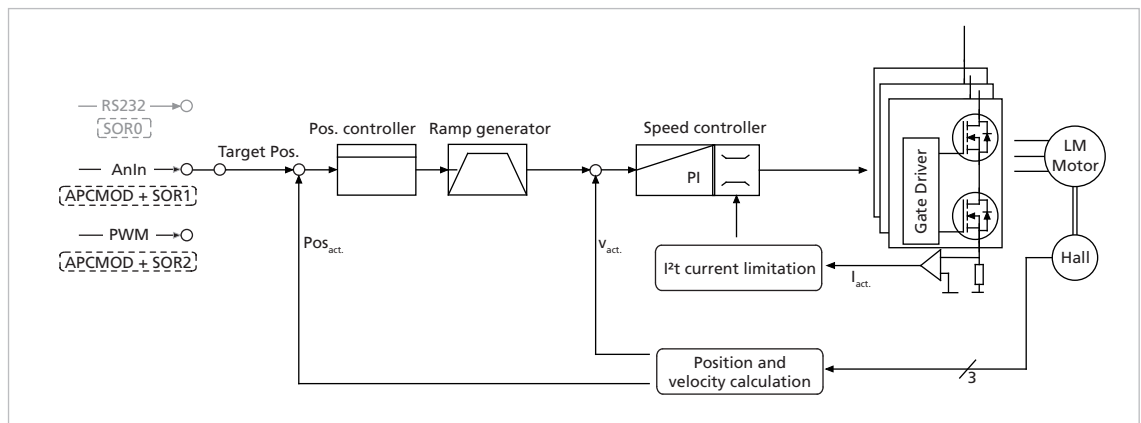


Fig. 2: Controller structure for set-point presetting via an analogue voltage

In this operating mode the target position can be preset using an analogue voltage at the AnIn input.

### 3.3.2.1 Basic settings

Operating mode APCMOD and SOR1 or SOR2.

The positioning range limits can be set via the command LL and activated via APL. The proportional amplification PP and a differential term PD can be set for the position controller.

The maximum position to be approached with a voltage of 10 V can be preselected with the LL command. At -10 V the drive moves in the opposite direction up to the set negative range limit.

Irrespective of the preset LL value, the maximum position is limited to 3 000 000 in APCMOD.



The resolution of the analogue input is limited to 12 bit (4096 steps). The direction can be predefined with the commands ADL and ADR.

## Functional description

### 3.3.2.2 Additional settings

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

See chap. 3.8.1, p. 40.

#### Velocity controller / current limitation

The controller parameters `POR` and `I` of the velocity controller can be adjusted. In addition, the current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

See chap. 3.4, p. 20.

### 3.3.2.3 Positioning via pulse width signal (PWM) at the analogue input (SOR2)

If `SOR2` is set in `APCMOD`, the pulse duty factor of a PWM signal can be used as position set-point.

*Tab. 1: Meaning of the pulse duty factor on delivery*

| Pulse duty factor | Meaning                  |
|-------------------|--------------------------|
| > 50%             | Positive target position |
| = 50%             | Target position = 0      |
| < 50%             | Negative target position |

### 3.3.2.4 Absolute positioning within a magnetic pole pitch

In motion control systems, after switching on, the initial position is absolutely initialised within a pole pitch (–1 500...1 500 corresponds to the spacing of the magnetic poles). This means that even if the power supply is disconnected, the position determination supplies the correct position value after restarting (if the cage bar has only been moved within one magnetic pole pitch).

The following commands enable the drive to be accurately positioned in the voltage range 0...10 V within one magnetic pole pitch and to return to the correct position even after the supply has been switched off, without homing.

| Function                                                       | Command             |
|----------------------------------------------------------------|---------------------|
| Switch over to analogue positioning                            | <code>APCMOD</code> |
| Hide negative range                                            | <code>LL-1</code>   |
| Limit 0...10 V at <code>AnIn</code> to one magnetic pole pitch | <code>LL3000</code> |

## Functional description

### 3.3.3 External encoder as actual position value (ENCMOD)

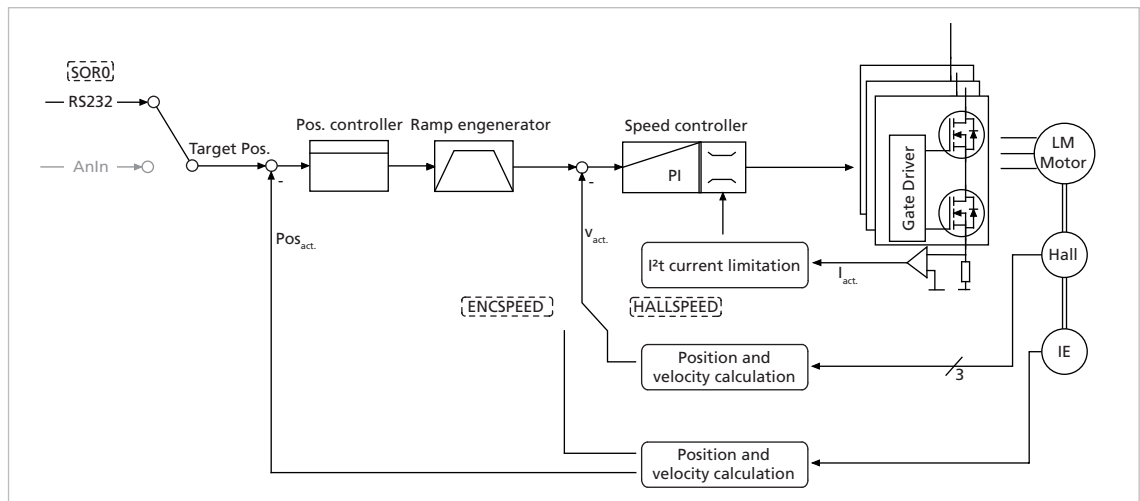


Fig. 3: Controller structure for using an external encoder as the actual value encoder

For high-precision applications, the actual values of LM motors can be derived from an external encoder.

- Depending on the application, the velocity can be derived from the encoder or from the Hall sensors.
- The external encoder can be connected directly to the cage bar. An encoder that is mounted to the application output (e.g. glass scale) is particularly advantageous. This allows the high precision to be set directly at the output.
- Commutation still occurs via the analogue Hall sensors.

#### 3.3.3.1 Basic settings

Operating mode ENCMOD and SOR0.

The positioning range limits can be set via the command LL and activated via APL. The proportional amplification PP and a differential term PD can be set for the position controller.

| Command | Argument                               | Function                              | Description                                                                                                                                                                                                                                                         |
|---------|----------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PP      | 1...255                                | Load Position Proportional Term       | Load position controller amplification.                                                                                                                                                                                                                             |
| PD      | 1...255                                | Load Position Differential Term       | Load position controller D-term.                                                                                                                                                                                                                                    |
| LL      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$ | Load Position Range Limits            | Load limit positions (the drive cannot be moved out of these limits). <ul style="list-style-type: none"> <li>■ Positive values specify the upper limit.</li> <li>■ Negative values specify the lower limit.</li> </ul> The range limits are only active if APL = 1. |
| APL     | 0...1                                  | Activate / Deactivate Position Limits | Activate range limits (LL) (valid for all operating modes except VOLTMOD). <ul style="list-style-type: none"> <li>■ 1: Position limits activated</li> <li>■ 0: Position limits deactivated</li> </ul>                                                               |

## Functional description

Tab. 2: Settings for external encoder

| Command   | Argument   | Function                    | Description                                                                                                       |
|-----------|------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------|
| ENCMOD    | –          | Encoder Mode                | Change to encoder mode. An external encoder serves as position detector (the current position value is set to 0). |
| ENCSPEED  | –          | Encoder As Speed Sensor     | Speed via encoder signals in encoder mode.                                                                        |
| HALLSPEED | –          | Hall Sensor As Speed Sensor | Speed via Hall sensors in encoder mode.                                                                           |
| ENCRES    | 8...65 535 | Load Encoder Resolution     | Load resolution of external encoder [4 times pulse/mm].                                                           |

### 3.3.3.2 Additional settings

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

See chap. 3.8.1, p. 40.

#### Velocity controller / current limitation

The controller parameters `POR` and `I` of the velocity controller can be adjusted. In addition, the current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

See chap. 3.4, p. 20.

### 3.3.3.3 Motion control commands

Positioning in the `ENCMOD` is executed in precisely the same way as in `CONTMOD` using the FAULHABER motion control commands (see chap. 7.4, p. 85).

| Command | Argument                                 | Function               | Description                                                                                                                                                                                                        |
|---------|------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EN      | –                                        | Enable Drive           | Activate drive.                                                                                                                                                                                                    |
| DI      | –                                        | Disable Drive          | Deactivate drive.                                                                                                                                                                                                  |
| LA      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Load Absolute Position | Load new absolute target position.                                                                                                                                                                                 |
| LR      | $-2,14 \cdot 10^9 \dots 2,14 \cdot 10^9$ | Load Relative Position | Load new relative target position, in relation to last started target position. The resulting absolute target position must lie between the values given as argument.                                              |
| M       | –                                        | Initiate Motion        | Activate position control and start positioning.                                                                                                                                                                   |
| HO      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Define Home Position   | <ul style="list-style-type: none"> <li>Without argument: Set actual position to 0.</li> <li>With argument: Set actual position to specified value.</li> </ul>                                                      |
| NP      | –                                        | Notify Position        | <ul style="list-style-type: none"> <li>Without argument: A "p" is returned when the target position is attained.</li> <li>With argument: A "p" is returned if the specified position is over-travelled.</li> </ul> |
| NPOFF   | –                                        | Notify Position Off    | Notify Position command that has not yet been triggered is deactivated again.                                                                                                                                      |

Example:

- Load target position: `LA40000`
- Start positioning: `M`

## Functional description

Attainment of the target position or any intermediate position is indicated by a "p" on the serial interface if "Notify Position" is set before the start of positioning, provided that ANSW1 or ANSW2 is set.

### Actual value resolution

In ENCMOD the resolution of the position values depends on the resolution of the encoder.

### Complex motion profiles

More complex motion profiles can be generated through appropriate presetting of new values (maximum speed, acceleration, end position) during positioning. After a value change, simply execute a new motion start command (M). The commands NP and NV can be used to control the sequence.

Further information on complex motion profiles is given in chap. 3.8.1.4, p. 43.

### Digital signal target position

The entry into the target corridor can be displayed via the fault output as a digital output signal in the POSOUT function. The signal is not reset until a further Motion start command (M).

Further information on configuration is given in chap. 3.7, p. 38.

## 3.4 Velocity control

In velocity control mode the velocity of the drive is controlled by a PI controller. Provided the drive is not overloaded, the drive follows the presetting without deviation.

The current velocity of LM motors can be detected both from the Hall signals and via an additional encoder.

The velocity can be preset via the serial interface or from sequence programs, via an analogue voltage preset or a PWM signal.

### 3.4.1 Velocity presetting via the serial interface

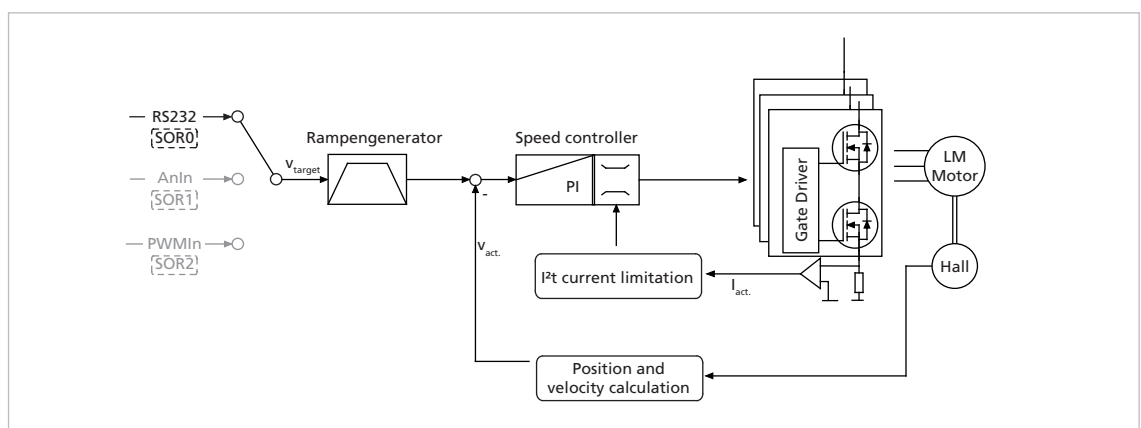


Fig. 4: Controller structure for velocity control

In this operating mode the drive can be operated by velocity controlled with set-point presetting via RS232 or from a sequence program.

## Functional description

### 3.4.1.1 Basic settings

Operating mode `CONTMOD` and `SOR0`.

The controller parameters `POR` and `I` and the sampling rate can be adjusted for the velocity controller.

| Command          | Argument | Function                        | Description                                                            |
|------------------|----------|---------------------------------|------------------------------------------------------------------------|
| <code>POR</code> | 1...255  | Load Velocity Proportional Term | Load velocity controller amplification.                                |
| <code>I</code>   | 1...255  | Load Velocity Integral Term     | Load velocity controller integral term.                                |
| <code>SR</code>  | 1...20   | Load Sampling Rate              | Load sampling rate of the velocity controller as a multiple of 200 µs. |

### 3.4.1.2 Velocity input

In LM motors the current velocity is determined in `CONTMOD` by evaluating the Hall sensor signals, which supply 3 000 pulses per magnetic pitch.

### 3.4.1.3 Additional settings

#### Movement limits

The `LL` command can also be used to define a movement range limit for velocity mode. The `APL1` command activates monitoring of these limits.

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

See chap. 3.8.1, p. 40.

#### Current limitation

The current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

See chap. 3.8.3, p. 44.

### 3.4.1.4 Motion control commands

An overview of all motion control commands is given in chap. 7.4, p. 85.

| Command         | Argument         | Function             | Description                                                                                  |
|-----------------|------------------|----------------------|----------------------------------------------------------------------------------------------|
| <code>EN</code> | –                | Enable Drive         | Activate drive.                                                                              |
| <code>DI</code> | –                | Disable Drive        | Deactivate drive.                                                                            |
| <code>V</code>  | –10 000...10 000 | Select Velocity Mode | Activate velocity mode and set specified value as target velocity (velocity control) [mm/s]. |

Example:

- Drive motor at 100 mm/s: `V100`

In order to change the direction, simply assign a negative velocity value (e.g. `V-100`).

- Stop motor: `V0`



Make sure that the maximum speed `SP` is not set below the desired target velocity.

## Functional description



### NOTICE!

Damage to the mechanical system due to too high target velocities (speeds).

- ▶ Due to the short stroke, use the speed controller with extreme caution.
- ▶ Define the positioning limits using the `APL1` command (default setting).

### 3.4.1.5 Complex motion profiles

Reaching the given speed is indicated by a "v", if "Notify Velocity" has been set before starting the speed mode and `ANSW1` or `ANSW2` is set:

| Command | Argument         | Function            | Description                                                            |
|---------|------------------|---------------------|------------------------------------------------------------------------|
| NV      | -10 000...10 000 | Notify Velocity     | A "v" is returned when the nominal speed is reached or passed through. |
| NVOFF   | -                | Notify Velocity Off | Velocity command that has not yet been triggered is deactivated again. |

### 3.4.2 Velocity presetting via an analogue voltage or a PWM signal (SOR1/SOR2)

In this operating mode, the drive velocity can be controlled with set value presetting via an analogue voltage (`SOR1`) or a PWM signal (`SOR2`).

#### 3.4.2.1 Basic settings

Operating mode `CONTMOD` and `SOR1` (AnIn) or `SOR2` (PWMin).

The controller parameters `POR`, `I` and the sampling rate can be adjusted for the velocity controller. In addition, commands are available for configuring the analogue velocity pre-setting.

| Command | Argument   | Function                        | Description                                                                                                                            |
|---------|------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| SP      | 0...10 000 | Load Maximum Speed              | Load maximum speed. Setting applies to all modes [mm/s].                                                                               |
| MV      | 0...10 000 | Minimum Velocity                | Presetting of minimum velocity for specification via analogue voltage ( <code>SOR1</code> , <code>SOR2</code> ) [ $\text{min}^{-1}$ ]. |
| MAV     | 0...10 000 | Minimum Analog Voltage          | Presetting of minimum start voltage for presetting speed via analogue voltage ( <code>SOR1</code> , <code>SOR2</code> ) [mV].          |
| ADL     | -          | Analog Direction Left           | Positive voltages at the analogue input result in left-hand movement of the cage bar ( <code>SOR1</code> , <code>SOR2</code> ).        |
| ADR     | -          | Analog Direction Right          | Positive voltages at the analogue input result in right-hand movement of the cage bar ( <code>SOR1</code> , <code>SOR2</code> ).       |
| DIRIN   | -          | Direction Input                 | Fault pin as direction input.                                                                                                          |
| POR     | 1...255    | Load Velocity Proportional Term | Load velocity controller amplification.                                                                                                |
| I       | 1...255    | Load Velocity Integral Term     | Load velocity controller integral term.                                                                                                |
| SR      | 1...20     | Load Sampling Rate              | Load sampling rate of the velocity controller as a multiple of 200 $\mu\text{s}$ .                                                     |

#### 3.4.2.2 Velocity input

By default, in LM motors the current speed is determined by evaluating the Hall sensor signals. Additional incremental encoders cannot be connected to motors for analogue velocity presetting (`SOR1`) or PWMin (`SOR2`).

## Functional description

### 3.4.2.3 Target value input

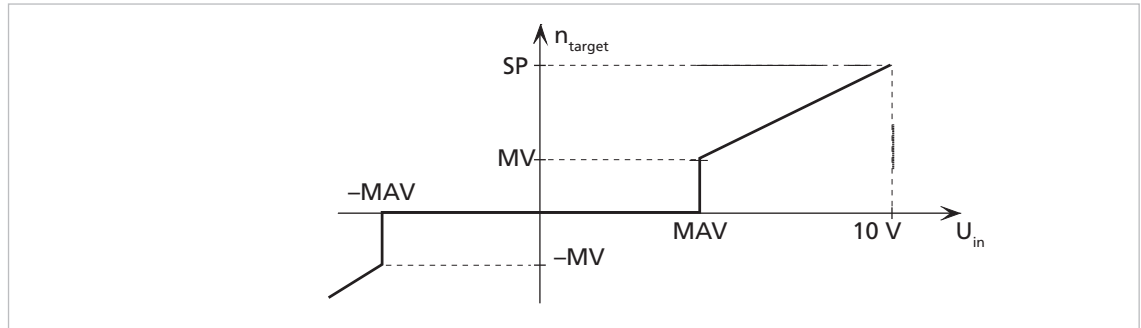


Fig. 5: Target value input

#### Example:

The drive is only to start moving with voltages over 100 mV or below –100 mV at the analogue input:

■ MAV100

#### Advantage:

As 0 mV is usually difficult to set at the analogue input, 0 mm/s is also not easy to implement. The dead band produced by the minimum start voltage prevents the motor from starting as a result of small interference voltages.

### 3.4.2.4 Additional settings

#### Movement limits

The **LL** command can also be used to define a movement range limit for velocity mode. The **APL1** command activates monitoring of these limits.

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the **AC**, **DEC** and **SP** commands.

See chap. 3.8.1, p. 40.

#### Current limitation

The current limitation values **LPC** and **LCC** can be used to protect the drive against overload.

See chap. 3.8.3, p. 44.

### 3.4.2.5 Set-point presetting via pulse width signal (PWM) at the analogue input (SOR2)

Tab. 3: Meaning of the pulse duty factor on delivery

| Pulse duty factor | Meaning |
|-------------------|---------|
| > 50%             | $v > 0$ |
| = 50%             | $v = 0$ |
| < 50%             | $v < 0$ |

The commands **SP**, **MV**, **MAV**, **ADL** and **ADR** can also be used here.



If **SOR2** is set in **APCMOD**, the pulse duty factor of a PWM signal can be used as velocity target.

## Functional description

### 3.4.2.6 Input circuit

The input circuit at the analogue input is designed as a differential amplifier. If the analogue input is open, an undefined velocity can be set. The input must be connected to AGND with low-impedance or set to the voltage level of the AGND, in order to generate 0 mm/s.

For a circuit example, see Technical Manual.

### 3.4.3 External encoder as actual velocity value (ENCMOD)

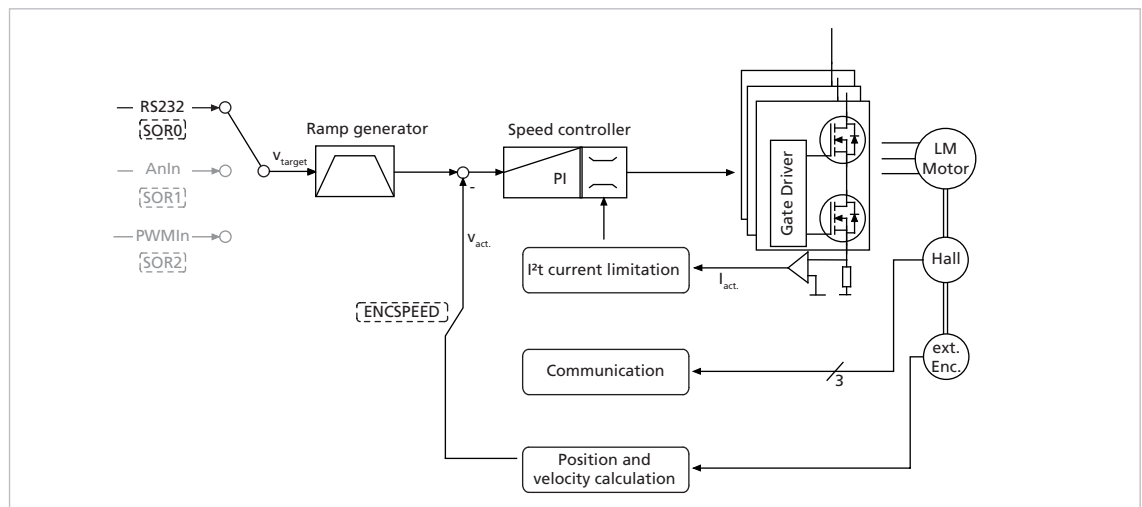


Fig. 6: Velocity control with external encoder as actual value

In this operating mode the drive can be operated by velocity controlled with set-point pre-setting via RS232 or from a sequence program. The velocity is evaluated via an additional encoder, external or built onto the motor. In particular, this enables a specific load speed to be controlled by an incremental encoder at the output.

The analogue Hall sensors of the motors are also evaluated in `ENCMOD` mode for the motor commutation.

### 3.4.3.1 Basic settings

Operating mode ENCMOD and SOR0.

The controller parameters `POR` and `I` and the sampling rate can be adjusted for the velocity controller.

| Command | Argument | Function                        | Description                                                                 |
|---------|----------|---------------------------------|-----------------------------------------------------------------------------|
| POR     | 1...255  | Load Velocity Proportional Term | Load velocity controller amplification.                                     |
| I       | 1...255  | Load Velocity Integral Term     | Load velocity controller integral term.                                     |
| SR      | 1...20   | Load Sampling Rate              | Load sampling rate of the velocity controller as a multiple of 200 $\mu$ s. |

## Functional description

### 3.4.3.2 Velocity input

The external incremental encoder's resolution must be specified with 4 edge evaluation using the `ENCRES` parameter.

In addition to `ENCMOD` mode, velocity evaluation on the basis of the encoder must be activated using the `ENCSPED` command.

| Command               | Argument   | Function                    | Description                                                                                                       |
|-----------------------|------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------|
| <code>ENCMOD</code>   | –          | Encoder Mode                | Change to encoder mode. An external encoder serves as position detector (the current position value is set to 0). |
| <code>ENCSPED</code>  | –          | Encoder As Speed Sensor     | Speed via encoder signals in encoder mode.                                                                        |
| <code>HALLSPED</code> | –          | Hall Sensor As Speed Sensor | Speed via Hall sensors in encoder mode.                                                                           |
| <code>ENCRES</code>   | 8...65 535 | Load Encoder Resolution     | Load resolution of external encoder [4 times pulse/mm].                                                           |

### 3.4.3.3 Additional settings

#### Movement limits

The `LL` command can also be used to define a movement range limit for velocity mode. The `APL1` command activates monitoring of these limits.

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

See chap. 3.8.1, p. 40.

#### Current limitation

The current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

See chap. 3.8.3, p. 44.

### 3.4.3.4 Motion control commands

An overview of all motion control commands is given in chap. 7.4, p. 85.

| Command         | Argument         | Function             | Description                                                                                  |
|-----------------|------------------|----------------------|----------------------------------------------------------------------------------------------|
| <code>EN</code> | –                | Enable Drive         | Activate drive.                                                                              |
| <code>DI</code> | –                | Disable Drive        | Deactivate drive.                                                                            |
| <code>V</code>  | –10 000...10 000 | Select Velocity Mode | Activate velocity mode and set specified value as target velocity (velocity control) [mm/s]. |

Example:

- Drive motor at 100 mm/s: `V100`

In order to change the direction, simply assign a negative velocity value (e.g. `V-100`).

- Stop motor: `V0`



Make sure that the maximum speed `SP` is not set below the desired target velocity.

## Functional description



### NOTICE!

**Damage to the mechanical system due to too high target velocities (speeds).**

- ▶ Due to the short stroke, use the speed controller with extreme caution.
- ▶ Define the positioning limits using the `APL1` command (default setting).

### 3.4.3.5 Complex motion profiles

Reaching the given speed is indicated by a "v", if "Notify Velocity" has been set before starting the speed mode and `ANSW1` or `ANSW2` is set:

| Command | Argument         | Function            | Description                                                            |
|---------|------------------|---------------------|------------------------------------------------------------------------|
| NV      | -10 000...10 000 | Notify Velocity     | A "v" is returned when the nominal speed is reached or passed through. |
| NVOFF   | -                | Notify Velocity Off | Velocity command that has not yet been triggered is deactivated again. |

## 3.5 Homing and limit switches

Homing on limit switches can be used to re-initialise the absolute position of an application after switching on.

After switching on, or by giving the `GOHOMSEQ` command, previously defined homing is performed up to the set limit switch and then the actions defined for it are performed. The ramp generator settings for maximum acceleration and the movement limits are taken into account.

### 3.5.1 Limit switch connections and switching level

The following connections can be used as reference and limit switch inputs:

- AnIn
- Fault
- 3<sup>rd</sup> input

In LM motors the zero crossing of the Hall sensor signals is also available as index pulse. The index pulse occurs once per magnetic pole pitch. The index pulse of an external encoder can also be connected to the fault pin, enabling the actual position to be exactly zeroed.

#### Digital input configuration

| Command | Argument | Function          | Description                                   |
|---------|----------|-------------------|-----------------------------------------------|
| SETPLC  | -        | Set PLC-Threshold | Digital inputs PLC-compatible (24 V level).   |
| SETTTL  | -        | Set TTL-Threshold | Digital inputs TTL-compatible (5 V level).    |
| REFIN   | -        | Reference Input   | Fault pin as reference or limit switch input. |

The limit switch functions for the fault pin are only accepted if `REFIN` is activated. The setting must be saved with `SAVE`.

## Functional description



### NOTICE!

#### Damage to the electronics

The electronics can be damaged if a voltage is applied to the fault pin while it is not configured as input.

- ▶ Configure the fault pin as input first before applying external voltage.

### 3.5.2 Motion control commands

The function of the inputs and the homing behaviour are set using the FAULHABER commands described in chap. 3.5.3, p. 27. A previously configured homing is then started with the following FAULHABER commands.

An overview of all motion control commands is given in chap. 7.4, p. 85.

| Command | Argument | Function                 | Description                                                                                                                                                                    |
|---------|----------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GOHOSEQ | –        | Go Homing Sequence       | Execute FAULHABER homing sequence. A homing sequence is executed (if programmed) irrespective of the current mode..                                                            |
| POHOSEQ | 0...1    | Power-On Homing Sequence | Start homing automatically after power-on: <ul style="list-style-type: none"> <li>▪ 0: No homing after power-on</li> <li>▪ 1: Power-On Homing Sequence is activated</li> </ul> |
| GOHIX   | –        | Go Hall Index            | LM motor to Hall zero point (Hall index) and set actual position value to 0.                                                                                                   |
| GOIX    | –        | Go Encoder Index         | Move to the encoder index at the Fault pin and set actual position value to 0.                                                                                                 |

If the drive is already located in the limit switch when `GOHOSEQ` is invoked, first of all it moves out of the switch, in the opposite direction to that specified for `HOSP`. The same applies to the Power On Homing Sequence (`POHOSEQ`).



Homing or index runs should start with an actual velocity close to 0 mm/s. If the actual velocity clearly differs from 0 mm/s when starting the homing or index run, it is not guaranteed that the set acceleration and deceleration ramp values are respected at the subsequent homing or index run.

### 3.5.3 Configuration of homing and limit switch inputs

The following commands use the following bit mask for configuration of the limit switch functions:

| Bit:   | 0              | 1         | 2         | 3 | 4 | 5 | 6 | 7 |
|--------|----------------|-----------|-----------|---|---|---|---|---|
| Input: | Analogue input | Fault-Pin | 3rd input | – | – | – | – | – |

- ▶ Set the bit at the position of the required input for each command and assign the resulting numeric value to the commands described below.

## Functional description

### 3.5.3.1 Polarity and limit switch function

Limit switches can respond to the rising or falling edge (or level).

In addition, the hard blocking function can be configured for the limit switches. The hard blocking function provides reliable protection against overshooting of the range limit switch. If the drive is located in an HB limit switch, then the direction of rotation set with **HD** will be blocked, i.e. the drive can only move further out of the limit switch.

The speed stays at 0 mm/s, if the target velocity is preset in the wrong direction.

| Command | Argument | Function       | Description                                                                                                                                                                                                                 |
|---------|----------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HP      | Bitmask  | Hard Polarity  | Define valid edge and polarity of respective limit switches: <ul style="list-style-type: none"> <li>1: Rising edge and high level effective</li> <li>0: Falling edge and low level effective</li> </ul>                     |
| HB      | Bitmask  | Hard Blocking  | Activate Hard Blocking function for relevant limit switch.                                                                                                                                                                  |
| HD      | Bitmask  | Hard Direction | Presetting of direction of rotation that is blocked with <b>HB</b> of respective limit switch: <ul style="list-style-type: none"> <li>1: Clockwise direction blocked</li> <li>0: Anticlockwise direction blocked</li> </ul> |

#### Example:

Setting of the Hard-Blocking function for Fault pin and 3<sup>rd</sup> input:

■  $2^1 + 2^2 = 2 + 4 = 6$ : HB6

### 3.5.3.2 Definition of homing behaviour

In order to be able to execute a homing sequence with the command **GOHOMSEQ** or as **POHOMSEQ**, a homing sequence must be defined for a specific limit switch. Definition of the hard blocking behaviour is an additional option.

| Command | Argument | Function                            | Description                                                                                            |
|---------|----------|-------------------------------------|--------------------------------------------------------------------------------------------------------|
| SHA     | Bitmask  | Set Home Arming for Homing Sequence | Homing behaviour ( <b>GOHOMSEQ</b> ):<br>Set position value to 0 at edge of respective limit switch.   |
| SHL     | Bitmask  | Set Hard Limit for Homing Sequence  | Homing behaviour ( <b>GOHOMSEQ</b> ):<br>Stop motor at edge of respective limit switch.                |
| SHN     | Bitmask  | Set Hard Notify for Homing Sequence | Homing behaviour ( <b>GOHOMSEQ</b> ):<br>Send a character to RS232 at edge of respective limit switch. |

These settings must be saved with **SAVE** so that they are available immediately after switching on.

## Functional description

### Example:

Homing with 3<sup>rd</sup> input as reference input (rising edge):

HP4 Low level or falling edge was evaluated at AnIn and at the fault pin.

The rising edge is evaluated at the 3<sup>rd</sup> input.

SHA4 Activate a homing sequence for 3<sup>rd</sup> input (all others are in bit mask = 0).

Action: Set Pos = 0 on reaching the limit switch.

SHL4 Activate a homing sequence for 3<sup>rd</sup> input (all others are in bit mask = 0).

Action: Stop motor

SHN4 Activate a homing sequence for 3<sup>rd</sup> input (all others are in bit mask = 0).

Action: Notify via RS232

### 3.5.3.3 Homing Speed

| Command | Argument         | Function          | Description                                                       |
|---------|------------------|-------------------|-------------------------------------------------------------------|
| HOSP    | -10 000...10 000 | Load Homing Speed | Load speed [mm/s] and direction for homing (GOHSEQ, GOHIX, GOIX). |

### Example:

Homing with 100 mm/s and negative direction:

■ HOSP-100

### 3.5.3.4 Direct programming via HA, HL and HN commands

These special commands can be used to define actions that are to be triggered at an edge of the relevant input, independently of a homing sequence. A programmed limit switch function will remain effective until the preselected edge occurs. The programming can be changed with a new command before an edge occurs.

| Command | Argument | Function    | Description                                                                                                    |
|---------|----------|-------------|----------------------------------------------------------------------------------------------------------------|
| HA      | Bitmask  | Home Arming | Set position value to 0 and delete relevant HA bit at edge of respective limit switch. Setting is not saved.   |
| HL      | Bitmask  | Hard Limit  | Stop motor and delete relevant HL bit at edge of respective limit switch. Setting is not saved.                |
| HN      | Bitmask  | Hard Notify | Send a character to RS232 and delete relevant HN bit at edge of respective limit switch. Setting is not saved. |

The settings are not saved with the SAVE command, therefore all configured limit switches are inactive again after power-on.

## Functional description

### HL/SHL command

- Positioning mode:

When the edge occurs, the motor positions itself on the reference mark with maximum acceleration.

- Velocity controller mode:

The motor is decelerated at the set acceleration value when the edge occurs, i.e. it goes beyond the reference mark. The reference mark can be precisely approached with a subsequent positioning command (command **M**).

Advantage: No abrupt motion changes.

### HN/SHN command

Hard Notify (**HN**) and Set Hard Notify (**SHN**) return values to the RS232 interface:

| Connection            | Return value |
|-----------------------|--------------|
| AnIn                  | h            |
| Fault                 | f            |
| 3 <sup>rd</sup> input | t            |

## Functional description

### 3.6 Enhanced operating modes

The `CONTMOD` command can be used to revert from an enhanced operating mode to normal mode.

#### 3.6.1 Stepper motor mode

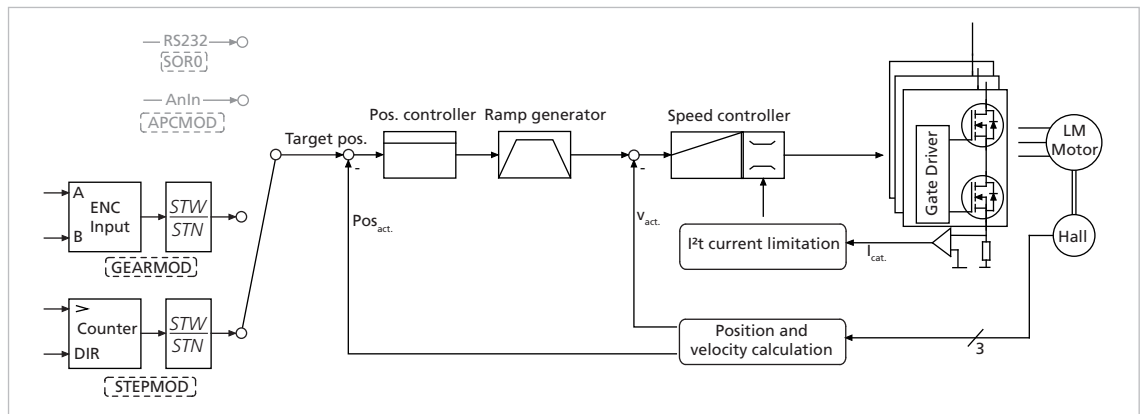


Fig. 7: Controller structure in stepper motor mode

In stepper motor mode the drive moves one programmable angle further for each pulse at the analogue input, and thus simulates the function of a stepper motor.

- The number of steps per magnetic pitch is freely programmable and of a very high resolution (encoder resolution)
- The individual step widths are freely programmable
- No detent force
- The full dynamics of the motor can be used
- The motor is very quiet
- The motor monitors actual position so that no steps are lost (even with maximum dynamics)
- No motor current flows in settled state (actual position reached)
- High efficiency

##### 3.6.1.1 Basic settings

In stepper motor mode, the analogue input acts as frequency input. The error output must be configured as direction input if the direction is to be changed via a digital signal.

Alternatively, the direction can also be preset via the commands `ADL` and `ADR`.

| Command | Argument | Function               | Description                                                                                         |
|---------|----------|------------------------|-----------------------------------------------------------------------------------------------------|
| STEPMOD | –        | Stepper Motor Mode     | Change to stepper motor mode.                                                                       |
| DIRIN   | –        | Direction Input        | Fault pin as direction input.                                                                       |
| ADL     | –        | Analog Direction Left  | Positive voltages at the analogue input result in left-hand movement of the cage bar (SOR1, SOR2).  |
| ADR     | –        | Analog Direction Right | Positive voltages at the analogue input result in right-hand movement of the cage bar (SOR1, SOR2). |

## Functional description

### 3.6.1.2 Input

Maximum input frequency: 400 kHz

Level: 5 V TTL or 24 V PLC-compatible, depending on configuration.

The number of steps of the emulated stepper motor can be set to virtually any required settings using the following formula:

$$\text{Traversing distance} = \text{pulses} \cdot \frac{\text{STW}}{\text{STN}} \cdot \tau_m$$

Traversing distance: traversing distance of the linear motor in mm

Pulses: number of pulses at the frequency input (= number of steps)

$\tau_m$ : magnetic pole pitch in mm

| Command | Argument   | Function         | Description                                                                   |
|---------|------------|------------------|-------------------------------------------------------------------------------|
| STW     | 1...65 535 | Load Step Width  | Load step width for step motor and gearing mode.                              |
| STN     | 1...65 535 | Load Step Number | Load number of steps per magnetic pole pitch for step motor and gearing mode. |

#### Example:

Motor should move 1/1000<sup>th</sup> of a magnetic pitch for each input pulse:

- STW1
- STN1000

### 3.6.1.3 Additional settings

#### Movement limits

With `APL1` the movement range limits set by `LL` are active in stepping mode too.

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the `AC`, `DEC` and `SP` commands.

#### Current limitation

The current limitation values `LPC` and `LCC` can be used to protect the drive against overload.

## Functional description

### 3.6.2 Gearing mode (electronic gear)

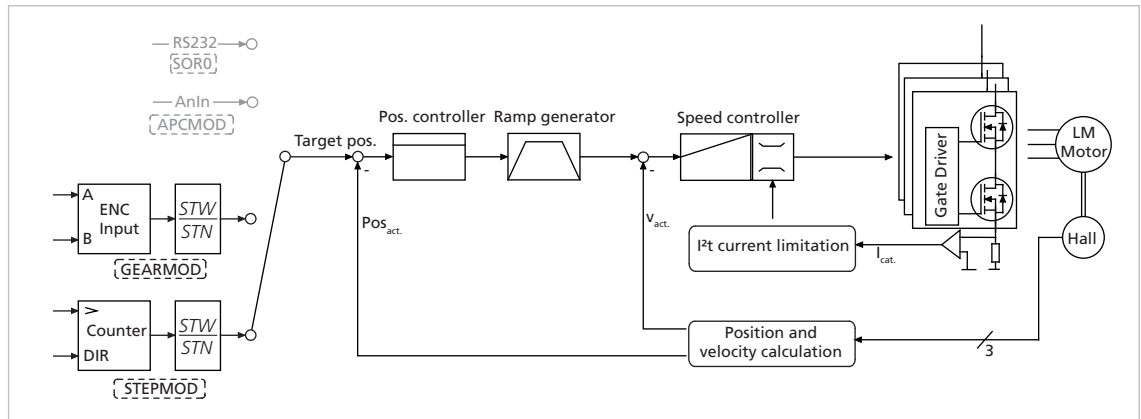


Fig. 8: Controller structure in gearing mode

Gearing mode enables the use of an external encoder as set-point source for the position. This enables several drives to be synchronised. If the direction is to be changed by a digital signal, the function of the fault pin must be reconfigured as a direction input.

Alternatively, the direction can be preset via the commands `ADL` and `ADR`.

#### 3.6.2.1 Basic settings

| Command | Argument | Function        | Description                   |
|---------|----------|-----------------|-------------------------------|
| GEARMOD | —        | Gearing Mode    | Change to gearing mode        |
| DIRIN   | —        | Direction Input | Fault pin as direction input. |

#### 3.6.2.2 Input

The two channels of an external encoder are connected to connections `AnIn` and `AGND` which may need to be connected to the 5 V encoder supply via a 2,7 kΩ pull-up resistor.

The gear ratio between the count of the external encoder and the resulting movement of the motor can be set using the following formula:

$$\text{Traversing distance} = \text{pulses} \cdot \frac{\text{STW}}{\text{STN}} \cdot \tau_m$$

Traversing distance: traversing distance of the linear motor in mm

Pulses: number of pulses at the frequency input (= number of steps)

$\tau_m$ : magnetic pole pitch in mm

| Command | Argument   | Function         | Description                                                                   |
|---------|------------|------------------|-------------------------------------------------------------------------------|
| STW     | 1...65 535 | Load Step Width  | Load step width for step motor and gearing mode.                              |
| STN     | 1...65 535 | Load Step Number | Load number of steps per magnetic pole pitch for step motor and gearing mode. |

#### Example:

Motor has to move one magnetic pitch at 1 000 pulses of the external encoder:

- STW1
- STN1000

## Functional description

### 3.6.2.3 Additional settings

#### Movement limits

With APL1 the movement range limits set by LL are active in Gearing Mode too.

#### Ramp generator

The slopes of the acceleration and deceleration ramps, and the maximum speed can be defined using the AC, DEC and SP commands.

See chap. 3.8.1, p. 40.

#### Current limitation

The current limitation values LPC and LCC can be used to protect the drive against over-load.

See chap. 3.8.3, p. 44.

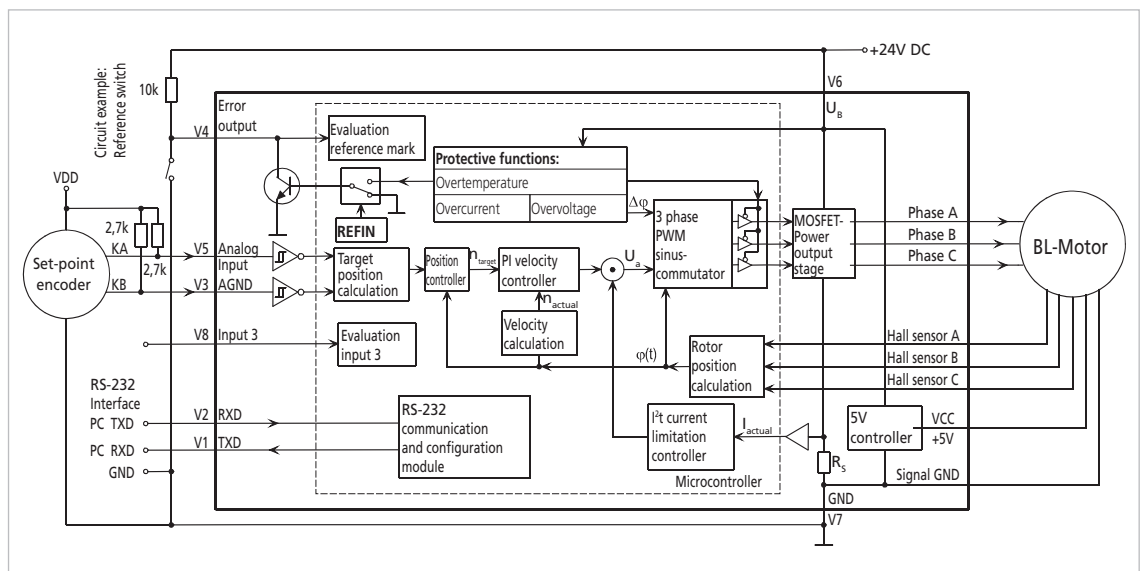


Fig. 9: Circuit example, gearing mode for MCLM 30xx and direction set via the fault pin

## Functional description

### 3.6.3 Voltage regulator mode

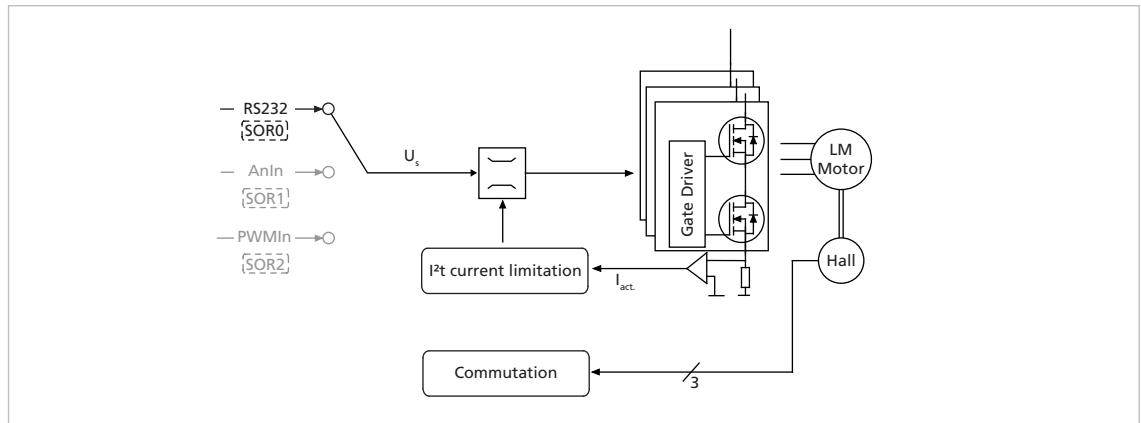


Fig. 10: Controller structure in voltage regulator mode

In voltage regulator mode a motor voltage is output proportional to the preset value. Current limitation remains active.

With this mode, it is possible to use a higher level controller. The controller then serves only as a power amplifier.

#### 3.6.3.1 Basic settings

| Command | Argument         | Function           | Description                                                                        |
|---------|------------------|--------------------|------------------------------------------------------------------------------------|
| VOLTMOD | –                | Set Voltage Mode   | Activate Voltage Regulator Mode.                                                   |
| U       | –32 767...32 767 | Set Output Voltage | Output motor voltage (corresponds to $-U_B \dots +U_B$ ) for SOR0 only in VOLTMOD. |

#### 3.6.3.2 Input

| SOR0 (RS232) | SOR1 (AnIn) | SOR2 (PWMIn) | $U_{MOT}$ |
|--------------|-------------|--------------|-----------|
| U-32767      | –10 V       | 0 %          | $-U_B$    |
| U0           | 0 V         | 50 %         | 0         |
| U32767       | 10 V        | 100 %        | $+U_B$    |

#### 3.6.3.3 Additional settings

The current limitation values  $LPC$  and  $LCC$  can be used to protect the drive against over-load.

## Functional description

### 3.6.4 Current control with analogue current presetting - fixed direction (SOR3)

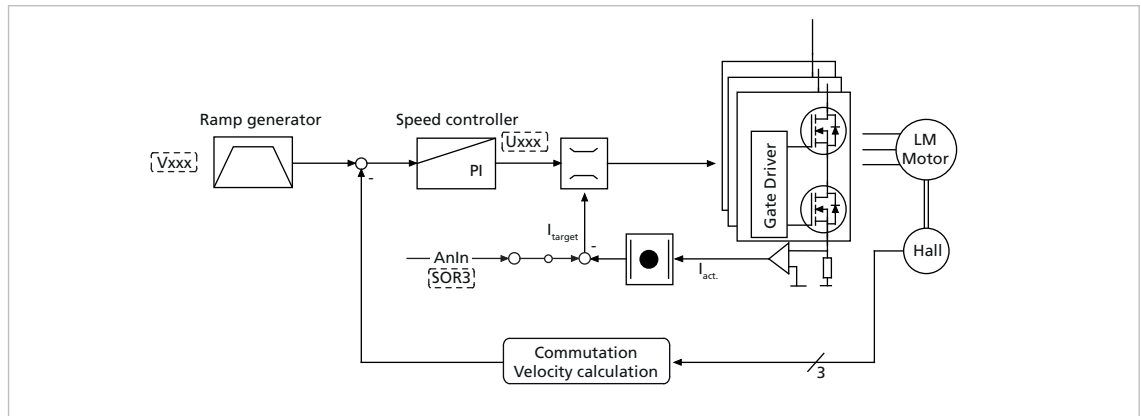


Fig. 11: Controller structure for analogue current presetting with fixed preset direction

You can switch to analogue target current presetting with the `SOR3` command. In this way, both in velocity mode and in voltage regulator mode, current amount can be limited proportional to the voltage at the analogue input. The set current is weighted with the maximum current `LPC`.

The motor is activated either in velocity mode by a previously fixed target velocity, or in voltage regulator mode via a voltage value. The error output must be configured as direction input if the direction is to be changed via a digital signal.

#### 3.6.4.1 Basic settings

| Command          | Argument                | Function                | Description                              |
|------------------|-------------------------|-------------------------|------------------------------------------|
| <code>SOR</code> | <code>3</code>          | Source For Velocity     | Current target value via analogue input. |
| <code>LPC</code> | <code>0...12 000</code> | Load Peak Current Limit | Load peak current [mA].                  |

#### 3.6.4.2 Input

If 10 V are present at the analogue input, the current is accordingly limited to the maximum current set with `LPC`.

Even if negative voltages are present at the analogue input, the current is limited to the amount of the applied voltage. Negative target current presettings therefore have no effect on the direction.

| <code>SOR3 (AnIn)</code> | $I_{max}$        | $n_{max}$       |
|--------------------------|------------------|-----------------|
| -10 V                    | <code>LPC</code> | <code>SP</code> |
| 0 V                      | 0                | <code>SP</code> |
| 10 V                     | <code>LPC</code> | <code>SP</code> |

The diagram illustrates a speed control system for an LM motor. It consists of the following components and signal flow:

- Ramp generator:** Generates a reference speed signal  $\{V_{xxx}\}$ .
- Speed controller:** A PI controller that receives the reference speed and the feedback speed. Its output is multiplied by a gain  $\{U_{xxx}\}$ .
- Gate Driver:** Receives the control signal and drives the LM Motor.
- LM Motor:** The motor being controlled, which provides mechanical output and feedback via a Hall sensor.
- Hall sensor:** Provides a feedback signal to the Commutation Velocity calculation block.
- Commutation Velocity calculation:** Processes the Hall sensor signal to calculate the actual speed  $I_{act}$ .
- Feedback loop:** The actual speed  $I_{act}$  is fed back to the Speed controller to adjust the motor's speed.

This mode corresponds to direct current control.

| Command | Argument   | Function                | Description                                                                        |
|---------|------------|-------------------------|------------------------------------------------------------------------------------|
| SOR     | 4          | Source For Velocity     | Target current value via analogue input with presetting of the via input polarity. |
| LPC     | 0...12 000 | Load Peak Current Limit | Load peak current [mA].                                                            |

| SOR4 (AnIn) | $I_{\max}$ | $n_{\max}$ |
|-------------|------------|------------|
| -10 V       | LPC        | -SP        |
| 0 V         | 0          | SP         |
| 10 V        | LPC        | SP         |

## Functional description

### 3.7 Fault pin as pulse output

The error connection (fault pin) can be configured as input or output for different tasks:

| Command | Argument | Function        | Description                                                                                                                                                                                                                                                                                                                                                                                              |
|---------|----------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ERROUT  | –        | Error Output    | Fault pin as error output.                                                                                                                                                                                                                                                                                                                                                                               |
| ENCOUT  | –        | Encoder Output  | Fault pin as pulse output.                                                                                                                                                                                                                                                                                                                                                                               |
| DIGOUT  | –        | Digital Output  | Fault pin as digital output. The output is set to low level.                                                                                                                                                                                                                                                                                                                                             |
| DIRIN   | –        | Direction Input | Fault pin as direction input. <ul style="list-style-type: none"> <li>▪ Velocity control (see chap. 3.4, p. 20)</li> <li>▪ Stepper motor mode (see chap. 3.6.1, p. 31)</li> <li>▪ Gearing Mode (see chap. 3.6.2, p. 33)</li> <li>▪ Voltage regulator mode (see chap. 3.6.3, p. 35)</li> <li>▪ Current control with analogue current presetting (see chap. 3.6.4, p. 36 and chap. 3.6.5, p. 37)</li> </ul> |
| REFIN   | –        | Reference Input | Fault pin as reference or limit switch input. <ul style="list-style-type: none"> <li>▪ Homing and limit switches (see chap. 3.5, p. 26)</li> </ul>                                                                                                                                                                                                                                                       |
| POSOUT  | –        | Position Output | Fault pin as digital output for display of the condition: "target position reached".                                                                                                                                                                                                                                                                                                                     |

#### 3.7.1 Fault pin as error output

In ERROUT mode the output is set as soon as one of the following errors occurs:

- One of the set current limitation values (LPC, LCC) is exceeded
- Set maximum permissible speed deviation (DEV) is exceeded
- Overvoltage detected
- Maximum coil or MOSFET temperature exceeded

#### 3.7.2 Additional settings

##### Delayed signalling

In order to hide the transient occurrence of errors during the acceleration phase, for example, an error delay can be set which specifies how long an error must be present before it is displayed at the error output:

| Command | Argument   | Function              | Description                                |
|---------|------------|-----------------------|--------------------------------------------|
| DCE     | 0...65 535 | Delayed Current Error | Delayed error output for ERROUT [1/100 s]. |

##### Example:

Wait 2 seconds before displaying error:

- DCE200

## Functional description

### Error notification via RS232

If one of the above errors occurs, automatic notification with an "r" can be implemented by setting "Notify Error", provided `ANSW1` or `ANSW2` is set:

| Command | Argument | Function     | Description                                                                                                                                                       |
|---------|----------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NE      | 0...1    | Notify Error | Notification in the event of errors: <ul style="list-style-type: none"> <li>1: An "r" is returned if an error occurs</li> <li>0: No error notification</li> </ul> |

### 3.7.3 Fault pin as pulse output

In the `ENCOUT` mode the fault pin is used as pulse output, which outputs an adjustable number of pulses per magnetic pitch. The pulses are derived from the Hall sensor signals of the LM motors and are limited to 4 000 pulses per second.

| Command | Argument | Function          | Description                                   |
|---------|----------|-------------------|-----------------------------------------------|
| LPN     | 1...255  | Load Pulse Number | Preset pulse number for <code>ENCOUT</code> . |

#### Example:

Output 16 pulses per magnetic pitch at the fault pin:

■ `LPN16`

At 100 mm/s,  $100 \cdot 16 = 1\,600$  pulses per second are generated at the fault pin.

**i** For speeds that would generate more than the maximum possible pulse number at the set LPN value, the maximum number is output. The set pulses are precisely achieved, but do not necessarily sync with the rotor position (delays possible).

Position determination via pulse counting is therefore possible, provided that no change occurs in the direction and the maximum possible pulse number is not exceeded.

### 3.7.4 Fault pin as digital output

In `DIGOUT` mode, the error connection can be used as universal digital output. The digital output can be set or cleared via the following commands:

| Command | Argument | Function      | Description                                           |
|---------|----------|---------------|-------------------------------------------------------|
| CO      | –        | Clear Output  | Set digital output <code>DIGOUT</code> to low level.  |
| SO      | –        | Set Output    | Set digital output <code>DIGOUT</code> to high level. |
| TO      | –        | Toggle Output | Switch digital output <code>DIGOUT</code> .           |

## Functional description

### 3.8 Technical information

#### 3.8.1 Ramp generator

In all modes, apart from voltage regulator mode and current control, the set-point is controlled by the ramp generator.

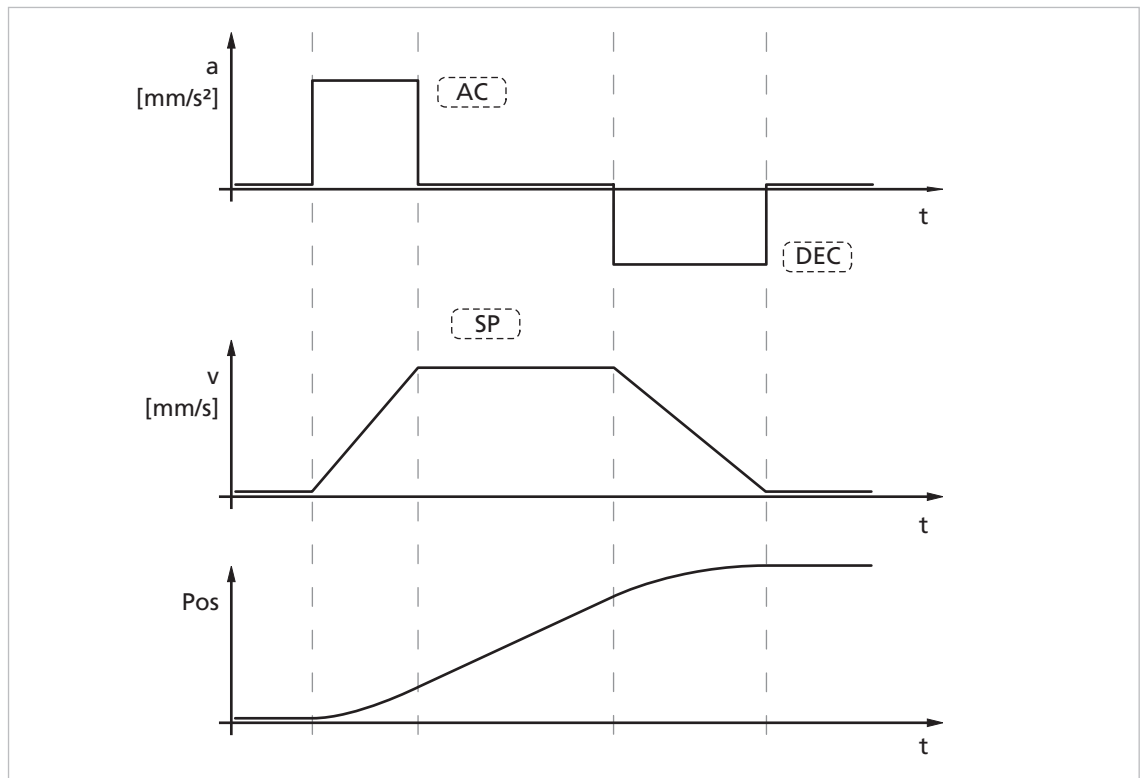


Fig. 13: Basic ramp generator function

This can be used to separately set the parameters for maximum acceleration (AC), maximum delay (DEC) and maximum speed (SP) for specific applications.



#### CAUTION!

##### Risk of injury by overshoot at maximum acceleration / delay

If the acceleration (AC) or delay (DEC) is set to the maximum value of 30 000 mm/s<sup>2</sup> or higher the effect of the ramp generator is switched off. With this setting, the maximum possible dynamic of the drive system is achieved. At this setting, at times the drive swings clearly beyond the target position.

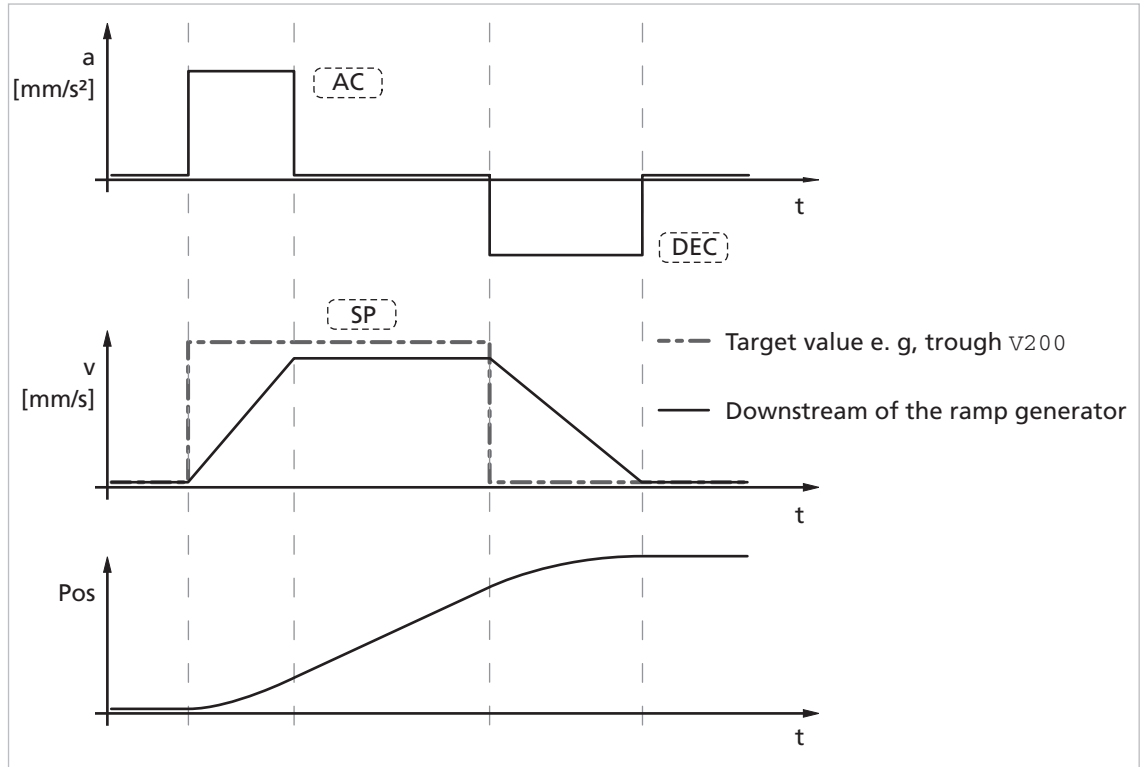
- ▶ Take into account this fact during use.

#### 3.8.1.1 Basic settings

| Command | Argument   | Function                  | Description                                              |
|---------|------------|---------------------------|----------------------------------------------------------|
| AC      | 0...30 000 | Load Command Acceleration | Load acceleration value [1/s <sup>2</sup> ].             |
| DEC     | 0...30 000 | Load Command Deceleration | Load deceleration value [1/s <sup>2</sup> ].             |
| SP      | 0...10 000 | Load Maximum Speed        | Load maximum speed. Setting applies to all modes [mm/s]. |

## Functional description

### 3.8.1.2 Ramp generator in velocity mode



*Fig. 14: Intervention of the ramp generator in velocity mode*

In velocity mode the ramp generator acts like a filter on the target velocity. The target value is limited to the maximum speed value (**SP**) and target value changes are limited according to the deceleration and acceleration ramps (**AC** and **DEC**).

#### **Notification of the higher level control**

Reaching the given speed is indicated by a "v", if "Notify Velocity" has been set before starting the speed mode and **ANSW1** or **ANSW2** is set.

## Functional description

### 3.8.1.3 Ramp generator in positioning mode

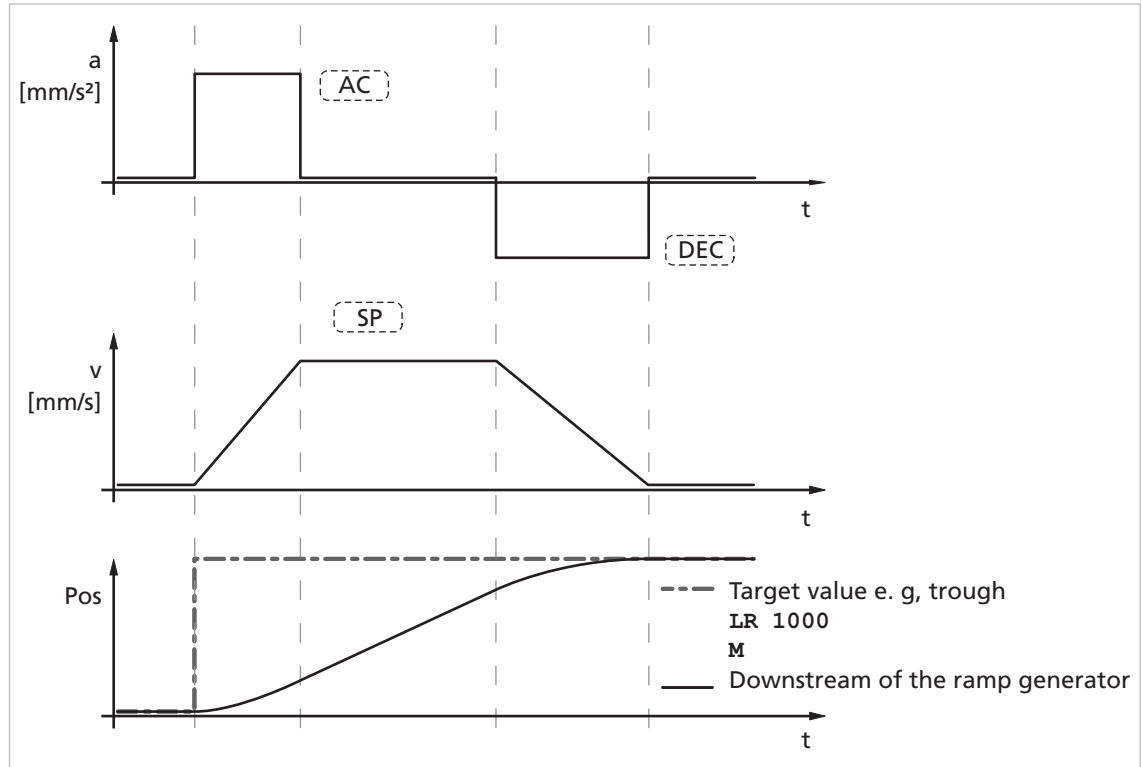


Fig. 15: Intervention of the ramp generator in positioning mode

In positioning mode a preset speed is determined by the position controller from the difference between the target position and actual position.

In the ramp generator, the preset speed output by the position controller is limited to the maximum speed value (SP) and accelerations are limited according to the acceleration ramp (AC).

In positioning mode the deceleration process is not extended as, before reaching the limit position, the speed has to be reduced so that the target position can be reached without overshooting.

According to the equation of motion:

$$2a \cdot s = v^2 \rightarrow v_{\max} = \sqrt{2a \cdot s}$$

a: acceleration [m/s²]

v: velocity [m/s]

s: remaining distance [m]

the maximum speed  $v_{\max}$  must be limited proportional to the remaining distance.

The allowable deceleration ramp, or rather the technically possible ramp depending on the motor and the inertia of the load, is set here using the parameter DEC.

#### Notification of the higher level control

Attainment of the target position or any intermediate position is indicated by a "p" on the serial interface if "Notify Position" is set before the start of positioning, provided that ANSW1 or ANSW2 is set.

## Functional description

### 3.8.1.4 Complex motion profiles

More complex motion profiles can be generated through appropriate presetting of new values (maximum speed, acceleration, end position) during positioning.

After a value change, simply execute a new motion start command (M). The commands NP and NV can be used to control the sequence.

The complex profile can be generated either by a higher level control or autonomously via a sequence program. Notes on design of the sequence programs are given in chap. 6, p. 68.

| Command | Argument         | Function            | Description                                                                                                                                                                                                        |
|---------|------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NP      | –                | Notify Position     | <ul style="list-style-type: none"> <li>Without argument: A "p" is returned when the target position is attained.</li> <li>With argument: A "p" is returned if the specified position is over-travelled.</li> </ul> |
| NPOFF   | –                | Notify Position Off | Notify Position command that has not yet been triggered is deactivated again.                                                                                                                                      |
| NV      | –10 000...10 000 | Notify Velocity     | A "v" is returned when the nominal speed is reached or passed through.                                                                                                                                             |
| NVOFF   | –                | Notify Velocity Off | Velocity command that has not yet been triggered is deactivated again.                                                                                                                                             |

#### Example:

Complex speed profile with notify by the drive:

| Start    | Update a) | Update b) | Update c) | Update d) |
|----------|-----------|-----------|-----------|-----------|
| LA[POS3] | AC[AC2]   | AC[AC1]   | SP[SP2]   | DEC[DEC4] |
| AC[AC1]  | NV[V2]    | NP[POS1]  | DEC[DEC3] | NP[POS3]  |
| SP[SP1]  | M         | M         | NP[POS2]  | M         |
| NV[NV1]  | M         |           |           |           |
| M        |           |           |           |           |

Drive response:

| V = V1 | V = V2 | POS = POS1 | POS = POS2 | POS = POS3 |
|--------|--------|------------|------------|------------|
| v      | v      | p          | p          | p          |

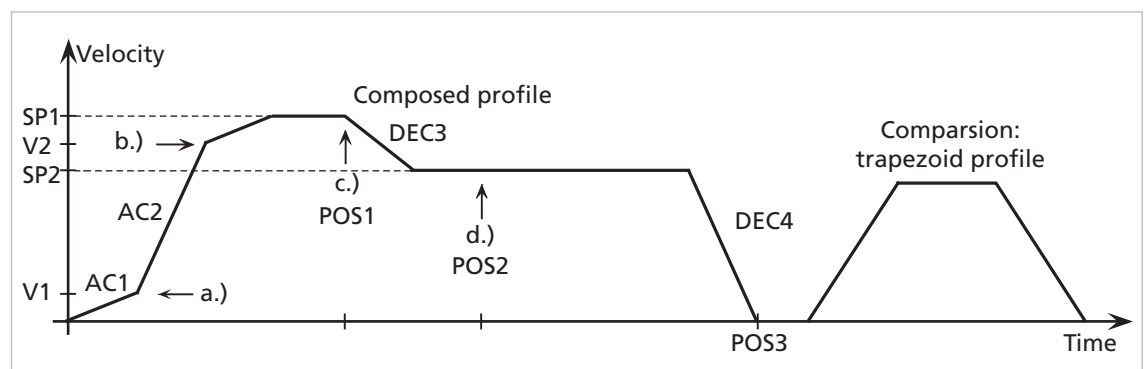


Fig. 16: Example of complex motion profile in comparison with trapezoidal profile

## Functional description

### 3.8.2 Sinus commutation

The outstanding feature of FAULHABER motion controllers for linear motors is their so-called sinus commutation. This means that the preset magnetic field is always ideally positioned relative to the cage bar. As a result, force fluctuations can be reduced to a minimum, even at very low speeds. In addition, the motor runs particularly quietly.

The sinus commutation is further enhanced by so-called flat-top modulation, which enables more modulation. As a result, higher no-load speeds are possible..

The `SIN0` command can even be used to set the system so that the sinus commutation switches to block commutation in the upper speed range. This full modulation enables the complete speed range of the motor to be utilised.

| Command          | Argument           | Function          | Description                                                                                                                                 |
|------------------|--------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <code>SIN</code> | <code>0...1</code> | Sinus Commutation | 1: No block commutation within the upper velocity range (default)<br>0: Block commutation within the upper velocity range (full modulation) |

### 3.8.3 Current controller and $I^2t$ current limitation

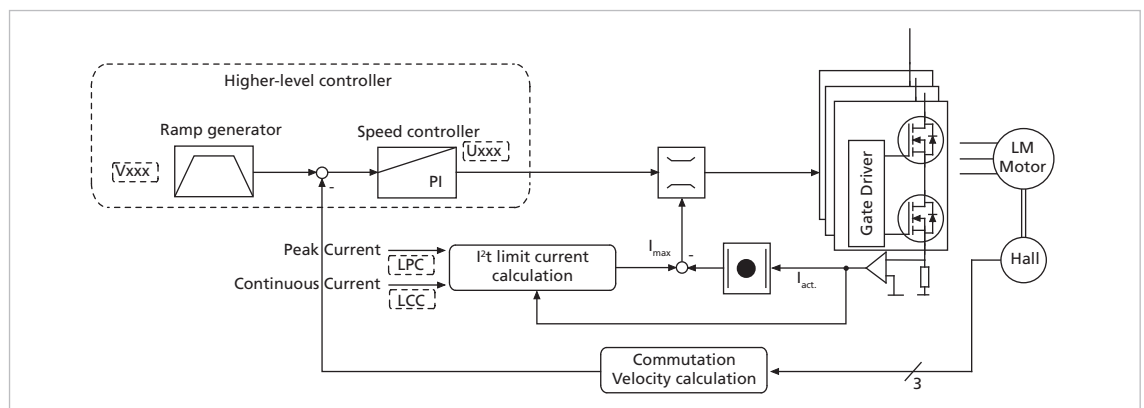


Fig. 17: Intervention of the current limiting controller

The FAULHABER Motion Controllers are equipped with an integral current controller, which enables force limitation.

The current controller operates as a limitation controller. Depending on the previous loading, the  $I^2t$  current limitation limits to the allowable peak current or continuous current. As soon as the motor current exceeds the currently allowed maximum value the current controller limits the voltage.

Due to its design as a current limiting controller, current control in the thermally relaxed state has no effect on the dynamic of the velocity control. The time response of this limitation can be adjusted using the parameter `CI`.

The default values for `CI` limit the current to the allowable value after around 5 ms.

## Functional description

### 3.8.3.1 Basic settings

| Command | Argument   | Function                      | Description                                |
|---------|------------|-------------------------------|--------------------------------------------|
| LPC     | 0...12 000 | Load Peak Current Limit       | Load peak current [mA].                    |
| LCC     | 0...12 000 | Load Continuous Current Limit | Load continuous current [mA].              |
| CI      | 1...255    | Load Current Integral Term    | Load integral term for current controller. |

### 3.8.3.2 Mode of operation of the current controller

When the motor starts, the peak current is preset as the set-point for the current controller. As the load increases, the current in the motor constantly increases until it finally reaches the peak current. The current controller then comes into operation and limits the current to this set-point.

A thermal current model operating in parallel calculates a model temperature from the actually flowing current. If this model temperature exceeds a critical value, continuous current is switched to and the motor current is regulated to this. Only when the load becomes so small that the temperature falls below the critical model temperature is peak current permitted again.

The aim of this so-called  $I^2t$  current limiting is not to heat the motor above the thermally allowable temperature by selecting a suitable continuous current. On the other hand, a high load should be temporarily possible in order to enable very dynamic movements.

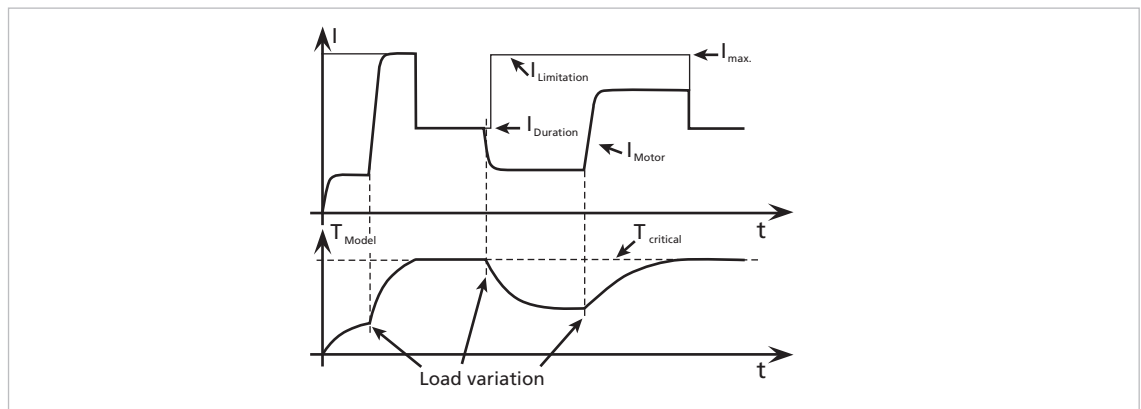


Fig. 18: Function of the  $I^2t$  current limitation

### 3.8.4 Overtemperature protection

If the MOSFET temperature of the external controllers or the coil temperature of the drives with integrated controller exceeds a preset limit value, the motor is switched off.

The following conditions must be fulfilled in order to reactivate the motor:

- Temperature below a preset limit value
- Target velocity set to 0 mm/s
- Actual motor speed < 50 mm/s

**i** When determining the MOSFET temperature, the housing temperature is measured and the power loss concluded from the current measurement. The MOSFET or coil temperature is calculated from these values via a thermal model. In most applications, this method represents a thermal motor protection device.

## Functional description

### 3.8.5 Under-voltage monitoring

If the supply voltage falls below the lower voltage threshold, the power stage is switched off. The Motion Controller remains active. When the voltage returns within the permissible range, the power stage is switched on again immediately.

### 3.8.6 Overvoltage regulation

If the motor is operated as a generator, it produces energy. Usually power supply units are not able to feed this energy back into the power line. For this reason, the supply voltage at the motor increases, and depending on the speed, the allowable maximum voltage may be exceeded.

In order to avoid irreparable damage to components, FAULHABER motion controllers for motors contain a controller which adjusts the displacement angle if a limit voltage (32 V) is exceeded. As a result, the energy generated in the motor is converted, and the voltage of the electronics remains limited to 32 V. This method protects the drive during generating operation and rapid braking.

### 3.8.7 Setting the controller parameters

The preset controller parameters must be optimised in order to optimally adjust the controller to the respective application.

 The digital controller operates at a sampling rate according to the data sheet. If necessary the sampling rate can be increased to the given multiple of the basic controller sampling rate via `SR`.

#### Default behaviour

Without further settings, the gain set in the parameter `POR` is effective for the speed controller.

In positioning mode the gain set via the parameter `POR` is increased within the target corridor by the value of the parameter `PD`. This enables faster adjustment to the stoppage in the target position without having to over-stimulate the controller during the transient phenomena. To this end, the parameter `PD` must be set carefully and should typically be a maximum of 50% of the base value `POR`. Otherwise there is a risk of instability.

#### Available controller parameters

| Command          | Argument | Function                        | Description                                                            |
|------------------|----------|---------------------------------|------------------------------------------------------------------------|
| <code>POR</code> | 1...255  | Load Velocity Proportional Term | Load velocity controller amplification.                                |
| <code>I</code>   | 1...255  | Load Velocity Integral Term     | Load velocity controller integral term.                                |
| <code>PP</code>  | 1...255  | Load Position Proportional Term | Load position controller amplification.                                |
| <code>PD</code>  | 1...255  | Load Position Differential Term | Load position controller D-term.                                       |
| <code>SR</code>  | 1...20   | Load Sampling Rate              | Load sampling rate of the velocity controller as a multiple of 200 µs. |

These values are suitably preassigned by selecting a motor type in the Motion Manager's Motor Wizard.

The **Controller tuning** tool can be used to further adjust several controller parameters, in order to optimally adjust the controller to the respective application.

## Functional description

### Possible procedure

1. Perform the default settings of the Motor Wizard.
3. Optimise position controller:
  - Specify appropriate motion profiles for the application using the **Controller tuning** tool.
  - If the system does not function stably with these settings, stability can be achieved by reducing the I term of the velocity controller or reducing the P term of the position controller.
  - Increase the P term of the position controller gradually up to the system's stability limit.
  - Restore the stability either by increasing the D term of the position controller or by reducing the I term of the velocity controller.

### 3.8.8 Special mode for position control

The `SR` command can be used to activate a special position control mode. To this end, the value 100 must be added to the required `SR` setting.

#### Example:

Required setting `SR10` with special mode:

- `SR110`

If this mode is activated, the parameter `POR` is successively reduced in a position-controlled application as soon as the drive is within the target corridor (can be set using the `CORRIDOR` command). This enables a much "gentler" stoppage to be achieved after reaching the target position. As soon as the drive is removed from the set target position, `POR` is immediately increased again to the set value.

-  The *Gain scheduling* function only becomes active at sampling rates with a factor larger than 3 (sampling rate > 3).

## Protocol description

### 4 Protocol description

An extensive set of ASCII commands is available for configuring and operating FAULHABER Motion Controllers. The structure of the command telegrams is described in the following.

 The drive can also be operated independently of the RS232 interface if the desired function, such as velocity or position controller, has been previously programmed via analogue input, stepper motor or electronic gear.

#### 4.1 Command frame

Structure of the ASCII commands:

|               |         |            |    |
|---------------|---------|------------|----|
| [Node number] | Command | [Argument] | CR |
|---------------|---------|------------|----|

- The node number is optional and is only required if several drives are being operated on one interface.
- The command consists of a letter character string.
- The optional argument consists of an ASCII numeric value.
- The end is always a CR character (Carriage Return, ASCII decimal code 13). Space characters are ignored, and no distinction is made between upper and lower case.

#### 4.2 Response frame

The response to query commands or asynchronous events is also an ASCII character string, followed by a CR character (Carriage Return, ASCII decimal code 13) and an LF character (Line Feed, ASCII decimal code 10).

|          |    |    |
|----------|----|----|
| Response | CR | LF |
|----------|----|----|

 The response frames do not contain a node number.

In bus mode you must therefore ensure that the response of the contacted node is received before a new command is sent.

Example: Actual position query

- Transmit: POS [CR]
- Receive: 98956 [CR] [LF]

Example: Drive nodes at 500 mm/s

- Transmit: V500 [CR]

## Protocol description

### Response behaviour settings

As a default, the send commands are not acknowledged. However, the `ANSW` command can be used to change the response behaviour:

| Command | Argument | Function    | Description                                                                                                                                                                                                                                                                                                                                                                   |
|---------|----------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSW    | 0...7    | Answer Mode | 0: No asynchronous responses<br>1: Allow asynchronous responses<br>2: All commands with confirmation and asynchronous responses<br>3: Debug mode, sent commands are returned (cannot be used if configuring with Motion Manager)<br>4...7: analogous to 0...3, but responses resulting from a command in the sequence program are not sent (cannot be set via Motion Manager) |

Possible answers to a pure send command if `ANSW2` is set:

- OK, when the command has been successfully executed
- Unknown command
- Invalid parameter
- Command not available
- Overtemperature - drive disabled

Example:

- Transmit: `V500[CR]`
- Receive: `OK[CR][LF]`

Possible answers to `SAVE` and `EEPSAV` commands:

- EEPROM writing done, after successful saving of the current settings in the data Flash memory
- Flash defect, if the save has failed

 If data is sent simultaneously by several devices, communication disturbance (interference) occurs.

- Do **not** send unaddressed query commands in network mode (see chap. 4.3.2, p. 51), as otherwise all units will answer simultaneously and the message frames will mix.
- Make sure that asynchronous (sporadic) responses are **not** sent simultaneously by several devices.
- Switch off command acknowledgement if using unaddressed send commands.

Example: debug mode

- Activate debug mode: `ANSW3`
- Transmit: `V100`
- Receive: `v,100: OK`

## Protocol description

### 4.3 Pre-conditions for communication

The units are delivered as standard without a valid node address (NODEADR0) and with a transfer rate of 9 600 baud. The settings can be changed via the interface, e.g. with the FAULHABER Motion Manager (see chap. 2.3, p. 10).

A change of the node number and Baud rate is acknowledged with the last setting for the node number and Baud rate.

#### 4.3.1 Operation of an individual Motion Controller

1. Establish a connection with a host interface (typically a PC or PLC).
    - Connect the Tx data cable on the host side with the Rx pin of the drive
    - Connect the Rx data cable on the host side with the Tx pin of the drive (null modem cable)
  2. Configure the host interface to match the drive settings (see chap. 4.4, p. 51):
    - The same Baud rate
    - 8 data bits, no parity, 1 stop bit, no flow control
  3. Switch on the Motion Controller.
-  Communication will be established. The drive will report a boot-up message at the last Baud rate setting.

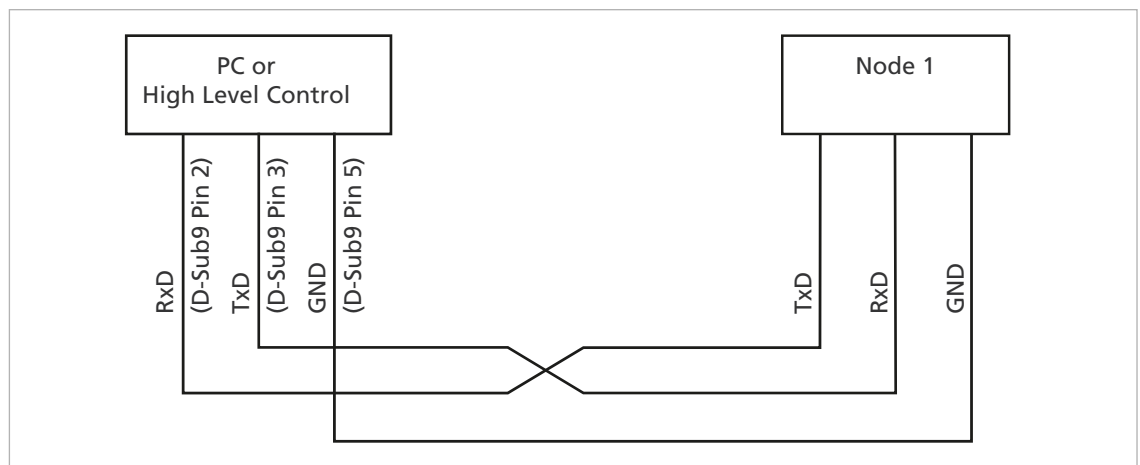


Fig. 19: Wiring between PC/controller and a drive

## Protocol description

### 4.3.2 RS232 network operation

Multiple Motion Controllers can be operated on a single RS232 host interface.

- ▶ Connect the Tx cables and Rx cables to the controller in parallel.

**i** When they are in network operation the drives may not send any asynchronous messages, because these can interfere with communications with another drive. Asynchronous responses can be deactivated via `ANSW0`.

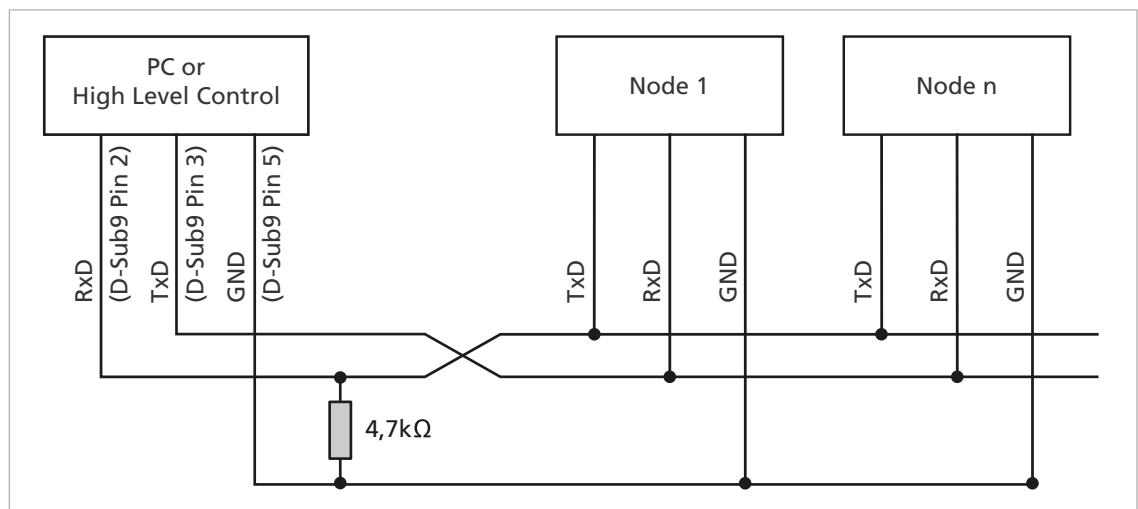


Fig. 20: Wiring with several Motion Control systems in RS232 network operation

## 4.4 Communication settings

### Baud rate

The following RS232 transfer rates can be set:

| Command | Argument                                                                                                                                                                           | Function         | Description                       |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------|
| BAUD    | 600 Bit/s (not supported by Motion Manager)<br>1 200 bit/s<br>2 400 bit/s<br>4 800 bit/s<br>9 600 bit/s (default)<br>19 200 bit/s<br>38 400 bit/s<br>57 600 bit/s<br>115 200 bit/s | Select baud rate | Transfer rate for RS232 interface |

The baud rate can be set via the interface using the `BAUD` command, if a connection already exists with the drive node.

Example: `BAUD 19200`

## Protocol description

### Serial network and node number

The node numbers 1 to 255 can be set.

To prepare the units for network operation, they must be individually connected to the PC and set to the required node address, e.g. with help of the FAULHABER Motion Manager. In order to address the individual drives in the network, the node number must be specified before each ASCII command to be sent.

Example: 3V100

Commands without a node number are adopted by all drive nodes in the network (Broadcast).

| Command | Argument | Function            | Description                                                                                                                                 |
|---------|----------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| NODEADR | 0...255  | Define Node Address | Set node number.                                                                                                                            |
| NET     | 0...1    | Set Network Mode    | Activate RS232 multiplex mode for network operation.<br>0: No network operation, single drive on an RS232<br>1: Network operation activated |

Example: Set drive unit to node number 3

NODEADR3

Example: Activate network operation

NET1

## Protocol description

### 4.5 Trace

An efficient trace function is available via an additional binary interface. This allows up to 2 values to be read out online in a resolution of up to 3 ms.

In order to be able to use the binary interface, it must first have been opened for the desired node with the `BINSEND1` command.

| Command | Argument | Function              | Description                                           |
|---------|----------|-----------------------|-------------------------------------------------------|
| BINSEND | 0...1    | Open Binary Interface | 1: Open binary interface<br>0: Close binary interface |



The FAULHABER Motion Manager provides a user-friendly means of setting and evaluating the trace functions.

#### 4.5.1 Configuring Trace

- ▶ Set the binary transmit mode for parameter 1/2 (curve 1/2).

2 binary characters are sent in direct success: [Command][Mode1/2]

The relevant value is switched to, depending on the value of Mode1/2:

| Command | Function                                 |
|---------|------------------------------------------|
| 200     | Set binary transmit mode for parameter 1 |
| 202     | Set binary transmit mode for parameter 2 |

| Mode1/2 | Parameter                                                            | Type       | Unit |
|---------|----------------------------------------------------------------------|------------|------|
| 0       | Actual velocity                                                      | Integer16  | mm/s |
| 1       | Target velocity                                                      | Integer16  | mm/s |
| 2       | Controller output                                                    | Integer16  | –    |
| 4       | Motor current                                                        | Integer16  | mA   |
| 44      | Housing temperature                                                  | Unsigned16 | °C   |
| 46      | Coil temperature                                                     | Unsigned16 | °C   |
| 200     | Current position                                                     | Integer32  | Inc  |
| 201     | Target position                                                      | Integer32  | Inc  |
| 255     | Mode2 only: No second parameter is sent (basic setting for power-on) | –          | –    |

## Protocol description

### 4.5.2 Requesting data

Following a mode adjustment with the 200 or 202 command it is necessary to wait for at least 2 ms before requesting valid data.

- ▶ Request a data package with 201.

↳ Depending on the set mode 3, 5, 7 or 9 bytes are sent back to the PC:

| Mode1     | Mode2     | Number of bytes | Received data                                                                                                                          | Type                     |
|-----------|-----------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 0...15    | 255       | 3               | 1. Byte: Low byte data<br>2. Byte: High byte data<br>3. Byte: Time code                                                                | Integer16                |
| 16...199  | 255       | 3               | 1. Byte: Low byte data<br>2. Byte: High byte data<br>3. Byte: Time code                                                                | Unsigned16               |
| 200...255 | 255       | 5               | 1. Byte: Lowest byte data<br>2. Byte: Second byte data<br>3. Byte: Third byte data<br>4. Byte: Highest byte data<br>5. Byte: Time code | Integer32                |
| 0...15    | 0...15    | 5               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...4.Byte: Data bytes of Mode2<br>5. Byte: Time code                                     | Integer16<br>Integer16   |
| 0...15    | 16...199  | 5               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...4.Byte: Data bytes of Mode2<br>5. Byte: Time code                                     | Integer16<br>Unsigned16  |
| 0...15    | 200...255 | 7               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...6.Byte: Data bytes of Mode2<br>7. Byte: Time code                                     | Integer16<br>Integer32   |
| 16...199  | 0...15    | 5               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...4.Byte: Data bytes of Mode2<br>5. Byte: Time code                                     | Integer16<br>Integer16   |
| 16...199  | 16...199  | 5               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...4.Byte: Data bytes of Mode2<br>5. Byte: Time code                                     | Unsigned16<br>Unsigned16 |
| 16...199  | 200...255 | 7               | 1.Byte...2.Byte: Data bytes of Mode1<br>3.Byte...6.Byte: Data bytes of Mode2<br>7. Byte: Time code                                     | Unsigned16<br>Integer32  |
| 200...255 | 0...15    | 7               | 1.Byte...4.Byte: Data bytes of Mode1<br>5.Byte...6.Byte: Data bytes of Mode2<br>7. Byte: Time code                                     | Integer32<br>Integer16   |
| 200...255 | 16...199  | 7               | 1.Byte...4.Byte: Data bytes of Mode1<br>5.Byte...6.Byte: Data bytes of Mode2<br>7. Byte: Time code                                     | Integer32<br>Unsigned16  |
| 200...255 | 200...255 | 9               | 1.Byte...4.Byte: Data bytes of Mode1<br>5.Byte...8.Byte: Data bytes of Mode2<br>9. Byte: Time code                                     | Integer32<br>Integer32   |

## Protocol description

---

The time code corresponds to a multiple of the time basis of 1 ms and defines the time interval to the last transmission.

## Commissioning

### 5 Commissioning

The drive unit must be connected to a PC via the RS232 interface in order to make the basic settings for commissioning.



Connection of the RS232 interface is described in the technical manual. For the communication setup, the same transfer rate must be set for all nodes.

#### 5.1 Basic settings

In the case of external motion controllers, several basic settings have to be made during the initial start-up to adjust the controller to the connected motor.

If drive units are integrated, these basic settings are made in the factory. It is only necessary to adjust to the respective application.



##### NOTICE!

##### Damage to components

- ▶ Perform the basic settings described in the following.

The following basic settings must be made for external motion controllers:

- Motor type or motor data (**KN**, **RM**) of the connected motor
- Resolution of an external encoder (**ENCRES**), if used
- Current limitation values (**LCC**, **LPC**), adjusted to the motor type and application
- Controller parameters (**POR**, **I**, **PP**, **PD**), adjusted to the motor type and application

In addition, FAULHABER Motion Manager can be used to synchronise the Hall sensor signals for smooth start-up and optimisation of the phase angle for the best efficiency.

The configuration must then be adjusted to the respective application for all motion controllers (integrated and external). In particular, the following basic settings are important:

- Operating mode
- Current limiting values
- Controller parameters
- Function of the digital inputs/outputs



##### NOTICE!

##### Damage to components

- ▶ If using the Fault Pin as input (**REFIN**, **DIRIN**) program the desired function before applying external voltage.

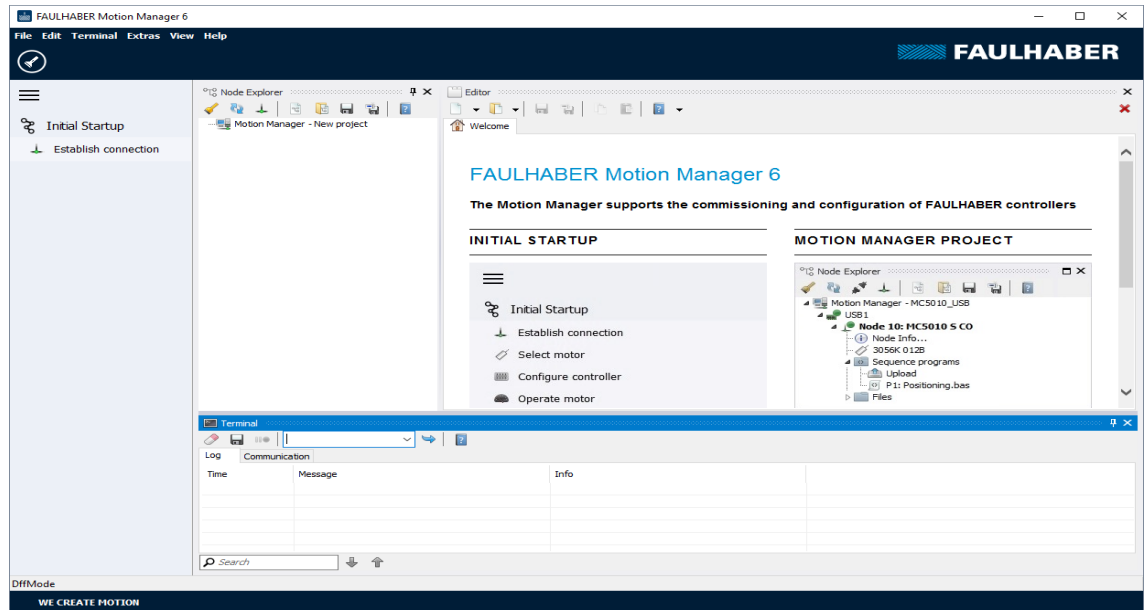
Configuration of these parameters with the help of the FAULHABER Motion Manager is explained in greater detail in the following chapter.

## Commissioning

### 5.2 Configuration using Motion Manager

FAULHABER Motion Manager PC software provides a simple option for configuring the drive unit and for performing initial tests and optimisation.

The software is available for Microsoft Windows and can be downloaded free of charge from the FAULHABER internet site: [www.faulhaber.com](http://www.faulhaber.com).



Motion control systems with electronics built onto the motor are already pre-parameterised in the factory.

Motion controllers with an externally connected motor must be equipped with current limitation values suitable for the motor and suitable controller parameters before being started up.

The motor selection wizard is available for selecting the motor and the suitable basic parameters.

Other settings, e.g. for the function of the fault pin, can be made under the **Configuration – Drive Functions** menu item, where a convenient dialog is provided (see chap. 5.2.3, p. 60). The configuration dialog is also available for direct access in the quick access bar of the Motion Manager.

The tool **Controller tuning**, with which the controller parameters of the speed and positioning controller can be adjusted to the application, is also provided.

## Commissioning

### 5.2.1 Establish connection

In order to communicate with the control in question, a connection with the control must be established by the PC on which the Motion Manager is installed. A wizard is available for setting up the communication connection via a one of the supported interfaces. The wizard appears automatically when a new project is created. It can be called up at any time by pressing the **Establish connection** button in the quick access toolbar or via the **Terminal** menu.

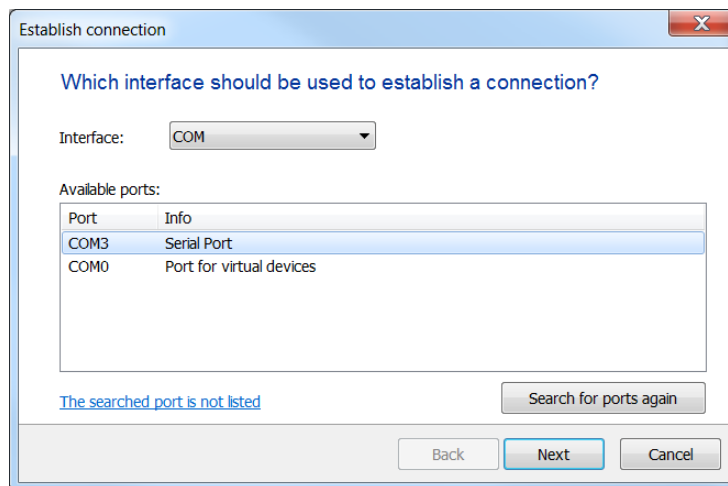


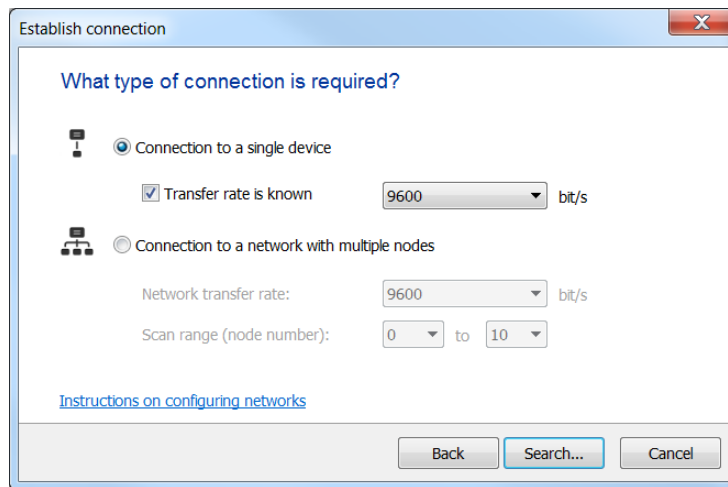
Fig. 21: Connection wizard

1. Select the COM interface.
2. Under **Available ports** select the desired interface connection.
3. Press **Next** button.



4. Select device family **Motion Controller V2.x**.
5. Press **Next** button.

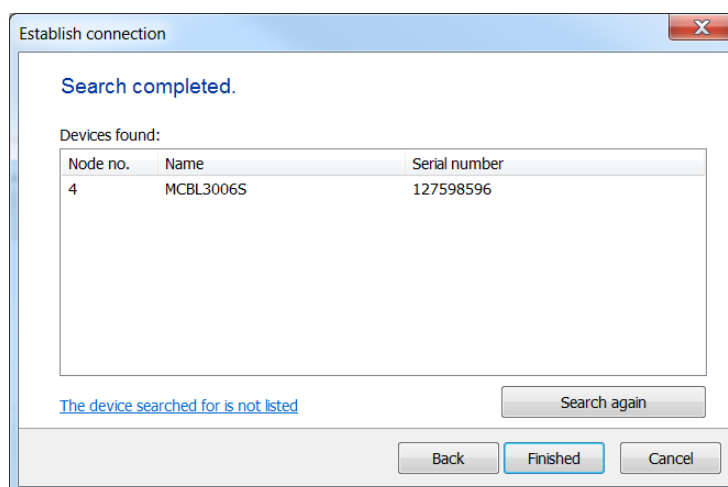
## Commissioning



6. Select the connection type and the transfer rate.

7. Press **Search...** button.

 Motion Manager will find and display devices, which are set to a suitable transfer rate.



8. Press **Finished** button.

### 5.2.2 Selecting the motor

External motion controllers must be adjusted to the connected motor. The wizard for motor selection is provided for this purpose; it can be opened via the quick access toolbar of the Motion Manager or via **Configuration** under **Initial Startup - Select motor**.

After selecting the required FAULHABER motor from a list and setting the sensor type used, as well as entering an inertia factor for the load to be operated, in addition to the motor and current limiting values, suitable controller parameters are also determined and transferred to the drive.

Refer to the Motion Manager instruction manual for details of how to use the wizard for motor selection.

## Commissioning

### 5.2.3 Configuring the drive

The Motor Wizard has already set sensible default settings for the motor/sensor combination selected.

A configuration dialog with several pages for further drive configuration and adjustment to the required application is available in the Motion Manager's quick access bar or under the menu item: **Configuration – Drive Functions...**

No settings are transferred to the drive until the **Send** button is pressed. The current state of the drive is also read back and the dialog is updated accordingly. Invalid combinations of settings are corrected at the same time, as they are not accepted by the drive.

The settings are permanently saved in the drive using the **EEPSAV** button.

### 5.2.4 Making basic settings

Within the scope of the commissioning, the following parameters are set in the **Basic Settings** tab:

- Operating mode
- Type of set-point presetting
- Optimisation for Hall sensors
- Controller mode
- Power-on state
- Communication settings

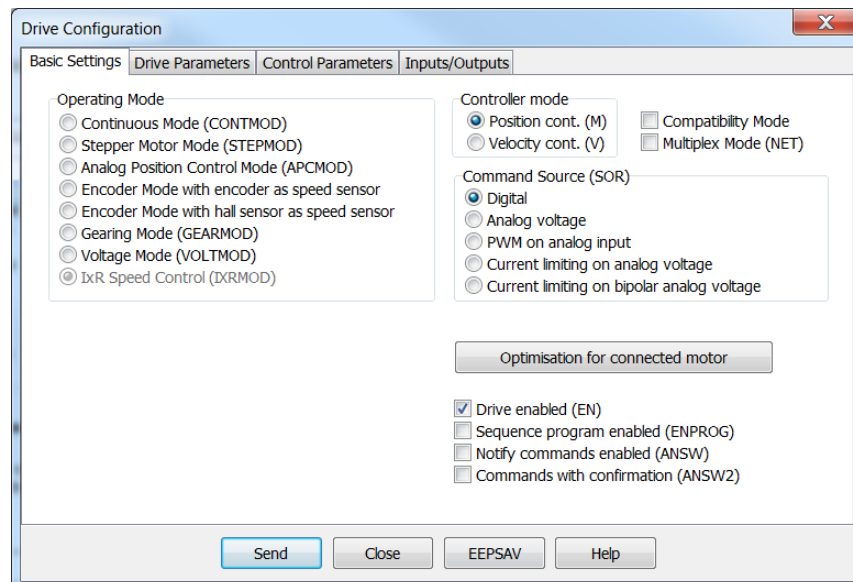


Fig. 22: Basic settings for the motor and encoder type

#### Optimisation for Hall sensors

A button, with which a wizard for optimisation to the connected motor can be started, is available for adjusting Hall sensor signals and phase angles to the connected motor.

 Ensure that the cage bar can freely move before starting the encoder optimisation.

## Commissioning

### Controller mode

FAULHABER Motion Controllers support the following main types of operation:

- Position control as servo drive
- Velocity control

The controller mode is partly automatically selected depending on the chosen operating mode.

### Operating mode

In addition to the controller mode, variations of the operation can also be selected.

The following options are available:

| Operating mode        | Description                                                                                                                                                                                                                                                                                                           |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CONTMOD               | Default setting for the selected controller mode.<br>The actual speed and actual position are determined in CONTMOD via the motor's Hall sensors. <ul style="list-style-type: none"> <li>■ CONTMOD for position control: See chap. 3.3.1, p. 14</li> <li>■ CONTMOD for velocity control: See chap. 1, p. 1</li> </ul> |
| STEPMOD               | Position control.<br>The target position is derived from the number of steps at the AnIn input (see chap. 3.6.1, p. 31).                                                                                                                                                                                              |
| APCMOD                | Position control.<br>The target position is preset by an analogue voltage at the AnIn input (see chap. 3.3.2, p. 16).                                                                                                                                                                                                 |
| ENCMOD with HALLSPEED | Position control with evaluation of the Hall signals for the actual velocity (see chap. 3.3.3, p. 18).                                                                                                                                                                                                                |
| GEARMOD               | Position control.<br>The target position is determined using the number of steps of an external encoder (see chap. 3.6.2, p. 33).                                                                                                                                                                                     |
| VOLTMOD               | Direct presetting of a voltage amplitude at the motor (see chap. 3.6.3, p. 35).                                                                                                                                                                                                                                       |

### Set-point presetting

The set-value presetting must be chosen in one of the following ways to match the selected type of operation and controller mode:

- Presetting via the serial interface or from a sequence program
- Set-point presetting for position or velocity via an analogue voltage
- Set-point presetting for position or velocity via a PWM voltage
- Set-point presetting for the limit current via an analogue voltage

### Power-on state

- In the default state the drive's power stage is initially inactive after power-on.

The power stage can be automatically activated after power-on by selecting the **Drive enabled (EN)** checkbox.

- In the default state, a sequence program is not worked through after the drive is switched on (power-on).

A sequence program stored in the drive can be automatically started immediately after power-on by selecting the **Program sequence enabled (ENPROG)** checkbox.

## Commissioning

### Communication settings

- The **Multiplex-Modus (NET)** checkbox is used to activate the selected drive for network mode.
- The **Asynchronous Responses (ANSW)** checkbox can be used to suppress asynchronous responses of the selected drive. They are enabled in the default state.
- The **Commands with confirmation (ANSW2)** checkbox can be used to suppress the confirmation frames for the commands sent to the drive. They are activated in the default state.

### 5.2.5 Setting the drive parameters

The **Drive Parameters** tab is used to make additional settings for the encoder and chosen type of operation.

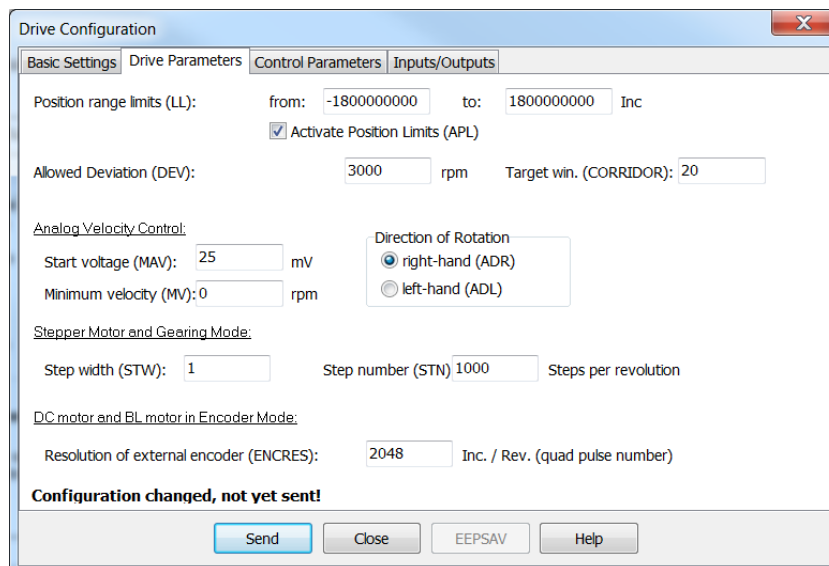


Fig. 23: Additional settings for the chosen type of operation

### Encoder resolution

If an incremental encoder attached to the motor is to be evaluated its effective resolution for 4 edge evaluation must be given.

### Set-point presetting in Stepper Mode or Gearing Mode

For set-point presetting in Stepper Mode and in Gearing Mode the conversion from step count of the external presetting per magnetic pole pitch must be given.

Example:

Motor has to perform a movement of one magnetic pole pitch at 1 000 pulses of the external encoder or at 1 000 steps:

- STW1
- STN1000

Detailed notes on using these parameters are given in the chapters with the functional description of Stepper Mode and Gearing Mode (see chap. 3.6.1, p. 31 and chap. 3.6.2, p. 33).

## Commissioning

### Velocity presetting via an analogue voltage

For presetting a velocity via an analogue voltage, a threshold value ( $MAV$ ) can be preset, from which the target value is evaluated starting with the minimum velocity ( $MV$ ).

Detailed notes on using these parameters is given in chap. 3.4.2, p. 22.

### Positioning range limits

In various types of operation the movement range can be monitored and limited. The limits of this movement range can be given in increments of the actual position using the parameter  $LL$ .

Range monitoring is activated by the  $APL1$  command.

### Maximum allowable velocity deviation and target corridor

The parameter  $CORRIDOR$  defines a range by which the target position within which the „Target position reached“ flag is set. If required, the target position is signalled asynchronously by a *Notify*.

Within this corridor the D term of the position controller is active and the ramp generator is inactive.

The parameter  $DEV$  can be used to preset a maximum allowable controller deviation for the velocity controller. If this barrier is exceeded for longer than set using the parameter  $DCE$  in the **Inputs/Outputs** tab, an error is signalled via the fault pin or on the serial interface.

## 5.2.6 Setting the controller parameters

The changes to the default set controller and current limitation parameters can be made in the **Controller Parameters** tab of the drive configuration dialog.

In addition, under the **Configuration – Controller Parameters...** menu item, there is another dialogue in which the online parameters can be changed and the result can be observed directly or can be recorded using the trace function in Motion Manager.

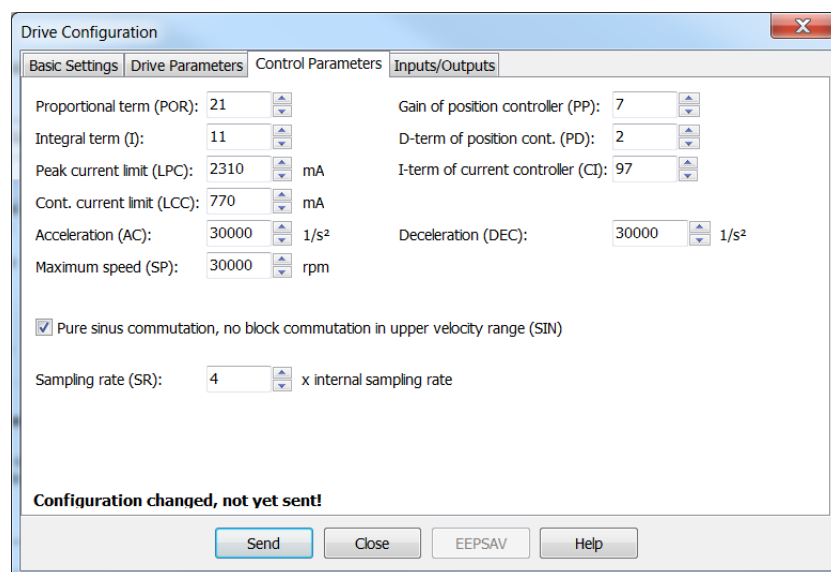


Fig. 24: Settings for the controller

## Commissioning

### Commutation settings

By default the motion controller for BL motors uses pure sinus commutation. This means the motor runs with the lowest possible losses and noise.

Alternatively, at higher velocities it is possible to also allow overriding of the output signals similar to block commutation. This enables the complete speed range of the motor to be utilised.



On changing between pure sinus commutation and operation with block commutation in the upper velocity range the controller amplification also increases.

### Current controller (LCC, LPC, CI)

The LCC parameter can be used to give the thermally allowable continuous current for the application.

Motors and the Motion Controller can be overloaded within certain limits. Therefore, higher currents can also be allowed for dynamic processes. The maximum peak current value is given via the LPC parameter.

Depending on the drive's load, the internal current monitoring limits the output current to the peak current (LPC) or the allowable continuous current (LCC).



### NOTICE!

#### Destruction of the motor

- ▶ Do **not** set the thermally allowable continuous current (LCC) higher than the thermally allowable continuous current of the motor according to its data sheet.
- ▶ Do **not** set the peak current (LPC) higher than the maximum peak output current of the existing electronics.

The current controller of the Motion Controller operates as a current limiting controller and therefore in an unlimited case has no effect on the dynamics of the velocity control. The speed of the limiting can be set using the parameter CI. If using the default values for your motor, the current is limited to the allowable value after around 5 ms.

If a FAULHABER motor was selected via the Motor Wizard, parameters are already set with which the motor can be operated safely.

Further details are given in chap. 3.8.3, p. 44.

### Velocity controller (I, POR, SR)

The velocity controller is designed as a PI controller. The following parameters can be set:

- Sampling rate SR as multiples of 100 µs
- Proportional gain POR
- Integral component I

If a FAULHABER motor was selected via the Motor Wizard, parameters are already set with which the motor can be operated.

If the motor is exposed to additional loads, the inertia of the load must be compensated for by a higher proportional term and if necessary slower sampling. In most applications the integral term can remain unchanged.

Further notes see chap. 3.8.7, p. 46.

## Commissioning

### Ramp generator (AC, DEC, SP)

The ramp generator limits the velocity change at the input of the velocity controller via the AC and DEC parameters and the maximum default speed via the SP parameter.

The AC and SP parameters can be freely selected depending on the application. The DEC parameter is used to specify the deceleration behaviour in positioning mode. For large loads, the deceleration ramp must be limited using the Profile Deceleration parameter, in order to achieve dead beat (overshoot-free) run-in in the target position.

Further notes see chap. 3.8.1, p. 40.

### Position controller (PP, PD)

The position controller is designed as a proportional controller. An additional D term also acts, but only within the target corridor (see **Drive Parameters** tab).

The proportional term uses the position deviation in increments to calculate the maximum default velocity for the secondary velocity controller. The ramp generator is used to additionally limit the acceleration and maximum velocity.

Dead beat run-in in the target position can be preferentially achieved by adjusting the deceleration ramp to the load. For a well-attenuated transient condition in the limit position, the parameter PP must be reduced proportionally to the load inertia.

Further notes see chap. 3.8.7, p. 46.

## 5.2.7 Setting inputs/outputs and use

The **Inputs/Outputs** tab of the drive configuration dialog can be used to specify the function of the digital inputs and outputs and to define the homing settings.

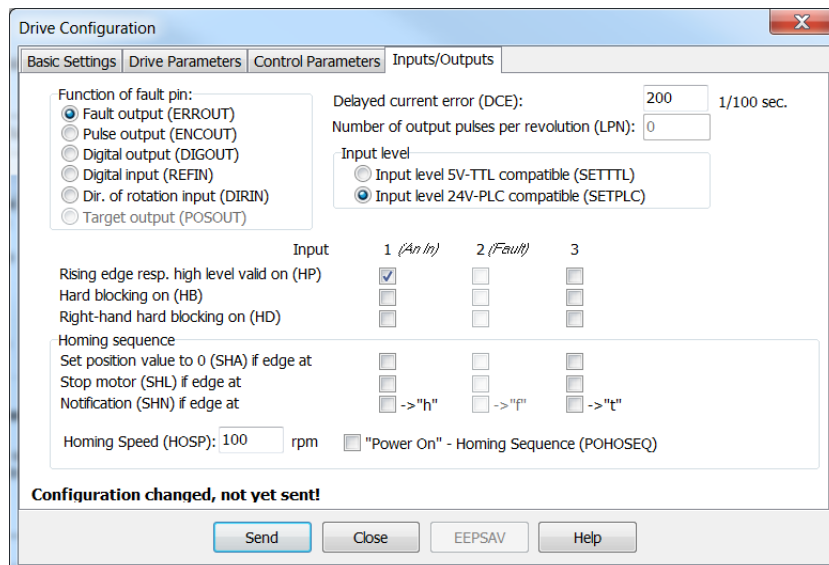


Fig. 25: Configuration of inputs/outputs

### Input level and edge

The switching thresholds of the digital inputs are either directly 5 V TTL compatible or are adjusted to the switching level of 24 V PCS outputs.

In addition, it is also possible to select which level is to be used as the active level for each input and to what extent the input is to be used as a limit switch (HB / HD).

## Commissioning

### Function of the fault pin

The fault pin can be used both as an input and as an output.



### NOTICE!

#### Destruction of the motor

- ▶ Do **not** connect 24 V to the fault pin, if the fault pin is configured as a digital output (ERROUT / DIGOUT / ENCOUNT).

The other settings for the 2nd input can only be made if the fault pin is configured as the reference or direction input.

For the default function as a fault output, the delay time can be specified via the `DCE` parameter in order to suppress the response, e.g. to individual short overcurrent pulses.

For the function as pulse output, the number of pulses per revolution of the motor can be set using the parameter `LPN`.

In the `POSOUT` function the output displays the entry into the target corridor as a digital signal (low means "target position is reached").

### Homing

Use as a reference switch can be set for each of the available inputs.

Either the actual position can be set to 0 by an edge at the selected input (`SHA`), the motor can be stopped (`SHL`) or a message can be set to the higher level control (`SHN`). The actions can be combined.

Homing defined in this way can be executed by the `GOHSEQ` command or automatically after switching on if `POHSEQ` is set.

## 5.2.8 Managing the data set

### Saving parameters

The settings of a drive can be saved as a backup or as a file for configuration of other drives.

The Motion Manager provides the option of reading out the current drive configuration and saving it.

### Transferring parameters to the drive

In the Motion Manager, previously saved parameter files can be opened, edited if necessary and transferred to the drive.



Run the `SAVE` or `EEPSAV` command to permanently save a transferred parameter set in the drive.

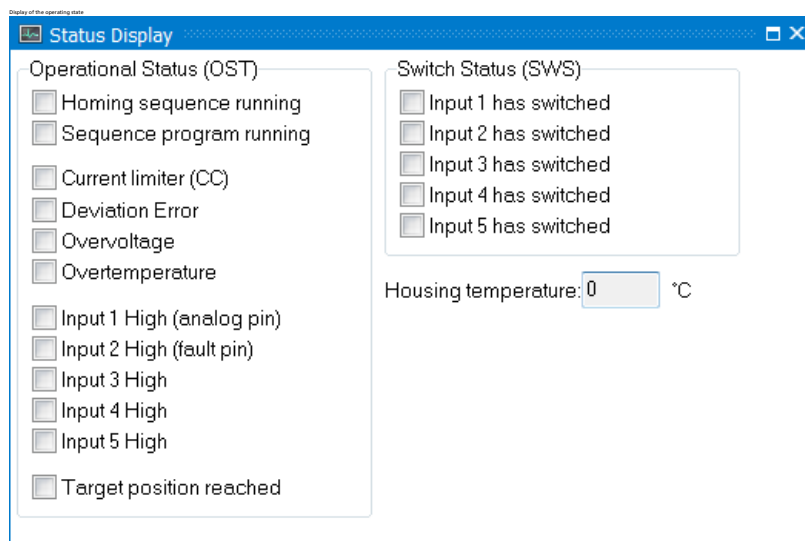
## Commissioning

### 5.2.9 Diagnosis

The status display is used for continuous checking of the main operating states.

Internal states, error flags and the state of the digital inputs are signalled. In addition, the internally measured housing temperature, the Statusword and further actual values are displayed.

The display is updated by Motion Manager via cyclical querying of the state data.



#### Internal states

The following partially autonomous states of the Motion Controller are displayed:

- Course of homing
- Active sequence program

Other internal states are the error flag and the housing temperature.

The current limiting flag is set if the maximum current has been set to continuous current ( $I_{CC}$ ) by the  $I^2t$  monitoring.

#### States of digital inputs

The state of the digital inputs is displayed as On or Off depending on the level setting.

#### Status of the limit switches

The display indicates whether one of the limit switches has switched, even if the assigned input is already back in the idle state.

### 5.2.10 Trace function

Motion Manager provides the tool **Graphic Analysis** as an additional diagnosis tool with which the internal parameters can be graphically recorded. This enables the dynamic behaviour of the drive to be monitored, which is useful, e.g. for optimisation of the controller parameters.

## Sequence programs

### 6 Sequence programs

Sequence programs that are stored directly in the data flash memory of the controller and executed from there can be created for stand-alone applications or for partially autonomous sequences.

The sequence programs can be created and transferred with the FAULHABER Motion Manager, but it is also possible to use a standard text editor and to subsequently transfer the programs with the Motion Manager or a terminal program.

During a program sequence commands can still be sent via the RS232. Almost all ASCII commands can be used in motion programs.

The command `PROGSEQ` can also be used in the network with a preceding node number. The subsequent command must be send also with a preceding node number. The addressed node stores all received instructions thereby, between the commands `PROGSEQ` and `END`.

| Command                                        | Argument | Function             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------|----------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>PROGSEQ</code><br><code>[...] END</code> | –        | Program Sequence     | <p>Defines the start and end of the sequence program.</p> <p>All commands sent to <code>PROGSEQ</code> are not executed, but transferred to the sequence program memory. An <code>END</code> marks the end of the sequence program.</p> <p>All commands after <code>END</code> are directly executed again.</p> <p>There is no <code>SAVE</code> command necessary for saving the program sequence.</p> <p>Command must not be executed more than 10 000 times, as otherwise the function of the Flash memory can no longer be guaranteed.</p> <p>These commands do not have to be entered in the FAULHABER Motion Manager, as they are automatically attached by the "Transfer program file..." function.</p> <p><b>Note:</b> The Xon/Xoff protocol must be used to transfer lengthy program sequences.</p> |
| <code>GPROGSEQ</code>                          | 1        | Get Program Sequence | <p>Reads out and sends back the stored program sequence. Each program line is output in lower case letters, ending with a CR character. At the end of the program, the "end:" line is sent with details of the program length in bytes followed by a CR and LF character.</p> <p><code>GPROGSEQ1</code>: Reads out the program sequence and indicates at which program line the program counter is currently located („PC--“).</p>                                                                                                                                                                                                                                                                                                                                                                           |
| <code>ENPROG</code>                            | –        | Enable Program       | <p>Execution of the program is released, i.e. the sequence is started. This status can be permanently stored with <code>SAVE/EEPSAV</code>, so that the drive starts up with the stored program sequence immediately after power-on.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <code>DIPROG</code>                            | –        | Disable Program      | Deactivate program execution.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <code>RESUME</code>                            | –        | Resume               | Continue program sequence after <code>DIPROG</code> at the point at which it was interrupted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <code>MEM</code>                               | –        | Memory               | Return available program memory in Word.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## Sequence programs

### 6.1 Control of sequence programs

There are a number of additional commands for controlling programs which are only useful within sequence programs and are consequently only available there.

The following commands stop the sequence until the relevant position is reached:

| Command | Function        | Sequence                                                                                                                  |
|---------|-----------------|---------------------------------------------------------------------------------------------------------------------------|
| NP      | Notify Position | Stops at the next <b>M</b> or <b>V</b> command, until the relevant position is reached.                                   |
| HN      | Hard Notify     | Stops at the <b>GOHOSEQ</b> command or at the next <b>M</b> or <b>V</b> command, until the limit switch is overtravelled. |
| NV      | Notify Velocity | Stops at the next <b>M</b> or <b>V</b> command, until the relevant speed is reached.                                      |
| GOHIX   | Go Hall Index   | Stops at the <b>GOHIX</b> command, until the Hall null position is reached.                                               |

If there are several Notify conditions, the first fulfilled condition effects continuation of the program.

Additional commands for use within sequence programs:

| Command | Argument                                      | Function                      | Description                                                                                                                                                                             |
|---------|-----------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DELAY   | 0...65 535                                    | Delay                         | Stop sequence for a defined time [1/100 s].                                                                                                                                             |
| TIMEOUT | 0...65 535                                    | Timeout                       | With Notify commands, only wait for the specified time and then continue the sequence again. Can also be used via RS232: Send an "o" if Notify condition has not been fulfilled.        |
| JMP     | 0...255                                       | Jump                          | Jump to the given address (can also be used via RS232).                                                                                                                                 |
| JMPGx   | 0...255                                       | Jump if greater than x        | Jump to the specified address if result of last query command is greater than variable x (A, B, C).                                                                                     |
| JMPLx   | 0...255                                       | Jump if less than x           | Jump to the specified address if result of last query command is less than variable x (A, B, C).                                                                                        |
| JMPEx   | 0...255                                       | Jump if equal x               | Jump to specified address if result of last query command is equal to variable x (A, B, C).                                                                                             |
| JPH     | 0...255                                       | Jump if Hard-Input activated  | Jump to the specified address if the analogue input is active ( <b>HP</b> determines the polarity).                                                                                     |
| JPF     | 0...255                                       | Jump if Fault-Input activated | Jump to the specified address if the Fault Pin input is active ( <b>HP</b> determines the polarity). Fault Pin must be configured as input ( <b>REFIN</b> ).                            |
| JPT     | 0...255                                       | Jump if 3. Input activated    | Jump to the specified address if the 3 <sup>rd</sup> input is active ( <b>HP</b> determines the polarity).                                                                              |
| SETx    | -2 147 483 648...<br>2 147 483 647<br>(Int32) | Set Variable x                | <ul style="list-style-type: none"> <li>Without argument: Result of last query command is loaded into the variable.</li> <li>Set variable x (A, B, C) to the specified value.</li> </ul> |
| GETx    | -                                             | Get Variable x                | Query content of variable x (A, B, C).                                                                                                                                                  |
| ADDx    | -2 147 483 648...<br>2 147 483 647<br>(Int32) | Add to Variable x             | Add or subtract variable x (A, B, C) with given value.                                                                                                                                  |
| SETARGx | -                                             | Set argument                  | Set value of variable x (A, B, C) as argument for the next command (if no argument is given there).                                                                                     |

## Sequence programs

| Command | Argument | Function                      | Description                                                                                                                                                                                                                                                                                                   |
|---------|----------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DxJNZ   | 0...255  | Decrement x, Jump if not Zero | Decrease the value of variable x (A, B, C) by one and jump to specified address if the value is not 0.                                                                                                                                                                                                        |
| ERI     | 0...255  | Error Interrupt               | An error interrupt is activated from execution of this command. This means that if an error subsequently occurs (overvoltage, current limitation, ...), then the sequence branches to the specified address. The error handling mode is ended if a <code>JMP</code> or <code>RETI</code> command is executed. |
| RETI    | –        | Return Error Interrupt        | Return from an error handling routine.<br><b>Important:</b> the interrupted command is not continued, even if it was not completed at the time of interruption.                                                                                                                                               |
| DIERI   | –        | Disable Error Interrupt       | The <code>ERI</code> command is deactivated, i.e. in the event of an error the program does not jump to the error handling routine.                                                                                                                                                                           |
| CALL    | 0...255  | Call Subroutine               | Call a subroutine at specified address.                                                                                                                                                                                                                                                                       |
| RET     | –        | Return from Subroutine        | Return from a subroutine.<br><b>Important:</b> only one subroutine level is possible, i.e. no subroutines can be called within subroutines.                                                                                                                                                                   |
| A       | 0...255  | Define Address                | Definition of current position as entry address for jump commands.                                                                                                                                                                                                                                            |

## 6.2 Response behaviour settings

As a default, the send commands are not acknowledged. However, the `ANSW` command can be used to change the response behaviour:

| Command | Argument | Function    | Description                                                                                                                                                                                                                                                                                                                                                                   |
|---------|----------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSW    | 0...7    | Answer Mode | 0: No asynchronous responses<br>1: Allow asynchronous responses<br>2: All commands with confirmation and asynchronous responses<br>3: Debug mode, sent commands are returned (cannot be used if configuring with Motion Manager)<br>4...7: analogous to 0...3, but responses resulting from a command in the sequence program are not sent (cannot be set via Motion Manager) |

## Sequence programs

### 6.3 Explanations of the commands and functions

#### 6.3.1 Jump commands

The program sequence can be specifically controlled with the jump commands.

The `JMP` command can also be used from the RS232. This is useful in cases where different program routines are to be called from the computer.

Example:

```
A1
JMP1      ;Endless loop

A2        ;Program sequence 2 (can only be called by JMP2 from the RS232 interface)

LA1000
NP
M

JMP1      ;Return to endless loop

A3        ;Program sequence 3 (can only be called by JMP3 from the RS232 interface)

LA-10000
NP
M

JMP1      ;Return to endless loop
```

The program sequences according to `A2` or `A3` can only be called by a `JMP2` or `JMP3` command from the RS232 interface. A `JMP2` from the RS232 interface results in the drive moving to position 10 000 and stopping there.

The `DxJNZ` commands serve to form loops with a predefined number of cycles.

Example:

Move by the same relative position 5 times.

```
SETA5     ;Set variable A to the value 5

A2        ;Define jump address 2

LR100     ;Load relative position

NP        ;Notify Position

M         ;Start positioning

DAJNZ2    ;Decrease A by 1 and jump to address 2, provided that variable A is not yet 0.
```

The commands `JPH`, `JPF` and `JPT` enable jumps that are only executed if the relevant input is active. This means that programs can be called via external switches.

The commands `JMPGx`, `JMPLx`, `JMPEx` enable jumps that refer to the result of the last query command.

## Sequence programs

Example:

```
SETA100  
  
GN  
  
JMPLA3
```

The command `JMPLA3` jumps to address 3 if the velocity value returned with `GN` is less than 100 mm/s (value of variable A).

Entry addresses are defined via command `A`. In the case of a jump, the sequence is continued at this point.

The value range for jump commands extends from 0 to 255. Accordingly, a maximum of 256 different entry points can be defined with `JMP`, `JPx`, `ERI` and `CALL`.

### 6.3.2 Error Interrupt

During execution of the `ERI` command, nothing happens initially. Only if an error situation subsequently occurs does the sequence jump immediately to the specified address. This enables sensible continuation of the program in the event of error.

The `RETI` command enables you to return to the position at which the sequence was interrupted. Note that the interrupted command is no longer executed, but is continued with the next command.

No new error interruption can take place within the error handling routine. The error handling status is cancelled as soon as the `RETI` or `JMP` command is executed. After this, the commands are interrupted again if an error occurs. It should therefore be ensured that the error situation disappears in the error handling routine. Otherwise, the error handling call will be repeated.

### 6.3.3 Homing

The `HN/SHN` command enables you to stop the sequence until the limit switch is reached. In order to correctly execute the `GOHOSEQ` command within a sequence, it is essential to set the `SHN` command accordingly when defining the homing sequence. This is necessary particularly if you wish to use the Power-On Homing sequence (`POHOSEQ1`).

## Sequence programs

### 6.3.4 Notify commands

Notify commands can be used to generate complicated motion profiles.

Example:

```
LA6000  
SP1000  
AC20  
NV100  
M  
AC100  
NV800  
M  
AC50  
NP  
M
```

With this sequence, the acceleration is increased during boot-up at 100 mm/s. It is decreased again at 800 mm/s.

The `NP` command without argument stops the sequence until the target position is reached.

### 6.3.5 CALL command

The `CALL` command enables subroutines to be called from different points, any number of times. You can only jump back from a subroutine again with the `RET` command.

All commands are permitted within a subroutine except for a repeated `CALL` command.

### 6.3.6 General information

If a sequence program is completely processed (no jump at the end of a program), then an "n" is sent to the RS232, if `ANSW1` or `ANSW2` is set.

In order to generate an endless program (useful for standalone operation), a jump command is required at the end of the program.

### 6.3.7 Memory size

The sequence programs are stored in binary coding in the Flash memory; 2 bytes are stored for each command, and 0 to 4 bytes for the argument. The maximum memory size available for sequence programs is 6 656 bytes (3 328 words).

## Sequence programs

### 6.3.8 Example: positioning routines called via RS232

The program enables the calling of different routines from the RS232 interface:

| Routine | Description                                                                                                                                                                                                                                                                   |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| JMP2    | Homing Sequence.<br>First move to a limit switch and then to the Hall sensor zero point (Hall index), in order to obtain the most precise reference point possible.                                                                                                           |
| JMP3    | Move to position 0 and stop there.                                                                                                                                                                                                                                            |
| JMP4    | Attempt to approach a position with low current limitation. As there may be an obstacle in the way in the application, the target position may not be attained. The motor should be stopped after 5 s, in any event. (Further evaluation occurs in the higher level control). |
| JMP5    | 1 000 cycles with following sequence: 10 revolutions forwards, 1 s pause, 5 magnetic pole pitches back again and then 0.5 s pause.                                                                                                                                            |

#### Configuration

|         |                                          |
|---------|------------------------------------------|
| SOR0    | ;Digital velocity presetting via RS232   |
| LR0     | ;Set current position as target position |
| M       | ;Switch to position control (motion 0)   |
| SHA1    | ;Homing Sequence with Notify at AnIn     |
| SHN1    |                                          |
| SHL1    |                                          |
| HOSP200 | ;Homing speed 200 mm/s                   |
| HP1     | ;Rising edge at limit switch effective   |
| ENPROG  | ;Start motion program after power-on     |
| ANSW0   | ;No asynchronous responses               |
| EEPSAV  | ;Save configuration                      |

#### Program

|         |                                                                              |
|---------|------------------------------------------------------------------------------|
| A1      |                                                                              |
| JMP1    | ;Endless loop                                                                |
| A2      | ;Entry point for homing sequence (JMP2)                                      |
| GOHOSEQ | ;Homing to reference switch                                                  |
| GOHIX   | ;Subsequent homing to Hall sensor zero point (Hall index)                    |
| JMP1    | ;Return to endless loop                                                      |
| A3      | ;Entry point for routine 1 (JMP3)                                            |
| LA0     | ;Set target position to 0                                                    |
| NP      | ;Notify at target position (sequence stops until target position is reached) |
| M       | ;Start positioning                                                           |
| JMP1    | ;Return to endless loop                                                      |

## Sequence programs

---

```
A4          ;Entry point for routine 2 (JMP4)

LPC500      ;Set current limitation values to 500 mA (continuous current # peak current)

LA60000

NP

TIMEOUT500 ;Continue sequence after 5 s, even if position has not yet been attained

M          ;Start positioning

VO         ;Stop motor

LR0

M          ;Switch back to positioning mode

JMP1       ;Return to endless loop

A5         ;Entry point for routine 3 (JMP5)

SETA1000   ;Predefine variable A

A6         ;Entry point for loop

LR300

NP

M

DELAY100

LR-1500

NP

M

DELAY50

DAJNZ6     ;Repeat loop 5 times

JMP1       ;Return to endless loop
```

The individual routines are called from the serial interface by sending the commands `JMP2`, `JMP3`, etc.

If the sequence is to wait until the end of a motion command (`M`, `GOHOSEQ`, etc.), a Notify (`NP` or `SHN1` in the Homing Sequence configuration) must be set first of all.

## Parameter description

### 7 Parameter description

#### 7.1 Basic setting commands

##### 7.1.1 Commands for special operating modes

| Command   | Argument | Function                     | Description                                                                                                                                                                                                                                                                                                                                          |
|-----------|----------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SOR       | 0...4    | Source For Velocity          | Source for velocity presetting. <ul style="list-style-type: none"> <li>0: Interface (Default)</li> <li>1: Voltage at analogue input</li> <li>2: PWM signal at analogue input</li> <li>3: Current target value via analogue input</li> <li>4: Target current value via analogue input with pre-setting of the direction via input polarity</li> </ul> |
| CONTMOD   | –        | Continuous Mode              | Switch back to normal mode from an enhanced mode.                                                                                                                                                                                                                                                                                                    |
| STEPMOD   | –        | Stepper Motor Mode           | Change to stepper motor mode.                                                                                                                                                                                                                                                                                                                        |
| APCMOD    | –        | Analog Position Control Mode | Position control with target value via analogue voltage.                                                                                                                                                                                                                                                                                             |
| ENCMOD    | –        | Encoder Mode                 | Change to encoder mode. An external encoder serves as position detector (the current position value is set to 0).                                                                                                                                                                                                                                    |
| HALLSPEED | –        | Hall Sensor As Speed Sensor  | Speed via Hall sensors in encoder mode.                                                                                                                                                                                                                                                                                                              |
| ENCSPEDD  | –        | Encoder As Speed Sensor      | Speed via encoder signals in encoder mode.                                                                                                                                                                                                                                                                                                           |
| GEARMOD   | –        | Gearing Mode                 | Change to gearing mode                                                                                                                                                                                                                                                                                                                               |
| VOLTMOD   | –        | Set Voltage Mode             | Activate Voltage Regulator Mode.                                                                                                                                                                                                                                                                                                                     |

## Parameter description

### 7.1.2 Parameters for basic setting

| Command | Argument                                                         | Function                | Description                                                                                                                                                                                                                                                                                                                                                                   |
|---------|------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ENCRES  | 8...65 535                                                       | Load Encoder Resolution | Load resolution of external encoder [4 times pulse/mm].                                                                                                                                                                                                                                                                                                                       |
| KN      | 0...16 383                                                       | Load Speed Constant     | Load speed constant $K_n$ in accordance with information in the data sheet [ $\text{min}^{-1}/\text{V}$ ].                                                                                                                                                                                                                                                                    |
| RM      | 10...320 000                                                     | Load Motor Resistance   | Load motor resistance $R_M$ according to specification in data sheet [ $\text{m}\Omega$ ].                                                                                                                                                                                                                                                                                    |
| TM      | 8...60                                                           | Load Magnetic Pitch     | Load magnetic pitch [mm].                                                                                                                                                                                                                                                                                                                                                     |
| STW     | 1...65 535                                                       | Load Step Width         | Load step width for step motor and gearing mode.                                                                                                                                                                                                                                                                                                                              |
| STN     | 1...65 535                                                       | Load Step Number        | Load number of steps per magnetic pole pitch for step motor and gearing mode.                                                                                                                                                                                                                                                                                                 |
| MV      | 0...10 000                                                       | Minimum Velocity        | Presetting of minimum velocity for specification via analogue voltage (SOR1, SOR2) [ $\text{min}^{-1}$ ].                                                                                                                                                                                                                                                                     |
| MAV     | 0...10 000                                                       | Minimum Analog Voltage  | Presetting of minimum start voltage for presetting speed via analogue voltage (SOR1, SOR2) [mV].                                                                                                                                                                                                                                                                              |
| ADL     | –                                                                | Analog Direction Left   | Positive voltages at the analogue input result in left-hand movement of the cage bar (SOR1, SOR2).                                                                                                                                                                                                                                                                            |
| ADR     | –                                                                | Analog Direction Right  | Positive voltages at the analogue input result in right-hand movement of the cage bar (SOR1, SOR2).                                                                                                                                                                                                                                                                           |
| SIN     | 0...1                                                            | Sinus Commutation       | 1: No block commutation within the upper velocity range (default)<br>0: Block commutation within the upper velocity range (full modulation)                                                                                                                                                                                                                                   |
| NET     | 0...1                                                            | Set Network Mode        | Activate RS232 multiplex mode for network operation.<br>0: No network operation, single drive on an RS232<br>1: Network operation activated                                                                                                                                                                                                                                   |
| BAUD    | 600, 1 200, 2 400, 4 800, 9 600, 19 200, 38 400, 57 600, 115 200 | Select Baudrate         | Specify transfer rate for RS232 interface.                                                                                                                                                                                                                                                                                                                                    |
| NODEADR | 0...255                                                          | Define Node Address     | Set node number.                                                                                                                                                                                                                                                                                                                                                              |
| ANSW    | 0...7                                                            | Answer Mode             | 0: No asynchronous responses<br>1: Allow asynchronous responses<br>2: All commands with confirmation and asynchronous responses<br>3: Debug mode, sent commands are returned (cannot be used if configuring with Motion Manager)<br>4...7: analogous to 0...3, but responses resulting from a command in the sequence program are not sent (cannot be set via Motion Manager) |

## Parameter description

### 7.1.3 General parameters

| Command  | Argument                               | Function                              | Description                                                                                                                                                                                                                                                        |
|----------|----------------------------------------|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LL       | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$ | Load Position Range Limits            | Load limit positions (the drive cannot be moved out of these limits). <ul style="list-style-type: none"> <li>Positive values specify the upper limit.</li> <li>Negative values specify the lower limit.</li> </ul> The range limits are only active if $APL = 1$ . |
| APL      | 0...1                                  | Activate / Deactivate Position Limits | Activate range limits (LL) (valid for all operating modes except <code>VOLTMOD</code> ). <ul style="list-style-type: none"> <li>1: Position limits activated</li> <li>0: Position limits deactivated</li> </ul>                                                    |
| SP       | 0...10 000                             | Load Maximum Speed                    | Load maximum speed. Setting applies to all modes [mm/s].                                                                                                                                                                                                           |
| AC       | 0...30 000                             | Load Command Acceleration             | Load acceleration value [ $1/s^2$ ].                                                                                                                                                                                                                               |
| DEC      | 0...30 000                             | Load Command Deceleration             | Load deceleration value [ $1/s^2$ ].                                                                                                                                                                                                                               |
| SR       | 1...20                                 | Load Sampling Rate                    | Load sampling rate of the velocity controller as a multiple of 200 $\mu s$ .                                                                                                                                                                                       |
| POR      | 1...255                                | Load Velocity Proportional Term       | Load velocity controller amplification.                                                                                                                                                                                                                            |
| I        | 1...255                                | Load Velocity Integral Term           | Load velocity controller integral term.                                                                                                                                                                                                                            |
| PP       | 1...255                                | Load Position Proportional Term       | Load position controller amplification.                                                                                                                                                                                                                            |
| PD       | 1...255                                | Load Position Differential Term       | Load position controller D-term.                                                                                                                                                                                                                                   |
| CI       | 1...255                                | Load Current Integral Term            | Load integral term for current controller.                                                                                                                                                                                                                         |
| LPC      | 0...12 000                             | Load Peak Current Limit               | Load peak current [mA].                                                                                                                                                                                                                                            |
| LCC      | 0...12 000                             | Load Continuous Current Limit         | Load continuous current [mA].                                                                                                                                                                                                                                      |
| DEV      | 0...30 000                             | Load Deviation                        | Load maximum permissible deviation of actual velocity from target velocity (deviation).                                                                                                                                                                            |
| CORRIDOR | 1...32 767                             | Load Corridor                         | Window around the target position.                                                                                                                                                                                                                                 |

## Parameter description

### 7.1.4 Commands for configuring the fault pin and the digital inputs

| Command | Argument   | Function              | Description                                                                          |
|---------|------------|-----------------------|--------------------------------------------------------------------------------------|
| ERROUT  | –          | Error Output          | Fault pin as error output.                                                           |
| ENCOUT  | –          | Encoder Output        | Fault pin as pulse output.                                                           |
| DIGOUT  | –          | Digital Output        | Fault pin as digital output. The output is set to low level.                         |
| POSOUT  | –          | Position Output       | Fault pin as digital output for display of the condition: "target position reached". |
| DIRIN   | –          | Direction Input       | Fault pin as direction input.                                                        |
| REFIN   | –          | Reference Input       | Fault pin as reference or limit switch input.                                        |
| DCE     | 0...65 535 | Delayed Current Error | Delayed error output for <code>ERROUT</code> [1/100 s].                              |
| LPN     | 1...255    | Load Pulse Number     | Preset pulse number for <code>ENCOUT</code> .                                        |
| CO      | –          | Clear Output          | Set digital output <code>DIGOUT</code> to low level.                                 |
| SO      | –          | Set Output            | Set digital output <code>DIGOUT</code> to high level.                                |
| TO      | –          | Toggle Output         | Switch digital output <code>DIGOUT</code> .                                          |
| SETPLC  | –          | Set PLC-Threshold     | Digital inputs PLC-compatible (24 V level).                                          |
| SETTTL  | –          | Set TTL-Threshold     | Digital inputs TTL-compatible (5 V level).                                           |

## Parameter description

### 7.1.5 Commands for configuring the homing and the limit switches

| Command | Argument         | Function                            | Description                                                                                                                                                                                                          |
|---------|------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HP      | Bitmask          | Hard Polarity                       | Define valid edge and polarity of respective limit switches: <ul style="list-style-type: none"> <li>1: Rising edge and high level effective</li> <li>0: Falling edge and low level effective</li> </ul>              |
| HB      | Bitmask          | Hard Blocking                       | Activate Hard Blocking function for relevant limit switch.                                                                                                                                                           |
| HD      | Bitmask          | Hard Direction                      | Presetting of direction of rotation that is blocked with HB of respective limit switch: <ul style="list-style-type: none"> <li>1: Clockwise direction blocked</li> <li>0: Anticlockwise direction blocked</li> </ul> |
| SHA     | Bitmask          | Set Home Arming for Homing Sequence | Homing behaviour (GOHOSEQ):<br>Set position value to 0 at edge of respective limit switch.                                                                                                                           |
| SHL     | Bitmask          | Set Hard Limit for Homing Sequence  | Homing behaviour (GOHOSEQ):<br>Stop motor at edge of respective limit switch.                                                                                                                                        |
| SHN     | Bitmask          | Set Hard Notify for Homing Sequence | Homing behaviour (GOHOSEQ):<br>Send a character to RS232 at edge of respective limit switch.                                                                                                                         |
| HOSP    | -10 000...10 000 | Load Homing Speed                   | Load speed [mm/s] and direction for homing (GOHOSEQ, GOHIX, GOIX).                                                                                                                                                   |
| POHOSEQ | 0...1            | Power-On Homing Sequence            | Start homing automatically after power-on: <ul style="list-style-type: none"> <li>0: No homing after power-on</li> <li>1: Power-On Homing Sequence is activated</li> </ul>                                           |
| HA      | Bitmask          | Home Arming                         | Set position value to 0 and delete relevant HA bit at edge of respective limit switch. Setting is not saved.                                                                                                         |
| HL      | Bitmask          | Hard Limit                          | Stop motor and delete relevant HL bit at edge of respective limit switch. Setting is not saved.                                                                                                                      |
| HN      | Bitmask          | Hard Notify                         | Send a character to RS232 and delete relevant HN bit at edge of respective limit switch. Setting is not saved.                                                                                                       |

#### Bit mask of the limit switches

The resulting decimal value must be transferred to the commands given here.

| Bit:   | 0              | 1         | 2         | 3 | 4 | 5 | 6 | 7 |
|--------|----------------|-----------|-----------|---|---|---|---|---|
| Input: | Analogue input | Fault-Pin | 3rd input | – | – | – | – | – |

## Parameter description

### 7.2 Query commands for basic setting

#### 7.2.1 Operating modes and general parameters

| Command   | Argument | Function                       | Description                                                                              |
|-----------|----------|--------------------------------|------------------------------------------------------------------------------------------|
| CST       | –        | Configuration Status           | Set operating mode (see Tab. 4).                                                         |
| GMOD      | –        | Get Mode                       | Set mode (see Tab. 5).                                                                   |
| GENCRES   | –        | Get Encoder Resolution         | Set encode resolution (ENCRES).                                                          |
| GKN       | –        | Get Speed Constant             | Motor speed constant $K_N$ [(mm/s)/V].                                                   |
| GRM       | –        | Get Motor Resistance           | Motor resistance $R_M$ [mΩ].                                                             |
| GTM       | –        | Get Magnetic Pitch             | Magnetic pole pitch ( $T_M$ ) [mm].                                                      |
| GSTW      | –        | Get Step Width                 | Set step width (STW).                                                                    |
| GSTN      | –        | Get Step Number                | Set number of steps (STN).                                                               |
| GMV       | –        | Get Minimum Velocity           | Set minimum velocity (MV) [mm/s].                                                        |
| GMAV      | –        | Get Minimum Analog Voltage     | Set minimum start voltage value (MAV) [mV].                                              |
| GPL       | –        | Get Positive Limit             | Set positive limit position (LL).                                                        |
| GNL       | –        | Get Negative Limit             | Set negative limit position (LL).                                                        |
| GSP       | –        | Get Maximum Speed              | Set maximum speed (SP) [mm/s].                                                           |
| GAC       | –        | Get Acceleration               | Set acceleration value (AC) [mm/s <sup>2</sup> ].                                        |
| GDEC      | –        | Get Deceleration               | Set deceleration value (DEC) [mm/s <sup>2</sup> ].                                       |
| GSR       | –        | Get Sampling Rate              | Set sampling rate (SR) of the speed controller as a multiple of the basic sampling time. |
| GPOR      | –        | Get Velocity Proportional Term | Set amplification value of the speed controller (POR).                                   |
| GI        | –        | Get Velocity Integral Term     | Set integral term of the speed controller (I).                                           |
| GPP       | –        | Get Position Proportional Term | Set amplification value of the position controller (PP).                                 |
| GPD       | –        | Get Position D-Term            | Set D component of the position controller (PD).                                         |
| GCI       | –        | Get Current Integral Term      | Set integral term of the current controller (CI).                                        |
| GPC       | –        | Get Peak Current               | Set peak current (LPC) [mA].                                                             |
| GCC       | –        | Get Continuous Current         | Set continuous current (LCC) [mA].                                                       |
| GDEV      | –        | Get Deviation                  | Set deviation value (DEV).                                                               |
| GCORRIDOR | –        | Get Corridor                   | Set window around the target position (CORRIDOR).                                        |
| GNODEADR  | –        | Get Node Address               | Set node number (NODEADR).                                                               |

## Parameter description

Tab. 4: Binary encoded return values of the operating mode (CST)

| Bit        | Description                                                                                                                                                                                                                                                                                                |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0<br>(LSB) | Reserved                                                                                                                                                                                                                                                                                                   |
| 1...2      | Automatic responses: <ul style="list-style-type: none"> <li>0: ANSW0 (no automatic responses)</li> <li>1: ANSW1 (asynchronous responses)</li> <li>2: ANSW2 (additional command acknowledgements)</li> <li>3: ANSW3 (Debug)</li> </ul>                                                                      |
| 3...5      | Velocity presetting: <ul style="list-style-type: none"> <li>0: SOR0 (RS232 interface)</li> <li>1: SOR1 (Analogue voltage)</li> <li>2: SOR2 (PWM signal)</li> <li>3: SOR3 (current limitation value)</li> <li>4: SOR4 (current limitation value with presetting of direction via input polarity)</li> </ul> |
| 6          | Reserved                                                                                                                                                                                                                                                                                                   |
| 7...9      | FAULHABER mode: <ul style="list-style-type: none"> <li>0: CONTMOD</li> <li>1: STEPMOD</li> <li>2: APCMOD</li> <li>3: ENCMOD / HALLSPEED</li> <li>4: ENCMOD / ENCSPEED</li> <li>5: GEARMOD</li> <li>6: VOLTMOD</li> </ul>                                                                                   |
| 10         | Power amplifier: <ul style="list-style-type: none"> <li>0: Disabled (DI)</li> <li>1: Enabled (EN)</li> </ul>                                                                                                                                                                                               |
| 11         | Position controller: <ul style="list-style-type: none"> <li>0: Switched off</li> <li>1: Switched on</li> </ul>                                                                                                                                                                                             |
| 12         | Analogue direction: <ul style="list-style-type: none"> <li>0: ADL</li> <li>1: ADR</li> </ul>                                                                                                                                                                                                               |
| 13         | Position Limits APL: <ul style="list-style-type: none"> <li>0: Deactivated</li> <li>1: Activated</li> </ul>                                                                                                                                                                                                |
| 14         | Sinus commutation SIN: <ul style="list-style-type: none"> <li>0: Allow block commutation</li> <li>1: Do not allow block commutation</li> </ul>                                                                                                                                                             |
| 15         | Bit 15, Network operation: <ul style="list-style-type: none"> <li>0: NET0 (Single device on an RS232)</li> <li>1: NET1 (Multiplex mode activated)</li> </ul>                                                                                                                                               |

Tab. 5: Return values of the modes (GMOD)

| Set FAULHABER mode | MCBL |
|--------------------|------|
| CONTMOD            | c    |
| STEPSMOD           | s    |
| APCMOD             | a    |
| ENCMOD             | h    |
| ENCSPEED           | e    |
| GEARMOD            | g    |
| VOLTMOD            | v    |

## Parameter description

### 7.2.2 Query commands for configuring the fault pin and the digital inputs

| Command | Argument | Function                  | Description                                  |
|---------|----------|---------------------------|----------------------------------------------|
| IOC     | –        | I/O Configuration         | Set input/output configuration (see Tab. 6). |
| GDCE    | –        | Get Delayed Current Error | Set value of the error output delay (DCE).   |
| GPN     | –        | Get Pulse Number          | Set pulse number (LPN).                      |

**Tab. 6:** Binary encoded return values of the input/output configuration (IOC)

| Bit                | Description                                                                                     |
|--------------------|-------------------------------------------------------------------------------------------------|
| 0...7<br>(0 = LSB) | Hard Blocking:<br>▪ 0...31: Function active for input 1...5                                     |
| 8...15             | Hard Polarity:<br>▪ 0...31: Rising edge at input 1...5                                          |
| 16...23            | Hard Direction:<br>▪ 0...31: Clockwise movement blocked at input 1...5                          |
| 24                 | State of digital output:<br>▪ 0: Low<br>▪ 1: High                                               |
| 25                 | Level of digital inputs:<br>▪ 0: TTL level (5 V)<br>▪ 1: PLC level (24 V)                       |
| 26...28            | Function of fault pin:<br>▪ 0: ERROUT<br>▪ 1: ENCOUT<br>▪ 2: DIGOUT<br>▪ 3: DIRIN<br>▪ 4: REFIN |

### 7.2.3 Query commands for configuring homing

| Command | Argument | Function             | Description                            |
|---------|----------|----------------------|----------------------------------------|
| HOC     | –        | Homing Configuration | Set homing configuration (see Tab. 7). |
| GHOSP   | –        | Get Homing Speed     | Set homing speed (HOSP).               |

**Tab. 7:** Binary encoded return values of the homing configuration (HOC)

| Bit             | Description                                                                             |
|-----------------|-----------------------------------------------------------------------------------------|
| 0...7 (0 = LSB) | SHA setting                                                                             |
| 8...15          | SHN setting                                                                             |
| 16...23         | SHL setting                                                                             |
| 24              | Power-On Homing Sequence:<br>▪ 0: deactivated<br>▪ 1: activated (homing after power-on) |

## Parameter description

### 7.3 Miscellaneous commands

| Command        | Argument | Function              | Description                                                                                                                                                                                                                                                                                              |
|----------------|----------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NE             | 0...1    | Notify Error          | Notification in the event of errors: <ul style="list-style-type: none"> <li>1: An "r" is returned if an error occurs</li> <li>0: No error notification</li> </ul>                                                                                                                                        |
| SAVE<br>EEPSAV | –        | Save Parameters       | Save current parameters and configuration setting to Flash memory. The drive will also start with these settings when next switched on.<br><br><b>Attention: Command must not be executed more than 10 000 times, as otherwise the function of the Flash memory can no longer be guaranteed.</b>         |
| RESET          | –        | Reset                 | Restart drive node.                                                                                                                                                                                                                                                                                      |
| RN             | –        | Reset Node            | Set application parameters to original values (ROM values) (current, acceleration, controller parameters, maximum speed, limit positions...).<br>Communication parameters, operating mode and hardware configuration are retained.                                                                       |
| FCONFIG        | –        | Factory Configuration | All configurations and values are reset to the standard delivery status. After this command the drive performs a reset.<br><br><b>Attention: Customer-specific factory settings are also lost, programmed sequence programs are retained.</b><br><br>The command can be executed a maximum 10 000 times. |

## Parameter description

### 7.4 Motion control commands

| Command | Argument                                 | Function               | Description                                                                                                                                                                                                        |
|---------|------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DI      | –                                        | Disable Drive          | Deactivate drive.                                                                                                                                                                                                  |
| EN      | –                                        | Enable Drive           | Activate drive.                                                                                                                                                                                                    |
| M       | –                                        | Initiate Motion        | Activate position control and start positioning.                                                                                                                                                                   |
| LA      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Load Absolute Position | Load new absolute target position.                                                                                                                                                                                 |
| LR      | $-2,14 \cdot 10^9 \dots 2,14 \cdot 10^9$ | Load Relative Position | Load new relative target position, in relation to last started target position. The resulting absolute target position must lie between the values given as argument.                                              |
| NP      | –                                        | Notify Position        | <ul style="list-style-type: none"> <li>Without argument: A “p” is returned when the target position is attained.</li> <li>With argument: A “p” is returned if the specified position is over-travelled.</li> </ul> |
| NPOFF   | –                                        | Notify Position Off    | Notify Position command that has not yet been triggered is deactivated again.                                                                                                                                      |
| V       | $-10\,000 \dots 10\,000$                 | Select Velocity Mode   | Activate velocity mode and set specified value as target velocity (velocity control) [mm/s].                                                                                                                       |
| NV      | $-10\,000 \dots 10\,000$                 | Notify Velocity        | A “v” is returned when the nominal speed is reached or passed through.                                                                                                                                             |
| NVOFF   | –                                        | Notify Velocity Off    | Velocity command that has not yet been triggered is deactivated again.                                                                                                                                             |
| U       | $-32\,767 \dots 32\,767$                 | Set Output Voltage     | Output motor voltage (corresponds to $-U_B \dots +U_B$ ) for SOR0 only in VOLTMOD.                                                                                                                                 |
| GOHOSEQ | –                                        | Go Homing Sequence     | Execute FAULHABER homing sequence. A homing sequence is executed (if programmed) irrespective of the current mode..                                                                                                |
| GOHIX   | –                                        | Go Hall Index          | LM motor to Hall zero point (Hall index) and set actual position value to 0.                                                                                                                                       |
| GOIX    | –                                        | Go Encoder Index       | Move to the encoder index at the Fault pin and set actual position value to 0.                                                                                                                                     |
| HO      | $-1,8 \cdot 10^9 \dots 1,8 \cdot 10^9$   | Define Home Position   | <ul style="list-style-type: none"> <li>Without argument: Set actual position to 0.</li> <li>With argument: Set actual position to specified value.</li> </ul>                                                      |

## Parameter description

### 7.5 General query commands

| Com-<br>mand | Argument                                                                                                 | Function             | Description                                                                                                                                                                            |
|--------------|----------------------------------------------------------------------------------------------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GTYP         | –                                                                                                        | Get Controller Type  | Designation (name) of the controller.                                                                                                                                                  |
| GSER         | –                                                                                                        | Get Serial Number    | Serial number.                                                                                                                                                                         |
| VER          | –                                                                                                        | Get Version          | Current software version.                                                                                                                                                              |
| POS          | –                                                                                                        | Get Actual Position  | Current actual position.                                                                                                                                                               |
| TPOS         | –                                                                                                        | Get Target Position  | Target position.                                                                                                                                                                       |
| GV           | –                                                                                                        | Get Velocity         | Current target velocity [mm/s].                                                                                                                                                        |
| GN           | –                                                                                                        | Get N                | Current actual velocity [mm/s].                                                                                                                                                        |
| GU           | –                                                                                                        | Get PWM Voltage      | Set PWM value in VOLTMOD.                                                                                                                                                              |
| GRU          | –                                                                                                        | Get Real PWM Voltage | Current controller output value.                                                                                                                                                       |
| GCL          | –                                                                                                        | Get Current Limit    | Current limitation current [mA].                                                                                                                                                       |
| GRC          | –                                                                                                        | Get Real Current     | Current actual current [mA].                                                                                                                                                           |
| TEM          | –                                                                                                        | Get Temperature      | Current housing temperature [°C].                                                                                                                                                      |
| GADV         | <ul style="list-style-type: none"> <li>Input 1: –10 000...10 000</li> <li>Input 3: 0...10 000</li> </ul> | Get Analog Voltage   | Read out the voltage applied at the given input (value): <ul style="list-style-type: none"> <li>1: Voltage at AnIn</li> <li>3: Voltage at 3. In</li> </ul> Scaling: 1 000 digits = 1 V |
| OST          | –                                                                                                        | Operation Status     | Current operating status (see Tab. 8).                                                                                                                                                 |
| SWS          | –                                                                                                        | Switch Status        | Temporary limit switch settings (see Tab. 9).                                                                                                                                          |

**Tab. 8:** *Binary encoded return values of the operating status (OST)*

| Bit     | Description                                        |
|---------|----------------------------------------------------|
| 0 (LSB) | Homing running                                     |
| 1       | Program sequence running                           |
| 2       | Program sequence stopped because of DELAY command  |
| 3       | Program sequence stopped because of NOTIFY command |
| 4       | Current limitation active                          |
| 5       | Deviation error                                    |
| 6       | Overvoltage                                        |
| 7       | Overtemperature                                    |
| 8       | Status input 1                                     |
| 9       | Status input 2                                     |
| 10      | Status input 3                                     |
| 13...15 | Reserved for further inputs                        |
| 16      | Position attained                                  |
| 17      | Limitation to continuous current                   |

## Parameter description

Tab. 9: Binary encoded return values of the temporary limit switch settings (SWS)

| Bit     | Description                                                                                      |
|---------|--------------------------------------------------------------------------------------------------|
| 0...7   | HA setting                                                                                       |
| 8...15  | HN setting                                                                                       |
| 16...23 | HL setting                                                                                       |
| 24...31 | Information which limit switch has already switched (is reset on resetting the respective input) |

## 7.6 Commands for sequence programs

### Commands for generating and executing sequence programs

| Command              | Argument | Function             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------|----------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROGSEQ<br>[...] END | –        | Program Sequence     | <p>Defines the start and end of the sequence program.</p> <p>All commands sent to PROGSEQ are not executed, but transferred to the sequence program memory. An END marks the end of the sequence program.</p> <p>All commands after END are directly executed again.</p> <p>There is no SAVE command necessary for saving the program sequence.</p> <p>Command must not be executed more than 10 000 times, as otherwise the function of the Flash memory can no longer be guaranteed.</p> <p>These commands do not have to be entered in the FAULHABER Motion Manager, as they are automatically attached by the "Transfer program file..." function.</p> <p><b>Note:</b> The Xon/Xoff protocol must be used to transfer lengthy program sequences.</p> |
| GPROGSEQ             | 1        | Get Program Sequence | <p>Reads out and sends back the stored program sequence. Each program line is output in lower case letters, ending with a CR character. At the end of the program, the "end:" line is sent with details of the program length in bytes followed by a CR and LF character.</p> <p>GPROGSEQ1: Reads out the program sequence and indicates at which program line the program counter is currently located („PC--“).</p>                                                                                                                                                                                                                                                                                                                                    |
| ENPROG               | –        | Enable Program       | <p>Execution of the program is released, i.e. the sequence is started. This status can be permanently stored with SAVE/EEPSAV, so that the drive starts up with the stored program sequence immediately after power-on.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| DIPROG               | –        | Disable Program      | Deactivate program execution.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| RESUME               | –        | Resume               | Continue program sequence after DIPROG at the point at which it was interrupted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| MEM                  | –        | Memory               | Return available program memory in Word.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## Parameter description

### Additional commands for use within sequence programs

| Command | Argument                                      | Function                      | Description                                                                                                                                                                                                                                                                         |
|---------|-----------------------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DELAY   | 0...65 535                                    | Delay                         | Stop sequence for a defined time [1/100 s].                                                                                                                                                                                                                                         |
| TIMEOUT | 0...65 535                                    | Timeout                       | With Notify commands, only wait for the specified time and then continue the sequence again. Can also be used via RS232: Send an "o" if Notify condition has not been fulfilled.                                                                                                    |
| JMP     | 0...255                                       | Jump                          | Jump to the given address (can also be used via RS232).                                                                                                                                                                                                                             |
| JMPGx   | 0...255                                       | Jump if greater than x        | Jump to the specified address if result of last query command is greater than variable x (A, B, C).                                                                                                                                                                                 |
| JMPLx   | 0...255                                       | Jump if less than x           | Jump to the specified address if result of last query command is less than variable x (A, B, C).                                                                                                                                                                                    |
| JMPEx   | 0...255                                       | Jump if equal x               | Jump to specified address if result of last query command is equal to variable x (A, B, C).                                                                                                                                                                                         |
| JPH     | 0...255                                       | Jump if Hard-Input activated  | Jump to the specified address if the analogue input is active (HP determines the polarity).                                                                                                                                                                                         |
| JPF     | 0...255                                       | Jump if Fault-Input activated | Jump to the specified address if the Fault Pin input is active (HP determines the polarity). Fault Pin must be configured as input (REFIN).                                                                                                                                         |
| JPT     | 0...255                                       | Jump if 3. Input activated    | Jump to the specified address if the 3 <sup>rd</sup> input is active (HP determines the polarity).                                                                                                                                                                                  |
| SETx    | -2 147 483 648...<br>2 147 483 647<br>(Int32) | Set Variable x                | <ul style="list-style-type: none"> <li>Without argument: Result of last query command is loaded into the variable.</li> <li>Set variable x (A, B, C) to the specified value.</li> </ul>                                                                                             |
| GETx    | -                                             | Get Variable x                | Query content of variable x (A, B, C).                                                                                                                                                                                                                                              |
| ADDx    | -2 147 483 648...<br>2 147 483 647<br>(Int32) | Add to Variable x             | Add or subtract variable x (A, B, C) with given value.                                                                                                                                                                                                                              |
| SETARGx | -                                             | Set argument                  | Set value of variable x (A, B, C) as argument for the next command (if no argument is given there).                                                                                                                                                                                 |
| DxJNZ   | 0...255                                       | Decrement x, Jump if not Zero | Decrease the value of variable x (A, B, C) by one and jump to specified address if the value is not 0.                                                                                                                                                                              |
| ERI     | 0...255                                       | Error Interrupt               | An error interrupt is activated from execution of this command. This means that if an error subsequently occurs (overvoltage, current limitation, ...), then the sequence branches to the specified address. The error handling mode is ended if a JMP or RETI command is executed. |
| RETI    | -                                             | Return Error Interrupt        | Return from an error handling routine.<br><b>Important:</b> the interrupted command is not continued, even if it was not completed at the time of interruption.                                                                                                                     |
| DIERI   | -                                             | Disable Error Interrupt       | The ERI command is deactivated, i.e. in the event of an error the program does not jump to the error handling routine.                                                                                                                                                              |
| CALL    | 0...255                                       | Call Subroutine               | Call a subroutine at specified address.                                                                                                                                                                                                                                             |

## Parameter description

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| Command | Argument | Function               | Description                                                                                                                                 |
|---------|----------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| RET     | –        | Return from Subroutine | Return from a subroutine.<br><b>Important:</b> only one subroutine level is possible, i.e. no subroutines can be called within subroutines. |
| A       | 0...255  | Define Address         | Definition of current position as entry address for jump commands.                                                                          |

