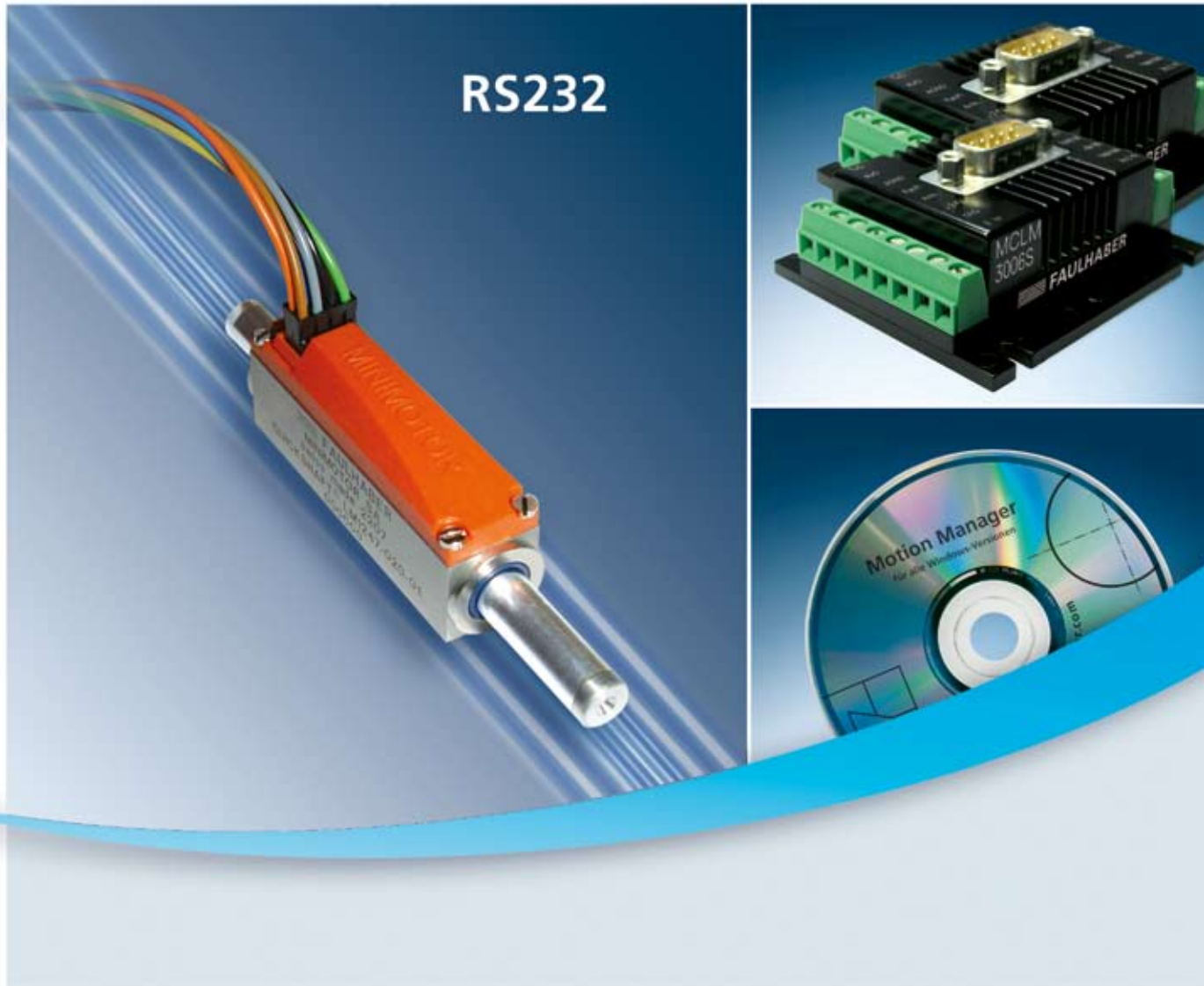
FAULHABER

EN Operating Instructions



MCLM 3003/06 S

FAULHABER GROUP
We create motion

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The pertinent regulations regarding safety engineering and interference suppression must be complied with.

Subject to modifications.

1 Overview

1.1 General description

This documentation describes the function and operation of the following devices with serial interface:

MCLM 3003/06 S
The MCLM 3003/06 S is an external motion controller for Linear DC-Servomotors with linear Hall sensors, which can be operated without additional encoders.

The Motion Controller is based on a high performance digital signal processor (DSP), which enables a high control quality, precise positioning and very low speeds.

The following tasks can be performed:

- **Velocity control** with high requirements on synchronous operation and minimal force fluctuations. A PI controller ensures observance of the target velocities.
- **Velocity profiles** such as ramp, triangular or trapezoidal movements can be realised. Gentle starting or deceleration can easily be implemented.
- **Positioning mode:** Starting from defined positions with high resolution (1/3000 polar pitch using linear Hall sensors of LM motors).
- Acquisition of **reference marks and limit switches.**
- Extended operating modes: **Stepper motor mode, Analog positioning mode, Electronic gear,** operation with **external incremental encoder.**
- **Force control** via adjustable current limitation.
- **Storage** of the set configurations.
- **Storage** and **execution** of sequence programs.

Various inputs and outputs are available for the implementation of these tasks:

- **Set value input** for target position.
  Analog or PWM signals can be used. The input can also be used as digital or reference input. A frequency signal or an external incremental encoder can also be connected here.
- **Error output**(Open Collector).
  Can also be reprogrammed as direction, digital or reference mark input, and as pulse or digital output.
- 1 additional **digital input.**

RS232 interface for connection to PC or control with transfer rates of up to 115 kBaud. An extensive set of ASCII commands is available for programming and operation. FAULHABER Motion Manager 3 software is freely available for Windows 95/98/ME/NT/2K/XP: this considerably simplifies operation and configuration of the units and also offers a graphic online analysis function for operating data.

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

Fields of application

Thanks to the compact design, the units can be integrated into diverse applications with minimal wiring. The flexible connection options open up a broad field of application in all areas, for example in decentralized automation technology systems, as well as in handling devices and machine tools.

Options

A separate supply for servomotor and control electronics is optionally available ex works (important for safety-relevant applications), in which case the 3rd input is omitted. Special preconfiguration of modes and parameters is possible on request. The Motion Manager software can be downloaded free of charge from www.faulhaber-group.com.

1 Overview

1.2 Quick start

To facilitate introduction, this chapter highlights the initial steps for commissioning and operation of FAULHABER Motion Controllers with serial interface.

However, the detailed documentation must always be read and adhered to, particularly chapter 2.5 Basic Settings.

The units are delivered as standard without a valid node address (NODEADR0) and with a transfer rate of 9600 baud. The settings can be changed via the interface, e.g. with the FAULHABER Motion Manager.

If the FAULHABER Motion Manager is to be used to change the connection parameters, proceed as follows:

1. Connect drive unit to a serial interface of the PC (e.g. COM1) via null modem cable and switch on.
2. Start FAULHABER Motion Manager.
3. Activate serial interface as communication interface and configure via the menu item "Terminal – Connections…".
4. Select menu item "Configuration – Connection parameters…".
5. Set desired transfer rate and node address.
6. Press "Send" button.
7. The settings are transferred to the controller. The Motion Manager then adjusts to the same baud rate and recalls the Scan function. The node should now be displayed with the correct node number in Node Explorer.
8. If the settings are to be permanently stored, the "EEPSAV" button must then be pressed. After switching off and on again, the drive will operate with the set configuration.

1.2.1 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 servomotor via the Motion Manager, follow the procedure below (assuming a matching baud rate):

1. Configure drive functions:

A user-friendly dialog that enables the desired settings to be made is available under the menu item "Configuration – Drive functions…".

You must check that the correct basic settings have been made for the connected motor (see chapter 2.5 Basic settings). For linear servomotors, the correct type must be set under "Drive parameters".

For operating the drive via the PC, the set value pre-setting must be set to digital (SOR0). If the settings are to be permanently stored, press the "EEPSAV" button.

2. Activate drive:

"EN" command.

Enter in command input field and press "Send" button or select in "Commands – Motion control – Enable drive" menu and press "Send" button.

3. Operate servomotor (example):

Move servomotor relatively by 1000 increments:
"LR1000" command to load the relative target position,
"M" command to move to loaded target position.

1.2.2 Operation via own host application

Set your host application to the controller transfer rate (default 9600 baud) with the following configuration:

- 8 data bits
- 1 stop bit
- No Parity

The Xon/Xoff protocol must be used for rapid command sequences or transfer of sequence programs and parameter sets.

An extensive set of ASCII commands is available for operating the FAULHABER Motion Controllers.
The ASCII commands are structured as follows:

[Node no.]	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.

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).

Example:
Actual position queries:
Transmit: POS [CR]
Receive: 98956 [CR][LF]

Drive nodes at position 2000:
Transmit: LA2000 [CR]

Transmit: M [CR]

If ANSW2 is set, you will receive an "OK" when the command has been successfully executed. If an execution error occurred you will receive one of the following character strings:

"Unknown command"
"Invalid parameter"
"Command not available"
"Overtemperature – drive disabled"

Example:
Transmit: LA100 [CR]
Receive: OK [CR][LF]

The EEPSAV command always responds with the character string "EEPROM writing done" after successful saving of the current settings in the data Flash memory, or with "Flash defect", if the save has failed. All commands are listed in Chapter 4 **Parameter Description**.

2 Installation

2.1 Connections and wiring

MCLM 3003/06 S:

The connections are indicated on the terminal strips and are assigned as follows:

Supply side:	
Connect.	**Meaning**
TxD	RS232 TxD
RxD	RS232 RxD
AGND	Analog GND
Fault	Error output
AnIn	Analog input
+24V	+24 V
GND	GND
3.In	3rd input/optional electronics supply (-3085 option)

Motor side:	
Connect.	**Meaning**
Ph A	Servomotor phase A (brown)
PH B	Servomotor phase B (orange)
Hall C	Hall sensor C (grey)
Hall B	Hall sensor B (blue)
SGND	GND signal (black)
+5V	VCC (red)
Hall A	Hall sensor A (green)
PH C	Servomotor phase C (yellow)

In addition, a 9-pin SUB-D connector is attached, with the following assignment:

Pin	Meaning
2	RxD
3	TxD
5	GND

Power supply connections (+24 V, GND)

The power supply should be adequately dimensioned for the connected Servomotor. Please pay attention to the polarity connection. An incorrect polarity connection will blow the internal fuse. This must be replaced in the factory!

Analog input (analog input, analog GND = AGND)

The analog input is executed as a differential input.

The analog GND should be connected to the power supply GND, in order to prevent a voltage drop in the supply cable from affecting the target velocity value.

The analog input has various uses, depending on the configuration:

- Current limitation value via analog voltage
- Presetting of target position via analog voltage
- Digital input for reference and limit switches
- Connection for an external encoder (Analog input to GND: Channel A / Analog GND to GND: Channel B) in gearing or encoder mode.

RS232 connections

The RS232 wiring is established via the connections RxD, TxD and the supply GND. The integrated RS232 interface allows direct connection with a PC with use of a null modem cable, in which the transmit cable (TxD) and the receive cable (RxD) are crossed.

Fault output

The fault output is characterised by the following characteristics:

- Switch that switches to GND (Open Collector)
- Output resistor in open state (High Level): 100 kΩ
- The switch is open in the event of error (High Level)
- Output current limited to approx. 30 mA, voltage in open state must not exceed the power supply (maximum U_B)
- Short-circuit proof

The error output is activated in the following situations:

- Current limitation active
- Over-voltage controller active (power supply over 32 V)
- Power stage switched off due to over-temperature

The error output connection can also be reconfigured for other functions:

- Pulse output
- Digital output
- Limit switch input
- Rotational direction input

3rd input

This connection can be used as reference or digital input. The drive can also be optionally provided with separate electronics supply at this connection ex-works (-3085 option), enabling the motor voltage to be switched off independently of the electronics supply.

2 Installation

2.1 Connections and wiring

2.1.1 Installation instructions

The place of installation must be selected so that clean and dry cooling air is available for cooling the unit. The units are intended for indoor operation. Large amounts of dust and high concentrations of chemical pollutants must be avoided. Cooling of the unit must be guaranteed, especially when installing in housings and cabinets. As the unit operates with surface cooling, temperatures of up to 85 °C can occur. Perfect functioning is only guaranteed if the supply voltage lies within the defined tolerance ranges. Wiring work may only be carried out on terminal strips and connections if the units are voltage-free. Please also note the additional instructions on installation in Chapter EMC.

2.1.2 External interference suppression

Compliance with the emitted interference limits requires the use of a ferrite ring or interference-suppression ring. Ferrite rings and interference-suppression rings, in addition to ESD protective caps, are available through specialist dealers or FAULHABER. Please refer to Chapter 5.3.3 for further details.

2.1.3 ESD protection

Caution: Electrostatic discharges to the connection contacts (ESD – Electrostatic-Sensitive Devices, e.g. D-Sub connectors and terminal strips) may lead to destruction of the device or other components. Such electrostatic discharges can be prevented by the use of protective caps.

2.1.4 Maintenance

The units are maintenance-free in principle. The air filters of cabinet units must be regularly checked and cleaned if required, depending on the quantity of dust. In the event of heavy soiling, the units themselves must be cleaned with halogen-free agents.

2.1.5 Specialised staff

Only trained specialised staff and instructed persons with knowledge in the field of automation technology and standards and regulations such as

EMC Directive, Low Voltage Directive, Machinery Directive, VDE Regulations (such as DIN VDE 0100, DIN VDE 0113/ EN 0204, DIN VDE 0160/EN 50178), Accident Prevention Regulations

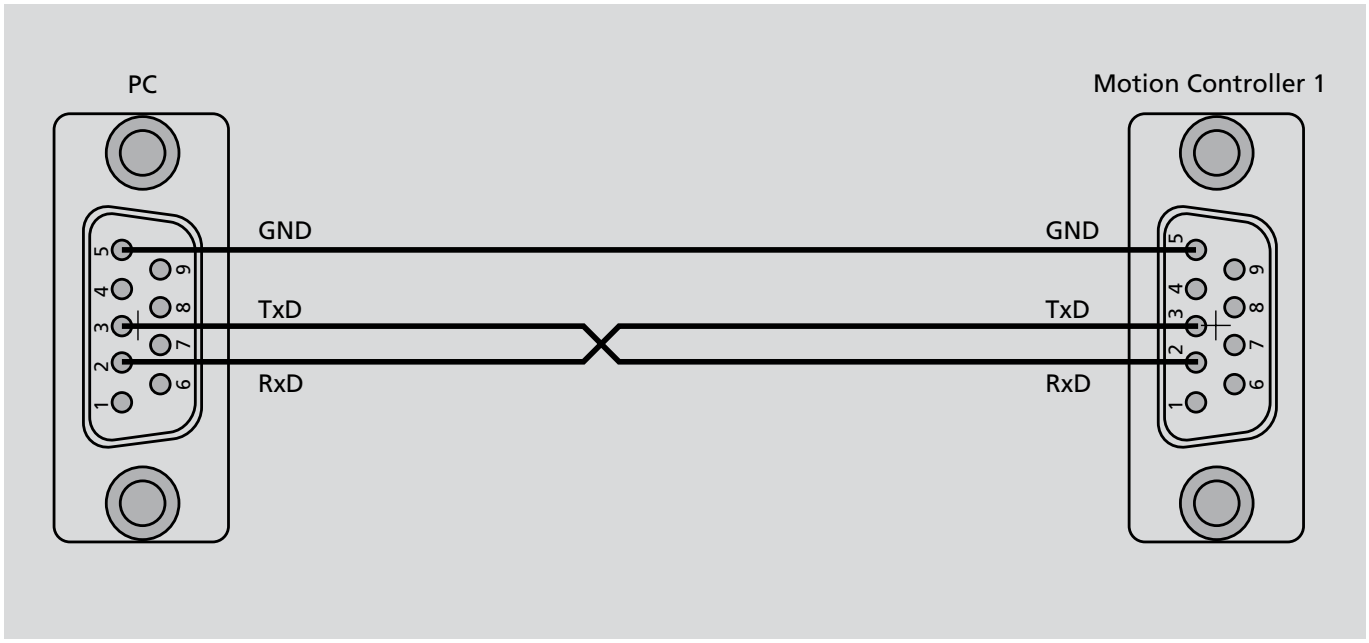
may install and commission the units. This description must be carefully read and heeded prior to commissioning.

2 Installation

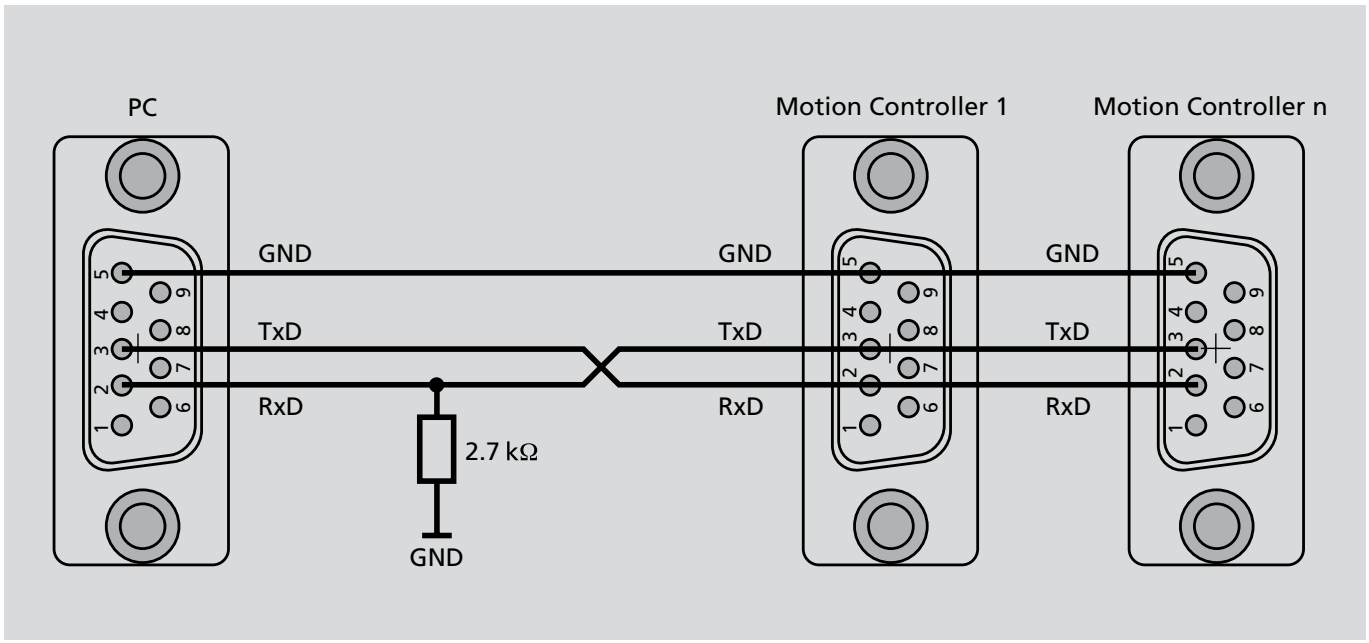
2.2 RS232-Wiring

Use a null modem cable in which the transmit cable (TxD) and the receive cable (RxD) are crossed, in order to connect the controller with the PC or control.

Wiring with one Motion Controller – parameter NET0



Wiring with more Motion Controllers – parameter NET1



2 Installation

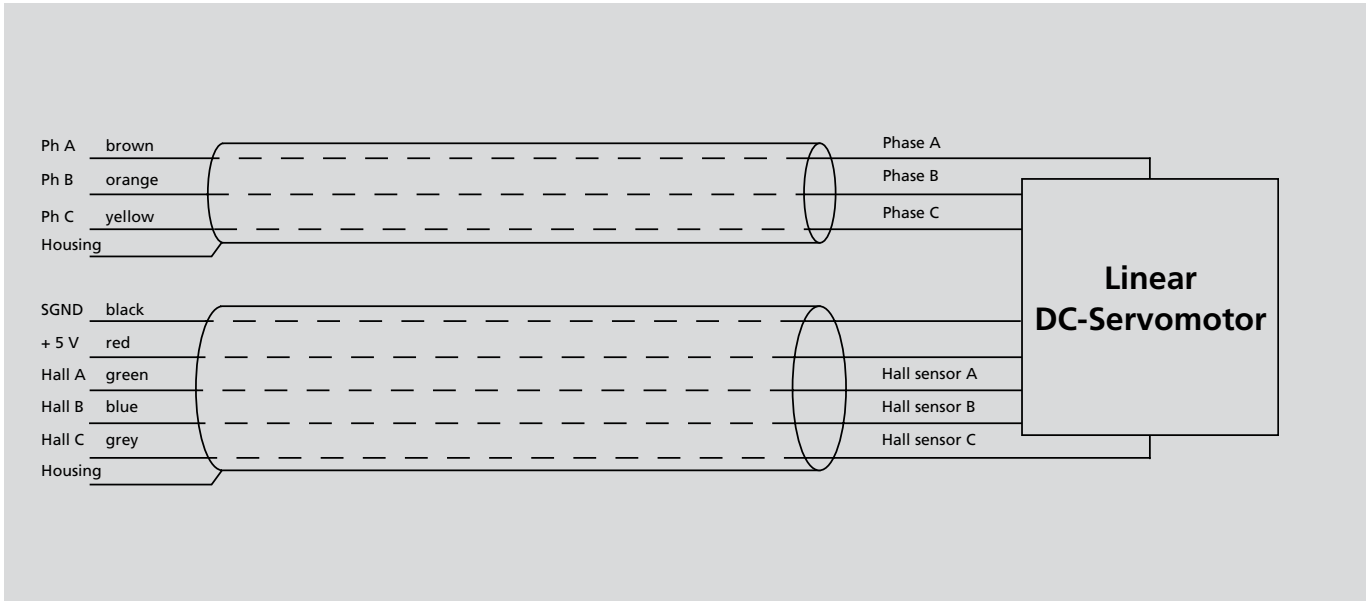
2.3 Servomotor connection

MCLM 3003/06 S:

The encoder and the linear Hall sensors signal wires are susceptible to interference, which makes it impossible to specify a maximum cable length. Shielded wires must always be used with cable lengths > 300 mm.

It must be generally noted that the wires between the Motion Controller and the motor must be kept as short as possible, since drive system properties such as quietness and running deteriorate as the length of the line increases.

MCLM connection



2 Installation

2.4 Baud rate and node number

The serial interface must be configured as follows:

- 8 data bits
- 1 stop bit
- No parity

The Xon/Xoff protocol must be used for rapid command sequences or transmission of sequence programs.

The following transfer rates can be set:
600 baud
1200 baud
2400 baud
4800 baud
9600 baud (default)
19200 baud
38400 baud
57600 baud
115200 baud

The setting can be changed via the interface if a connection already exists with the drive node:

Command	Function	Description
BAUD	Select baud	Preset transfer rate for RS232 interface

Example:
Change transfer rate to 19200 baud:
BAUD 19200

Important: If the baud rate of the controller has been changed, the baud rate of the PC and control must also be adjusted to the new baud rate to enable communication with the drive unit again.

If several drives are to be operated on a serial interface, each drive unit must have a unique node number between 1 and 255.

Command	Function	Description
NODEADR	Define Node Address	Set node number

Example:
Set drive unit to node number 3:
NODEADR3

All units are delivered with node number 0. In order to prepare the units for network operation, they must first be individually connected to the PC and set to the desired node address using the FAULHABER Motion Manager.

A serial network can be constructed using the so-called daisy-chain technique, in which the transmit cable of the Master (PC, PLC) is connected to the receive cable of the first node, from where it is looped through to the receive cable of the second node, and so on. The same procedure is followed with the receive cable of the Master, which is looped through to all transmit cables of the drive node. The current generation of Motion Controllers do not require a multiplexer board for serial network operation. Multiplex mode is activated with a new command:

Command	Function	Description
NET	Set Network Mode	Activate RS232 Multiplex mode for network operation. 1: Network operation activated 0: No network operation, single drive on an RS232

Example:
Activate network operation:
NET1

In order to address the individual drives in the network, the node number must be specified before each ASCII command to be sent (e.g. 3LA1000). Commands without a node number are adopted by all drive nodes in the network (Broadcast).

Important: No unaddressed query commands may be sent in network mode, as otherwise all units will answer simultaneously and the message frames will mix, resulting in communication errors.
It must also be ensured that no asynchronous responses are sent by several units simultaneously, and that the command acknowledgement is switched off when using unaddressed transmit commands.

Use the ANSW command to set the response behaviour:

Command	Function	Description
ANSW	Answer Mode	0: No asynchronous responses 1: Permit asynchronous responses 2: All commands with confirmation and asynchronous responses

Example:
Switch off asynchronous responses and command confirmation:
ANSW0

2 Installation

2.5 Basic settings

During initial commissioning of external Motion Controllers, a number of basic settings must be made in order to adjust the controller to the connected servomotor. Use the latest version of FAULHABER Motion Manager (download from Internet) for easy execution of these adjustments.

Failure to observe these basic settings can result in destruction of components!

At delivery, the Motion Controller MCLM 3003/06 S is set to the Linear DC-Servomotor type LM 1247-020-01 as standard. If you wish to connect another motor, you must select the correct motor first of all. For a linear servomotor not shown in the list, select motor type 0 (MOTTYP0)

The FAULHABER Motion Manager then enables the Hall sensor signals to be synchronised for smooth starting and the phase angle to be optimised for best efficiency.

4 times the encoder resolution is entered (quadrature signal processing) via the ENCRES command or the Drive Parameters dialogue in the Motion Manager ("Configuration – Drive functions" menu).

In addition, the controller parameters and the current limitation values must be adapted to the connected servomotor and application.

If using the Fault Pin as input (REFIN, DIRIN), the desired function must be programmed before applying external voltage!

3 Functional Description

The Motion Controller can be configured for different operating modes.

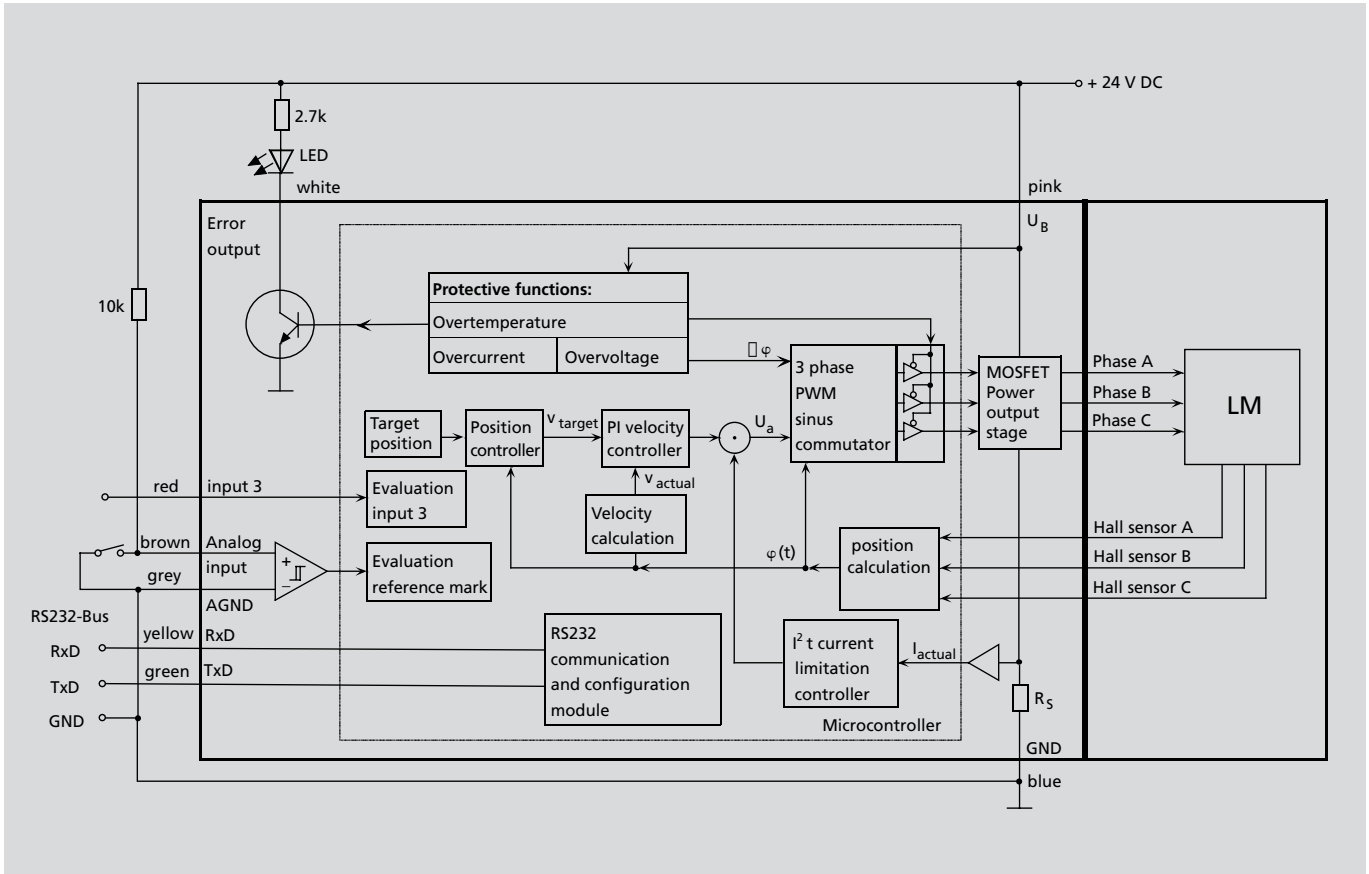
As standard the drive unit is delivered as a servomotor with set value presetting via the serial interface. The drive can be reconfigured by means of the corresponding FAULHABER commands.

If the settings are to be permanently stored, the command SAVE (EEPSAV) must be executed after the configuration; this saves the current settings in the Flash data memory, from where they are reloaded when the unit is next switched on. The prerequisite for operation of the drive in one of the operating modes specified here is that the power stage is activated (EN).

All commands and objects listed below are summarised and explained in the **Parameter Description** chapter.

The FAULHABER Motion Manager 3 enables simple setting of the configuration parameters and operating modes via corresponding dialogue windows. The specified commands can be entered in plain text or selected from the Commands menu.

Circuit example:
MCLM 3006 S with reference switch at analog input and fault pin set as digital output



3 Functional Description

3.1 Position control

In this operating mode, target positions can be preset via the serial interface: FAULHABER operating mode CONTMOD or ENCMOD and SOR0 are set.

Profile and controller parameters are executed via the FAULHABER basic setting commands (General Parameters). In particular the acceleration values AC and DEC, the maximum speed SP, the current limitation values LPC and LCC, as well as the controller parameters POR, I, PP and PD must be adapted to the respective application. The positioning range limits can be set via the command LL and activated via APL. The positioning is executed via the FAULHABER motion control commands:

Command	Function	Description
LA	Load Absolute Position	Load new absolute target position Value range: $-1.8 \cdot 10^9 ... 1.8 \cdot 10^9$
LR	Load Relative Position	Load new relative target position, in relation to last started target position. The resulting absolute target position must lie between $-2.14 \cdot 10^9$ und $2.14 \cdot 10^9$.
M	Initiate Motion	Activate position control and start positioning

The speed and acceleration are given in linear integer values $\frac{mm}{s}$ and $\frac{mm}{s^2}$.

In case the firmware of your MCLM3006C is the version 3150.06A (answer of the ASCII command VER) please contact the manufacturer for a firmware update.

Example:

1. Set acceleration to 100 mm/s²: AC100
2. Set positioning speed to 100 mm/s: SP100
3. Load target position: LA500
4. Start positioning: M

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

Command	Function	Description
NP	Notify Position	Without argument: A "p" is returned when the target position is attained. With argument: A "p" is returned when the specified position is over-travelled.
NPOFF	Notify Position Off	A Notify Position command that has not yet been triggered is deactivated again.

If the linear Hall sensors of the linear servomotors are used as position transducers 3000 pulses per polar pitch are supplied.

In the case of APL0, relative positionings can also be executed beyond the range limits. If the upper (1800000000) or lower limit (–1800000000) is exceeded, counting is continued at 0 without loss of increments.

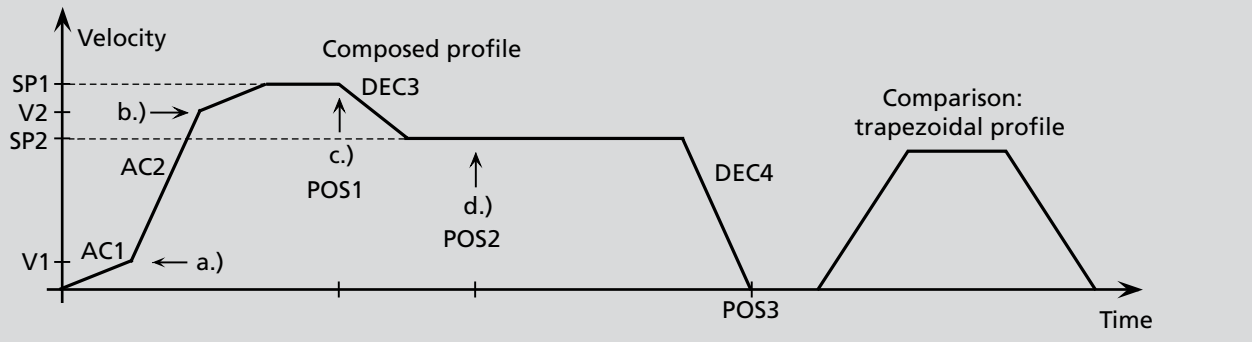
Complex motion profiles
Complicated motion profiles can be generated through skilful presetting of new values (maximum speed, acceleration, end position) during positioning. After a value change, simply execute a new motion start command (M). The commands NP and NV can be used to control the sequence.

Example:
Sequence (respective command sequences after receipt of the Notify condition):

Start:	a.)	b.)	c.)	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[V1]			M	
M				

The following diagram shows the described sequence.

Example of complex motion profile in comparison with trapezoidal profile:



3 Functional Description

3.2 Homing and limit switches

The connections

- AnIn
- Fault
- 3. In

can be used as reference and limit switch inputs.

In linear servomotors the zero crossing of the Hall sensor signals is also available as index pulse, occurring once per polar pitch. The index pulse of an external encoder can also be connected to the fault pin, enabling the actual position to be exactly zeroed.

The AnIn and Fault connections are designed as interrupt inputs, which means that they are edge-triggered. The 3. In digital input is not edge-triggered, so that the signal must be at least 500 µs to be reliably detected.

Set levels of digital inputs:

Command	Function	Description
SETPLC	Set PLC-Inputs	Digital inputs PLC-compatible (24 V level)
SETTTL	Set TTL-Inputs	Digital inputs TTL-compatible (5 V level)

The signal level of the digital inputs can be set using the above commands:

PLC (Default): Low: 0...7.0 V / High: 12.5 V...U_B
TTL: Low: 0...0.5 V / High: 3.5 V...U_B

Configure fault pin as reference or limit switch input:

Command	Function	Description
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 (setting must be saved with SAVE or EEPSAV)!

Important: Configure the fault pin as input before applying external voltage!

The function of the inputs and the homing behaviour is set with the FAULHABER commands described below. A previously configured homing is then started with the following FAULHABER commands:

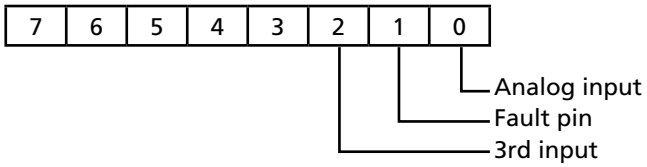
Command	Function	Description
GOHOSEQ	Go Homing Sequence	Execute FAULHABER homing sequence. A homing sequence is executed (if programmed) irrespective of the current mode.
GOHIX	Go Hall Index	Move linear servomotor to Hall zero point (Hall index) and set actual position value to 0
GOIX	Go Encoder Index	Move to the encoder index at the Fault pin and set actual position value to 0 (DC motor or ext. encoder).
POHOSEQ	Power-On Homing Sequence	Start homing automatically after switch-on. 1: Power-On homing sequence activated 0: No homing after switch-on

3 Functional Description

3.2 Homing and limit switches

Configuration of homing and limit switches:

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



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

Polarity and limit switch function:

Command	Function	Description
HP	Hard Polarity	Define effective edge and polarity of respective limit switches: 1: Rising edge and high level effective. 0: Falling edge and low level effective.
HB	Hard Blocking	Activate Hard-Blocking function for relevant limit switch.
HD	Hard Direction	Presetting of direction which is blocked by HB of the respective limit switch. 1: Forward direction blocked 0: Backward direction blocked

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 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 target velocities are preset in the wrong direction.

Example:
Setting of the Hard-Blocking function for Fault pin and 3th input:

$2^1 + 2^2 = 2 + 4 = 6 \rightarrow$ HB6

Definition of homing behaviour:

Command	Function	Description
SHA	Set Home Arming for Homing Sequence	Homing behaviour (GOHOSEQ): Set position value to 0 at edge of respective limit switch.
SHL	Set Hard Limit for Homing Sequence	Homing behaviour (GOHOSEQ): Stop servomotor at edge of respective limit switch.
SHN	Set Hard Notify for Homing Sequence	Homing behaviour (GOHOSEQ): Send a character to RS232 at edge of respective limit switch.

In order to be able to execute a homing sequence with the command GOHOSEQ, a homing sequence must be defined for a specific limit switch!

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.

Example:
Homing with 3rd input as reference input (rising edge):

HP4
SHA4
SHL4
SHN4

Alternatively, the homing sequence can also be set with the command CAHOSEQ in conjunction with the commands HA, HL and HN.

Homing Speed:

Command	Function	Description
HOSP	Load Homing Speed	Load speed and direction of shaft for homing (GOHOSEQ, GOHIX). Unit: mm/s

Example: homing with speed = -30 mm/s

HOSP -30

3 Functional Description

3.2 Homing and limit switches

Direct programming via HA, HL and HN commands:

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

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. The settings are not saved with the SAVE command, so all limit switches are inactive again after switch-on.

HL/SHL command:

Positioning mode: When the edge occurs, the servomotor positions itself on the reference mark with maximum acceleration.

Velocity controller mode: The servomotor 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 command:

Hard Notify (HN) return values to the RS232 interface

Connection	Return value
“AnIn“	h
“Fault“	f
“3.In“	t

3 Functional Description

3.3 Extended operating modes

Use the CONTMOD command to revert from an extended operating mode to normal mode.
You may adjust the digital input range to SETTTL/SETPLC to match the input signal levels.

3.3.1 Stepper motor mode

Command	Function	Description
STEPMOD	Stepper Mode	Change to Stepper mode

In stepper motor mode, the analog 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	Function	Description
DIRIN	Direction Input	Fault pin as shaft direction input

The drive moves one programmable step further for each pulse at the analog input:

- The number of steps per polar 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 servomotor can be used
- The servomotor is very quiet
- The servomotor monitors actual position so that no steps are “lost” (even with maximum dynamics)
- No current flows in settled state (actual position reached)
- High efficiency

Input:
Maximum input frequency: 400 kHz
Level: 5 V TTL or 24 V PLC-compatible, depending on configuration.

Stepper mode enables position-accurate velocity control; any rational ratios can be set for input frequency to servomotor speed, via step width and step number, in accordance with the following formula:

$$\text{Displacement} = \text{pulses} \cdot \frac{STW}{STN} \cdot \text{polar pitch } \tau_m$$

Displacement ...Displacement that are generated on the drive

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

STW ...Step width (step width factor = number of steps per encoder pulse at the frequency input)

STN ...Step number (number of steps = number of steps per polar pitch)

Value range of STN and STW: 0 to 65535

Command	Function	Description
STW	Load Step Width	Load step width for step and gearing mode
STN	Load Step Number	Load number of steps per polar pitch for step and gearing mode

Example:
Motor should move 1/1000th of a polar pitch for each input pulse:
STW1
STN1000

The acceleration and speed values (AC, DEC, SP) are also taken into account in step mode. These permit gentle starting and deceleration. The position range limits set via LL must also be activated with the APL1 command in order to prevent the exit of the shaft.

3.3.2 Gearing mode (electronic gear)

Gearing mode enables the use of an external encoder as set-point source for the position.

Command	Function	Description
GEARMOD	Gearing Mode	Change to gearing mode

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 can be set in accordance with the following formula:

$$\text{Displacement} = \text{pulses} \cdot \frac{STW}{STN} \cdot \text{polar pitch } \tau_m$$

Displacement ...Displacement that are generated on the drive

Impulse ...Actually counted pulses resulting from a four-edge evaluation

STW ...Step width (step width factor = number of steps per encoder pulse)

STN ...Step number (number of steps = number of steps per polar pitch)

3 Functional Description

3.3 Extended operating modes

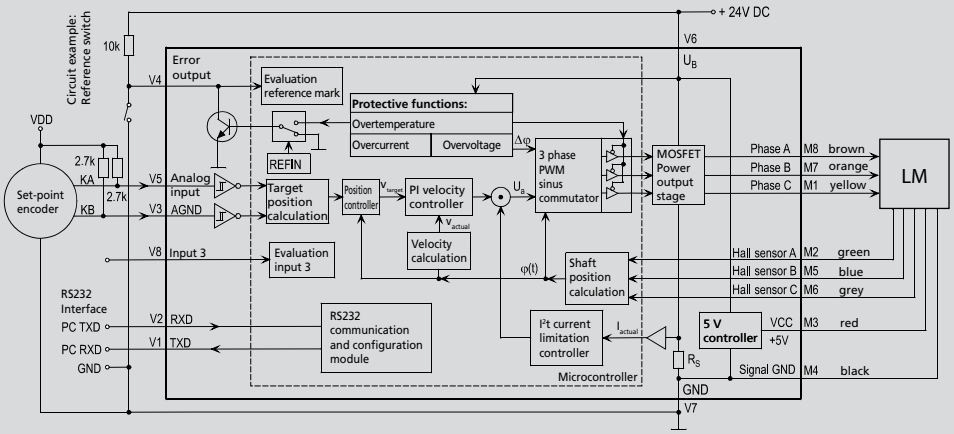
Value range of STN and STW: 0 to 65535

Command	Function	Description
STW	Load Step Width	Load step width for step and gearing mode
STN	Load Step Number	Load number of steps per polar pitch for step and gearing mode

Example: Motor has to move half of polar pitch at 500 pulses of the external encoder:
STW1, STN500

The shaft direction can be predefined with the commands ADL and ADR, or via an external signal at the fault pin (DIRIN command).

The acceleration and speed values (AC, DEC, SP) are also taken into account in gearing mode. These permit gentle starting and deceleration. The position range limits set via LL must also be activated with the APL1 command.



Circuit example gearing mode for MCLM 3003/06 S

3.3.3 Analog positioning mode

In analog positioning mode, the position set-point can be preset via a potentiometer or an external analog voltage.

Command	Function	Description
APCMOD	Analog Position Control Mode	Change to position control via analog voltage

The maximum position to be approached with a voltage of 10 V can be preselected with the LL command. With a voltage of –10 V, the drive moves in the opposite direction.

Command	Function	Description
LL	Load Position Range Limits	Load limit positions (the drive does not move out of these limits in positioning mode, positive values specify the upper limit and negative values specify the lower limit). APCMOD: Position value at 10 V

Irrespective of the preset LL value, the maximum position is limited to 3 000 000 in APCMOD. Note: The resolution of the analog input is limited to 12 bit (4096 steps).

The shaft direction can be predefined with the commands ADL and ADR. The acceleration and speed values (AC, DEC, SP) are also taken into account in APCMOD. These permit gentle starting and deceleration.

Positioning via pulse width signal (PWM) at the analog input (SOR2):

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

At delivery:

- Pulse duty factor >50% ➔ positive target position
- Pulse duty factor =50% ➔ target position = 0
- Pulse duty factor <50% ➔ negative target position

Absolute positioning within one magnetic pitch:

Thanks to the linear Hall sensors, the absolute position can be recorded within the polar pitch. This means that even if the power supply is disconnected, the position determination supplies the correct position value after restarting.

The following commands enable the drive to be accurately positioned in the voltage range 0 V to 10 V and to return to the correct position even after the supply has been switched off, without homing :
APCMOD ...change to analog positioning
LL3000 ...fix maximum position within polar pitch

3 Functional Description

3.3 Extended operating modes

3.3.4 External encoder to determine actual position

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

- The resolution of the position values and the maximum speed are dependent on the resolution of the encoder in this case.
- The position limits must be adjusted when the external encoder is used.
- Depending on the application, the velocity can be derived from the encoder or from the Hall sensors.
- A linear encoder 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 analog Hall sensors.

Command	Function	Description
ENCMOD	Encoder Mode	Change to encoder mode External encoder serves as position transducer (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 in encoder mode

The two channels of the external encoder are connected to connections AnIn (CH A) and AGND (CH B), which may need to be connected to the 5 V encoder supply via a 2.7 kΩ pull-up resistor (see the figure on page 20 for reference).

The maximum limit position (value preset with the LL command) covers the value range from 0 to 1800000000 for the positive and 0 to –1800000000 for the negative limit position.

Input:
Maximum input frequency: 400 kHz
Level: low 0 ... 0.5 V / high 3.5 V… U_B

Set encoder resolution:

Command	Function	Description
ENCRES	Load Encoder Resolution	Load resolution of external encoder. Value range: 0 to 65535 (4 times pulse/mm)

Example:
External linear encoder with 1000 pulses/mm:
Set ENCRES4000

Because of the quadrature signal processing, four times the number of pulses must always be specified for ENCRES.

3.3.5 Analog target current presetting

You can switch to analog target current presetting with the SOR3 command. The limitation current is then proportional to the voltage at the analog input, and the internal I^2t current limitation is deactivated. The set current is weighted with the maximum current LPC. If 10 V are present at the analog input, the current is accordingly limited to the maximum current set with LPC. Even if negative voltages are present at the analog input, the current is limited to the amount of the applied voltage. Negative target current presettings therefore have no effect on the direction of shaft!

3 Functional Description

3.4 Special functions of the error connection

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

Command	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
REFIN	Reference Input	Fault pin as reference or limit switch input

The REFIN and DIRIN functions have already been explained in the relevant chapters.

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

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	Function	Description
DCE	Delayed Current Error	Delayed error output for ERROUT in 1/100 sec.

Example:
Only display error after 2 seconds: DCE200

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

Command	Argument	Function	Description
NE	0-1	Notify Error	Error notification: 1: An “r” is sent back if an error occurs 0: No error notification

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 polar pitch. The pulses are derived from the Hall sensor and are limited to 4000 pulses per second.

Command	Function	Description
LPN	Load Pulse Number	Preset pulse number for ENCOUT. Value range: 1 to 255

Example:
Output 100 pulses per polar pitch at the fault pin: LPN100
In case of 18 mm/s, 100 pulses per second.

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 the timing does not necessarily have to exactly agree (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.

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 deleted via the following commands.

Command	Function	Description
CO	Clear Output	Set digital output DIGOUT to low level
SO	Set Output	Set digital output DIGOUT to high level
TO	Toggle Output	Switch digital output DIGOUT

3 Functional Descriptions

3.5 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 sent also with a preceding node number. The addressed node stores all received instructions thereby, between the commands PROGSEQ and END.

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:

NP ...Notify Position
The sequence stops at the next M command, until the relevant position is reached.

HN ...Hard Notify
The sequence stops at the GOHOSEQ command or at the next M or V command, until the limit switch is overtravelled.

NV ...Notify Velocity
The sequence stops at the next M or V command, until the relevant speed is reached.

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

GOHIX ...Go Hall Index

The sequence stops at the GOHIX command, until the Hall zero position is reached.

Because of the magnetic pitch of the motor, depending on the shaft position there are several Hall zero position in the whole stroke.

The following commands are available for sequence programs:

Command	Argument	Function	Description
PROGSEQ […] END	–	Program Sequence	Defines the start and end of the sequence program. All commands sent to PROGSEQ are not executed, but transferred to the sequence program memory. An END marks the end of the sequence program. All commands after END are directly executed again. There is no SAVE command neccessary for saving the programm sequence. Attention: Command must not be executed more than 10,000 times, as otherwise the function of the Flash memory can no longer be guaranteed. These commands do not have to be entered in the FAULHABER Motion Manager, as they are automatically attached by the “Transfer program file…” function.
GPROGSEQ	–	Get Program Sequence	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 line “end:” is sent, with specification of the program length in bytes followed by a CR and LF character.
ENPROG	–	Enable Program	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 switch-on.
DIPROG	–	Disable Program	Deactivate program execution.
RESUME	–	Resume	Continue program sequence after DIPROG at the point at which it was interrupted.
MEM	–	Memory	Send back available program memory in bytes.

3 Functional Description

3.5 Sequence programs

Additional commands for use within sequence programs:

Command	Argument	Function	Description
DELAY	Value	Delay	Stop sequence for a defined period Argument: in 1/100 seconds Value range: 0 to 65535
TIMEOUT	Value	Timeout	In the case of Notify commands, only wait for the preset time and then continue the sequence again. Send a "o" to RS232 if Notify condition was not fulfilled. Argument: in 1/100 seconds Value range: 0 to 65535 (can also be used via RS232).
JMP	Address	Jump	Jump to the specified address (can also be used via RS232).
JMPGx	Address	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	Address	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	Address	Jump if equal x	Jump to specified address if result of last query command is equal to variable x (A, B, C).
JPH	Address	Jump if Hard-Input activated	Jump to the specified address if the analog input is active (HP determines the polarity).
JPF	Address	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	Address	Jump if 3. Input activated	Jump to the specified address if the 3rd input is active (HP determines the polarity).
SETx	Value	Set Variable x	Set variable x (A, B, C) to the specified value. Value range: Int16 Without argument: Result of last query command is loaded into the variable.
GETx	–	Get Variable x	Query content of variable x (A, B, C).
DxJNZ	Address	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	Address	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. Important: 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	Address	Call Subroutine	Call a subroutine at specified address.
RET	–	Return from Subroutine	Return from a subroutine. Please note that only one subroutine level is possible, i.e. no subroutines can be called within subroutines!
A	Address	Define Address	Definition of current position as entry address for jump commands.

3 Functional Descriptions

3.5 Sequence programs

Explanations of the commands and functions:

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)
LA1000
NP
M
JMP1      ... Return to endless loop
A3        ... Program sequence 3
              (can only be called by JMP3 from the RS232)
LA-1000
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. A JMP2 from the RS232 results in the drive moving to position 1000 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 (analog, fault or 3.IN) 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.

Example:

```
SETA 100
GN
JMPLA3
```

The command JMPLA3 jumps to address 3 if the velocity value returned with GN is less than 100 rpm (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.

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. Please 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.

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).

Notify commands

Notify commands enable you to generate complicated motion profiles.

3 Functional Description

3.5 Sequence programs

Example:
LA1000
SP500
AC50
NV100
M
AC100
NV200
M
AC50
NP
M

With this sequence, the acceleration is increased during boot-up at 100 mm/s². It is decreased again at 50 mm/s².

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

The 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.

General

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 stand-alone operation), a jump command is required at the end of the program.

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 storage size available for sequence programs is 6656 bytes (3328 words).

Examples:

1.) Positioning routines called via RS232

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

- JMP2: Homing Sequence. 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 seconds, in any event. (Further evaluation occurs in the higher level control).

Configuration

SOR0	➔	Digital velocity presetting via RS232
LR0	➔	No motion
M	➔	Switch to position control (Motion 0)
SHA1	➔	Homing Sequence with Notify at AnIn
SHN1		
SHL1		
HOSP20	➔	Homing speed 20 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
A4	➔	Entry point for routine 2 (JMP4)
LPC500	➔	Set current limitation values to 500 mA (continuous current ≤ peak current)
LA1000		
NP		
TIMEOUT500	➔	Continue sequence after 5 sec., even if position has not yet been attained
M	➔	Start positioning
V0	➔	Stop motor
LR0		

(continue to page 27)

3 Functional Descriptions

3.5 Sequence programs

(continue from page 26)

```
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
LR1500
NP
M
DELAY100
LR-1000
NP
M
DELAY50
DAJNZ6     ➔ Repeat loop 1000 times
JMP1       ➔ Return to endless loop
```

Comment:

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.

2.) Sequence controlled via digital input (without RS232)

- After power-on, the drive moves to the limit switch and then the Hall index.
- With a positive edge at the fault pin digital input, the drive moves forward 1500 increments.
- If the level is still high after 1500 increments, the drive moves to position 0.

Configuration

```
SOR0       ➔ Digital velocity presetting via RS232
LR0        ➔ No motion
M          ➔ Switch to position control (Motion 0)
REFIN      ➔ Reprogram error output to input
SHA1       ➔ Homing Sequence with Notify at AnIn
SHN1
SHL1
HOSP-20    ➔ Homing velocity 20 mm/s backwards
HP1        ➔ Rising edge at limit switch effective
POHOSEQ1   ➔ Execute Homing Sequence after
             power-on
ENPROG     ➔ Start motion program after power-on
ANSW0      ➔ No asynchronous responses
EEPSAV     ➔ Save configuration
```

Program

```
GOHOSEQ    ➔ Homing to reference switch
GOHIX      ➔ Subsequent homing to Hall sensor
             zero point (Hall index)
A1
HP3        ➔ High level at input 2 (Fault pin input)
             effective
A2
JPF2       ➔ Endless loop until low level at input 2
HP1        ➔ Low level at input 2 (Fault pin input)
             effective
A3
JPF3       ➔ Endless loop until high level at input 2
             (evaluation of positive edge)
LR1500
NP
M          ➔ Move forward 5000 increments
DELAY50    ➔ Wait 0.5 seconds until input 2 is queried
JPF1       ➔ Jump back to start in case of low level
             at input 2
LA0
NP
M          ➔ Move to position 0,
             if high level at input 22
JMP1       ➔ Jump to start
```

Comment:

With this program, an RS232 interface is no longer required for operation (stand-alone application).

The desired sequence is started with short pulses at the input (e.g. key) and the return is triggered with a continuous signal (e.g. switch).

3 Functional Description

3.6 Trace function

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 command BINSEND1.

Command	Argument	Function	Description
BINSEND	0 – 1	Open Binary Interface	1 = Open binary interface 0 = Close binary interface

Trace configuration:

1. Setting of binary transmit mode for parameter 1 (curve 1):
   2 binary characters are sent in direct succession: [Command][Mode1]
   The relevant value is switched to, depending on the value of Mode1.

   Command:
   200: Set binary transmit mode for parameter 1

   Mode 1:

   0: Current 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]

2. Setting of binary transmit mode for parameter 2 (curve 2):
   2 binary characters are sent in direct succession: [Command][Mode2]
   The relevant value is switched to, depending on the value of Mode2.

   Command:
   202: Set binary transmit mode for parameter 2

   Mode 2:

   0: Current 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: No second parameter is sent (basic setting at power-on)

Data request:

A binary character is sent: [Request]
Depending on the set modes (Commands 200 and 202), 3,5,7 or 9 bytes are sent back to the PC.

Request:
201: Request for a data packet

After setting a mode you must wait at least 2 ms before requesting valid data.

Received data (after request 201):

1.) Mode1 between 0 and 15,
Mode2 at 255 (inactive)

➔ 3 byte… 1st byte: Low byte data
2nd byte: High byte data
3rd byte: Time code

The data are in Integer16 format.

2.) Mode1 between 16 and 199,
Mode2 at 255 (inactive)
➔ 3 byte ... Coding as in 1.)
The data are in Unsigned16 format.

3.) Mode1 between 200 and 255,
Mode2 at 255 (inactive)
➔ 5 byte ... 1st byte: Lowest byte data
2nd byte: Second byte data
3rd byte: Third byte data
4th byte: Highest byte data
5th byte: Time code
The data are in Integer32 format.

4.) Mode1 corresponding to 1.), 2.) or 3.) and Mode2 less than 255:
➔ 5 to 8 byte ... Byte 1 to 2 (4):
Data bytes of Mode1
Byte 3 (5) to 4 (6) (8):
Data bytes of Mode2
Byte 5 (7): Time code

The data bytes of Mode2 are coded as for Mode1.

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

3 Functional Description

3.7 Technical information

3.7.1 Sinus commutation

The MCLM 3003/06 S are characterised by a so-called sinus commutation. This means that the preset magnetic field is always ideally positioned in relation to the shaft. As a result, force fluctuations can be reduced to a minimum, even at very low speeds. In addition, the servomotor moves particularly quietly.

In the current version, the sinus commutation has been extended by a so-called flat-top modulation, which enables 15 % more modulation. As a result, higher no-load speeds are possible. With the SIN0 command, the system can even be set so that over 30 % more modulation is possible. In this mode, the sinus commutation in the upper speed range switches over to a block commutation. This full modulation enables the complete speed range of the servomotor to be utilised.

Command	Function	Description
SIN	Sinus Commutation	0: Full modulation 1: Limitation to sinus form

3.7.2 Current controller and I^2t current limitation

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

The following parameters can be set:

Command	Function	Description
LPC	Load Peak Current Limit	Load peak current Value range: 0 to 12000 mA
LCC	Load Continuous Current Limit	Load continuous current Value range: 0 to 12000 mA
CI	Load Current Integral Term	Load integral term for current controller Value range: 1…255

1.) Peak current

FAULHABER command:
LPC1500 ➔ set peak current to 1500 mA

The current is limited to the peak current, provided that the thermal current model calculates a non-critical temperature.

2.) Continuous current

FAULHABER command:
LCC600 ➔ set continuous current to 600 mA

If the thermal current model reaches a critical temperature, continuous current is switched to.

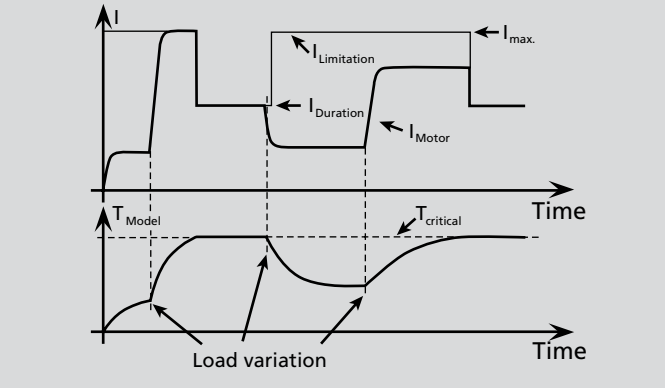
Mode of operation of the current controller:

When the servomotor starts, the peak current is preset as the set-point for the current controller. As the load increases, the current in the servomotor 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 limitation is to prevent heating of the servomotor beyond the thermally permissible temperature through appropriate selection of the continuous current. On the other hand, a high load should be temporarily possible in order to enable very dynamic movements.

Functioning of the I^2t current limitation:



3.7.3 Overtemperature protection

If the MOSFET temperature of the external controllers 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

Note on determination of the coil 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 servomotor protection device.

3 Functional Description

3.7 Technical information

3.7.4 Undervoltage 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.

3.7.5 Overvoltage regulation

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

In order to avoid severe damage to components, the MCLM 3003/06 S contain a position limiter which adjusts the shaft displacement position if a limit voltage (32 V) is exceeded.

3.7.6 Adjustment of the controller parameters

The controller parameters are already preset for common applications. However, in order to optimally adapt the controller to the respective application, the controller parameters must be optimized. Various theoretical and practical adjustment rules exist, but these will not be described in more detail here. A simple, practical method of adjusting the controller is explained below.

The digital controller operates at a sampling rate of 100 µs. When needed the sampling rate can be increased up to 2 ms via the command SR.

The following controller parameters are available:

Command	Function	Description
POR	Load Velocity Proportional Term	Load velocity controller amplification. Value range: 1 – 255.
I	Load Velocity Integral Term	Load velocity controller integral term. Value range: 1 – 255.
PP	Load Position Proportional Term	Load position controller amplification Value range: 1 – 255.
PD	Load Position D-Term	Load position controller D-term. Value range: 1 – 255.
SR	Load Sampling Rate	Load sampling rate of the velocity controller as a multiplier of 100 µs. Value Range: 1...20 ms/10

Possible procedure

Set parameters of position controller:

1.) Set initial configuration
- Default value for P term: 80; PP80
- Default value for D term: 10; PD10

2.) Motion profiles appropriate for the application must now be run. 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.

3.) The P term of the position controller can now be increased until the system becomes unstable, in order to optimise the motion profile.

4.) The stability can then be restored through the following measures:
- Increasing the D term of the position controller (example: PD20)
- Reducing the I term of the velocity controller

Positioning parameters tuning examples:

1. Positioning via analogue Hall sensor (CONTMOD)

a) very strong and fast position control with minimal overshot
POR70, I3, PP220, PD10, SR10, AC30000, DEC4000, SP1000

b) soft and fast position control (only parameters changed)
POR25, DEC3000

c) soft and slow positioning
SP10, POR38, I80, SR10

2. Positioning via linear encoder with 200 Inc/mm (ENCMOD with ENCSPEED)

a) very strong and fast position control with minimal overshot
POR190, I20, PP220, PD10, SR1, AC30000, DEC10000, SP1000

b) soft and fast position control (only parameters changed)
POR28, DEC3000,

c) soft and slow positioning
SP10, POR38, I60, SR10,

4 Parameter Description

All ASCII commands that are available for operation of the FAULHABER Motion Controllers are listed below.

The ASCII commands have the following structure:

[Node no.]	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.

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).

Example:

Actual position queries:
Transmit: POS[CR]
Receive: 98956[CR][LF]

If ANSW2 is set, you will receive an "OK" when the command has been successfully executed. If an execution error occurred you will receive one of the following character strings:

"Unknown command"
"Invalid parameter"
"Command not available"
"Overtemperature – drive disabled"

Example:

Transmit: LA1000[CR]
Receive: OK[CR][LF]

The SAVE/EEPSAV command always responds with the character string "EEPROM writing done" after successful saving of the current settings in the data Flash memory, or with "Flash defect", if the save has failed.

4 Parameter Description

4.1 Basic setting commands

The commands listed here are used for the configuration of basic setting parameters:

4.1.1 Commands for special operating modes

Command	Argument	Function	Description
SOR	0-3	Source For Velocity	Source for velocity presetting 0: Serial interface (default) 1: Voltage at analog input 2: PWM signal at analog input 3: Current set-point via analog input
CONTMOD	–	Continuous Mode	Switch back from an extended mode to normal mode
STEPMOD	–	Stepper Motor Mode	Switch to stepper mode
APCMOD	–	Analog Position Control Mode	Switch to position control via analog voltage
ENCMOD	–	Encoder Mode	Switch 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 in encoder mode
GEARMOD	–	Gearing Mode	Switch to gearing mode

4.1.2 Parameters for basic settings

Command	Argument	Function	Description
ENCRES	Value	Load Encoder Resolution	Load resolution from external encoder. Value: 0 to 65535 (4 times pulse/mm)
MOTTYP	0	LM Motor Type	Setting for connected LM motor. 0: BL special motor according to KN and RM
KN	Value	Load Speed Constant	Equivalent speed constant K_n according to K_e parameter in data sheet Unit: mm/V.
RM	Value	Load Motor Resistance	Equivalent motor resistance R_M according to specification in data sheet. Unit: mOhm.
STW	Value	Load Step Width	Load step width for step motor and gearing mode Value range: 0...65535
STN	Value	Load Step Number	Load number of steps per polar pitch for step motor and gearing mode Value range: 0...65535
ADL	–	Analog Direction Left	Positive voltages at the analog input result in left movement of the shaft (SOR1, SOR2)

4 Parameter Description

4.1 Basic setting commands

ADR	–	Analog Direction Right	Positive voltages at the analog input result in right movement of the shaft (SOR1, SOR2)
SIN	0-1	Sinus Commutation	1: No block commutation in the upper velocity range (default) 0: Block commutation in the upper velocity range (full modulation)
NET	0-1	Set Network Mode	Activate RS232 multiplex mode for network operation. 1: Network operation activated 0: No network operation, single drive on an RS232
BAUD	Value	Select Baud Rate	Preset transfer rate for RS232 interface
NODEADR	Value	Define Node Address	Set node number Value range: 0…255
ANSW	0-2	Answer Mode	0: No asynchronous responses 1: Permit asynchronous responses 2: All commands with confirmation and asynchronous responses

4.1.3 General parameters

Command	Argument	Function	Description
LL	Value	Load Position Range Limits	Load limit positions (the drive cannot be moved out of these limits). Positive values specify the upper limit and negative values the lower. The range limits are only active if APL1 is. Value range: $-1.8 \cdot 10^9 ... +1.8 \cdot 10^9$
APL	0-1	Activate / Deactivate Position Limits	Activate range limits (LL) (valid for all operating modes). 1: Position limits activated 0: Position limits deactivated
SP	Value	Load Maximum Speed	Load maximum speed. Value range: –10000 to 10000 mm/s Setting applies for all modes.
AC	Value	Load Command Acceleration	Load acceleration value. Value range: 0…30000 mm/s²
DEC	Value	Load Command Deceleration	Load deceleration value Value range: 0…30000 mm/s²
SR	Value	Load Sampling Rate	Load sampling rate of the velocity controller as a multiplier of 100 µs. Value Range: 1...20 ms/10
POR	Value	Load Velocity Proportional Term	Load velocity controller amplification. Value range: 1…255
I	Value	Load Velocity Integral Term	Load velocity controller integral term. Value range: 1…255
PP	Value	Load Position Proportional Term	Load position controller amplification. Value range: 1…255
PD	Value	Load Position Differential Term	Load position controller D-term. Value range: 1…255
CI	Value	Load Current Integral Term	Load integral term for current controller. Value range: 1…255
LPC	Value	Load Peak Current Limit	Load peak current. Value range: 0…12000 mA
LCC	Value	Load Continuous Current Limit	Load continuous current. Value range: 0…12000 mA
DEV	Value	Load Deviation	Load maximum permissible deviation of actual velocity from target velocity (deviation) Value range: 0…32767
CORRIDOR	Value	Load Corridor	Window around the target position. Value range: 0…65535

4 Parameter Description

4.1 Basic setting commands

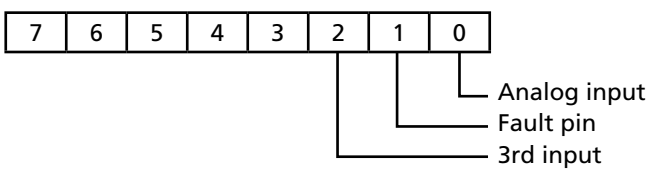
4.1.4 Configuration of fault pin and digital inputs

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.
DIRIN	–	Direction Input	Fault pin as rotational direction input
REFIN	–	Reference Input	Fault pin as reference or limit switch input
DCE	Value	Delayed Current Error	Delayed error output for ERROUT in 1/100 sec. Value range: 0…65535
LPN	Value	Load Pulse Number	Preset pulse number for ENCOUT. Value range: 1…255
CO	–	Clear Output	Set digital output DIGOUT to low level
SO	–	Set Output	Set digital output DIGOUT to high level
TO	–	Toggle Output	Switch digital output DIGOUT
SETPLC	–	Set PLC inputs	Digital inputs PLC-compatible (24 V level)
SETTTL	–	Set TTL inputs	Digital inputs TTL-compatible (5 V level)

4.1.5 Configuration of homing and limit switches in FAULHABER mode

Command	Argument	Function	Description
HP	Value	Hard Polarity	Define valid edge and polarity of respective limit switches: 1: Rising edge or high level valid. 0: Falling edge or low level valid.
HB	Value	Hard Blocking	Activate Hard Blocking function for relevant limit switch.
HD	Value	Hard Direction	Presetting of direction of shaft that is blocked with HB of respective limit switch. 1: right movement blocked 0: left movement blocked
SHA	Value	Set Home Arming for Homing Sequence	Homing behaviour (GOHOSEQ): Set position value to 0 at edge of respective limit switch.
SHL	Value	Set Hard Limit for Homing Sequence	Homing behaviour (GOHOSEQ): Stop motor at edge of respective limit switch.
SHN	Value	Set Hard Notify for Homing Sequence	Homing behaviour (GOHOSEQ): Send character to RS232 at edge of respective limit switch.
HOSP	Value	Load Homing Speed	Load speed and direction of shaft for homing (GOHOSEQ, GOHIX, GOIX). Value range: –10000 … 10000 mm/s
POHOSEQ	0-1	Power-On Homing Sequence	Start homing automatically after power-on. 1: Power-On Homing Sequence activated. 0: No homing after power-on.
HA	Value	Home Arming	Set position value to 0 and delete relevant HA bit at edge of respective limit switch. Setting is not stored.
HL	Value	Hard Limit	Stop motor and delete relevant HL bit at edge of respective limit switch. Setting is not stored.
HN	Value	Hard Notify	Send character to RS232 and delete relevant HN bit at edge of respective limit switch. Setting is not stored.

Limit switch bit mask:



4 Parameter Description

4.2 Query commands for basic settings

4.2.1 Operating modes and general parameters

Command	Argument	Function	Description	
CST	–	Configuration Status	Set operating mode. Return value binary coded (LSB=Bit 0): Bit 0, don't care Bit 1-2: Automatic responses 0: ANSW0 (no automatic responses) 1: ANSW1 (asynchronous responses) 2: ANSW2 (additional command acknowledgements) Bit 3-4, Velocity presetting: 0:SOR0 (RS232 interface) 1:SOR1 (Analog voltage) 2:SOR2 (PWM signal) 3:SOR3 (current limitation value) Bit 5-6, reserved Bit 7-9, FAULHABER mode: 0:CONTMOD 1:STEPMOD 2:APCMOD 3:ENCMOD / HALLSPEED 4:ENCMOD / ENCSPEED 5:GEARMOD Bit 10, Power amplifier: 0:Disabled (DI) 1:Enabled (EN) Bit 11, Position controller: 0: Switched off 1: Switched on Bit 12, Analog direction of shaft: 0:ADL 1:ADR Bit 13, Position Limits APL: 0:Deactivated 1:Activated Bit 14, Sinus commutation SIN: 0:Permit block commutation 1:Do not permit block commutation Bit 15, Network operation 0: NET0 (Single device on an RS232) 1: NET1 (Multiplex mode activated)	
GMOD	–	Get Mode	MCLM	Get FAULHABER mode
			c	CONTIMOD
			s	STEPMOD
			a	APCMOD
			h	ENCMOD
			e	ENCSPEED
			g	GEARMOD

4 Parameter Description

4.2 Query commands for basic settings

Command	Argument	Function	Description
GENCRES	–	Get Encoder Resolution	Get encoder resolution ENCRES
GMOTTYP	–	Get Motor Type	Get servomotor type (MOTTYP)
GKN	–	Get Speed Constant	Speed constant for MOTTYP0
GRM	–	Get Motor Resistance	Motor resistance for MOTTYP0
GTYP	–	Get Controller Type	Query controller designation
GSER	–	Get Serial Number	Query serial number
GSTW	–	Get Step Width	Get step width STW
GSTN	–	Get Step Number	Get step number per revolution STN
GMV	–	Get Minimum Velocity	Get minimum speed MV in mm/s
GMAV	–	Get Minimum Analog Voltage	Get minimum start voltage value MAV in mV
GPL	–	Get Positive Limit	Get positive limit position LL
GNL	–	Get Negative Limit	Get negative limit position LL
GSP	–	Get Maximum Speed	Get maximum speed SP in mm/s
GAC	–	Get Acceleration	Get acceleration value AC in mm/s²
GDEC	–	Get Deceleration	Get deceleration value DEC in mm/s²
GSR	–	Get Sampling Rate	Get sampling rate of velocity controller in ms/10
GPOR	–	Get Velocity Prop. Term	Get amplification value of velocity controller POR
GI	–	Get Velocity Integral Term	Get integral term of velocity controller I
GPP	–	Get Position Prop. Term	Get amplification value of position controller PP
GPD	–	Get Position D-Term	Get D-term of position controller PD
GCI	–	Get Current Integral Term	Get integral term of current controller CI
GPC	–	Get Peak Current	Get peak current PC in mA
GCC	–	Get Continuous Current	Get continuous current CC in mA
GDEV	–	Get Deviation	Get deviation value DEV
GCORRIDOR	–	Get Corridor	Get window around target position
GNODEADR	–	Get Node Address	Get node number

4 Parameter Description

4.2 Query commands for basic settings

Query commands of predecessor models that are no longer supported for reasons of compatibility:

Command	Argument	Function	Description
GST	–	Get Status	Report current status. 7 ASCII characters “0” and “1” from left to right: Pos. 0: 1: Position controller active 0: Velocity controller active Pos. 1: 1: Velocity presetting analog or PWM 0: Velocity presetting via RS232 Pos. 2: 1: Velocity presetting via PWM (Pos. 1 = 1) 0: Velocity presetting analog (Pos. 1 = 1) Pos. 3: 1: Drive is active (enabled) 0: Drive is inactive (disabled) Pos. 4: 1. Target position attained 0: Target position not attained Pos. 5: 1. Positive limit switch edge effective 0: Negative limit switch edge effective Pos. 6: 1: Limit switch at high level 0: Limit switch at low level
GFS	–	Get Fault Status	Report status of error output. 4 ASCII characters “0” and “1” from left to right (0=no error, 1=error): Pos. 0: Overtemperature protection Pos. 1: Current limitation controller Pos. 2: Reserved (always 0) Pos. 3: Overvoltage regulator
GAST	–	Get Actual Status	Report current status. 4 ASCII characters “0” and “1” from left to right: Pos. 0: 1: Limit switch 2 at high level 0: Limit switch 2 at low level Pos. 1: 1: Limit switch 3 at high level 0: Limit switch 3 at low level Pos. 2: 1: Right movement with positive values 0: Left movement with positive values Pos. 3: 1: Homing still active 0: Homing ended

4 Parameter Description

4.2 Query commands for basic settings

Command	Argument	Function	Description
GSCS	–	Get Special Configuration Set	Report special settings. 8 ASCII characters “0” and “1” from left to right: Pos. 0: 1: Release homing after power-on 0: Homing blocked after power-on Pos. 1: 1: Fault pin is input 0: Fault pin is output Pos. 2: 1: Pulse output at fault pin (Pos. 1=0) 0: Error signal at fault pin (Pos. 1=0) Pos. 3: 1: Pos. 1=1: Fault pin is shaft direction input Pos. 1=0: Fault pin is digital output 0: Pos. 1=1: Fault pin is limit switch input 2 Pos. 1=0: Fault pin is not digital output Pos. 4: 1: Positive edge at limit switch 2 effective 0: Negative edge at limit switch 2 effective Pos. 5: 1: Positive edge at limit switch 3 effective 0: Negative edge at limit switch 3 effective Pos. 6: 1: Release motion program 0: Motion program blocked Pos. 7: 1: Release automatic responses 0: No automatic responses
GES	–	Get Enhanced Status	Report enhanced status. 5 ASCII characters “0” and “1” from left to right: Pos. 0: Reserved Pos. 1: Reserved Pos. 2: 1: Analog target current presetting active 0: No analog target current presetting Pos. 3: 1: Position limits active in all modes 0: Position limits inactive Pos. 4: 1: Deviation error is present 0: No deviation error present
GAHS	–	Get Actual Homing Status	Current reference switch settings. 5 ASCII characters “0” to “7” from left to right: Pos. 0: HA value Pos. 1: HL value Pos. 2: HN value Pos. 3: HB value Pos. 4: HD value
GHSC	–	Get Homing Sequence Configuration	Setting of homing sequence. 3 ASCII characters “0” to “7” from left to right: Pos. 0: SHA value Pos. 1: SHL value Pos. 2: SHN value

4 Parameter Description

4.2 Query commands for basic settings

4.2.2 Configuration of fault pin and digital inputs

Command	Argument	Function	Description
IOC	–	I/O Configuration	Set input/output configuration. Return value binary coded (LSB=Bit 0): Bit 0-7, Hard Blocking: 0-7: Function active for input 1-3 Bit 8-15, Hard Polarity: 0-7: Rising edge at input 1-3 Bit 16-23, Hard Direction: 0-7: Right movements stored at input 1-3 Bit 24, State of digital output: 0: Low 1: High Bit 25, Level of digital inputs: 0: TTL level (5V) 1: PLC level (24 V) Bit 26-28, Function of fault pin: 0: ERROUT 1: ENCOUT 2: DIGOUT 3: DIRIN 4: REFIN
GDCE	–	Get Delayed Current Error	Set value of error output delay DCE
GPN	–	Get Pulse Number	Set pulse number LPN

4.2.3 Configuration of homing

Command	Argument	Function	Description
HOC	–	Homing Configuration	Set homing configuration. Return values binary coded (LSB=Bit 0): Bit 0-7, SHA setting for input 1-8 Bit 8-15, SHN setting for input 1-8 Bit 16-23, SHL setting for input 1-8 (input 6-8: Reserved) Bit 24, Power-On Homing Sequence 0: deactivated 1: activated (homing after power-on)
GHOSP	–	Get Homing Speed	Get homing speed in mm/s

4 Parameter Description

4.3 Miscellaneous commands

Command	Argument	Function	Description
NE	0-1	Notify Error	Notification in the event of error 1: An "r" is returned if an error occurs 0: No notification in the event of error
SAVE EEPSAV	–	Save Parameters	Save current parameters and configuration setting to Flash memory. The drive will also start with these settings when next switched on. Attention: Command must not be executed more than 10,000 times, as otherwise the function of the Flash memory can no longer be guaranteed.
RESET	–	Reset	Restart drive node.
RN	–	Reset Node	Set parameters to original values (ROM values) (current, acceleration, controller parameters, maximum speed, limit positions…)
FCONFIG	–	Factory Configuration	All configurations and values are reset to the delivery status. The drive is deactivated after this command.

4 Parameter Description

4.4 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	Value	Load Absolute Position	Load new absolute target position. Value range: $-1.8 \cdot 10^9 \ldots 1.8 \cdot 10^9$
LR	Value	Load Relative Position	Load new relative target position, in relation to last started target position. Resulting absolute target position must be between $-2.14 \cdot 10^9$ and $2.14 \cdot 10^9$.
NP	–/Value	Notify Position	Without argument: A "p" is returned when the target position is attained. With argument: When the specified position is over-travelled, a "p" is returned Value range: $-1.8 \cdot 10^9 \ldots 1.8 \cdot 10^9$
NPOFF	–	Notify Position Off	A Notify Position command that has not yet been triggered is deactivated again.
GOHOSEQ	–	Go Homing Sequence	Execute FAULHABER homing sequence. A homing sequence is executed (if programmed) independently of the current mode.
GOHIX	–	Go Hall Index	Move linear servomotor 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 (ext. encoder)
HO	–/Value	Define Home-Position	Without argument: Set actual position to 0. With argument: Set actual position to specified value. Value range: $-1.8 \cdot 10^9 \ldots +1.8 \cdot 10^9$

4 Parameter Description

4.5 General query commands

Command	Argument	Function	Description
POS	–	Get Actual Position	Current actual position
TPOS	–	Get Target Position	Target position of last M command
GV	–	Get Velocity	Current target velocity in mm/s
GN	–	Get N	Current actual velocity in mm/s
GRU	–	Get Real PWM Voltage	Current controller output value
GCL	–	Get Current Limit	Current limitation current in mA
GRC	–	Get Real Current	Current actual current in mA
TEM	–	Get Temperature	Current housing temperature in °C
VER	–	Get Version	Current software version
OST	–	Operation Status	Display current operating status. Return value binary coded (LSB=Bit 0): Bit 0: Homing running Bit 1: Program sequence running Bit 2: Program sequence stopped because of DELAY command Bit 3: Program sequence stopped because of NOTIFY command Bit 4: Current limitation active Bit 5: Deviation error Bit 6: Overvoltage Bit 7: Overtemperature Bit 8: Status input 1 Bit 9: Status input 2 Bit 10: Status input 3 Bit 13-15: Reserved for further inputs Bit 16: Position attained
SWS	–	Switch Status	Temporary limit switch settings. Return value binary coded (LSB = Bit 0): Bit 0-7: HA setting for input 1-8 Bit 8-15: HN setting for input 1-8 Bit 16-23: HL setting for input 1-8 Bit 24-31: Specifies which limit switch 1-8 has already switched (is reset again when the respective input is reset)

4 Parameter Description

4.6 Commands for sequence programs

Commands for generating and executing sequence programs:

Command	Argument	Function	Description
PROGSEQ […] END	–	Program Sequence	Defines the start and end of a sequence program. All commands sent to PROGSEQ are not executed, but transferred to the sequence program memory. An END marks the end of the sequence program. There is no SAVE command neccessary for saving the programm sequence. Attention: Command must not be executed more than 10,000 times, as otherwise the function of the Flash memory can no longer be guaranteed. All commands after END are directly executed again. These commands do not have to be entered in the FAULHABER Motion Manager, as they are automatically attached by the "Transfer program file…" function.
GPROGSEQ	–	Get Program Sequence	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 line "end:" is sent, with specification of the program length in bytes followed by a CR and LF character.
ENPROG	–	Enable Program	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 switch-on.
DIPROG	–	Disable Program	Deactivate program execution.
RESUME	–	Resume	Continue program sequence after DIPROG at the point where it was interrupted.
MEM	–	Memory	Send back available program memory in words.

4 Parameter Description

4.6 Commands for sequence programs

Additional commands for use within sequence programs:

Command	Argument	Function	Description
DELAY	Value	Delay	Stop sequence for a defined period Argument: in 1/100 seconds Value: 0…65535
TIMEOUT	Value	Timeout	With Notify commands, only wait for the specified time and then continue the sequence again. A "o" on RS232 if Notify condition has not been fulfilled. Argument: in 1/100 seconds Value: 0….65535 (Can also be used via RS232).
JMP	Adr	Jump	Jump to specified address. (Can also be used via RS232). Address: 0…255
JMPGx	Adr	Jump if greater than x	Jump to specified address if result of last query command is greater than the variable x (A, B, C).
JMPLx	Adr	Jump if less than x	Jump to specified address if result of last query command is less than the variable x (A, B, C).
JMPEx	Adr	Jump if equal x	Jump to specified address if result of last query command is equal to the variable x (A, B, C).
JPH	Adr	Jump if Hard-Input activated	Jump to specified address if Analog Input is active (HP defines the polarity). Address: 0…255
JPF	Adr	Jump if Fault-Input activated	Jump to specified address if Fault Pin Input is active (HP defines the polarity). Address: 0…255
JPT	Adr	Jump if 3. Input activated	Jump to specified address if the 3rd Input is active (HP defines the polarity). Address: 0…255
SETx	Value	Set Variable x	Set Variable x (A, B, C) to specified value. Value: 0…65535
GETx	–	Get Variable x	Query content of Variable x (A, B, C).
DxJNZ	Adr	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. Address: 0…255
ERI	Adr	Error Interrupt	An Error Interrupt is activated from execution of this command. This means that whenever an error occurs after this (overvoltage, current limitation…), the sequence branches to the specified address. Error handling mode is ended when a JMP or RETI command is executed. Address: 0…255
RETI	–	Return Error Interrupt	Return from an error handling routine. Important: The interrupted command will no longer be executed, even if it had not been completed at the time of the interruption!
DIERI	–	Disable Error Interrupt	The ERI command is deactivated, i.e. in the event of an error the sequence no longer jumps to the error handling routine.
CALL	Adr	Call Subroutine	Call a subroutine at specified address. Address: 0…255
RET	–	Return from Subroutine	Return from a subroutine. Please note that only one subroutine level is possible, i.e. no subroutines may be called within subroutines!
A	Adr	Define Address	Definition of the current position as entry address for jump commands Address: 0…255

5 Appendix

5.1 EC Directive/National legislation

According to the EC Directive, all electrically driven machines, equipment and systems produced, imported and sold within the European Union must carry a CE mark.

The EC Directive consists of the following individual Directives which are important for the users of electric motors.

Machinery Directive (98/37/EC):

It applies to independently functioning machines or a chain of machines forming whole plants or systems. For built in components, non-operational machines, a manufacturer's declaration is submitted according to Annex II B of the Machinery Directive 98/37/EC.

Low Voltage Directive (2006/95/EC):

It applies to all drives with a nominal voltage from 75 to 1,500 V DC, or from 50 to 1,000 V AC. The drives described in this instruction manual do not fall within the scope of this Directive as they are designed for smaller voltages.

EMC Directive (2004/108/EC):

The Electromagnetic Compatibility (EMC) Directive applies to all electronic and electrical equipment, plant and systems, which are also sold to end users (consumers). These speed controllers therefore fall within the scope of this Directive.

The CE mark indicates that the speed controllers listed in this instruction manual fulfil the requirements

of the EMC Directive.

Compliance is documented by the Declaration of Conformity.

5.2. Declaration of Conformity and CE marking

FAULHABER drive systems and components are parts manufactured and supplied exclusively for the purpose of further processing by persons who have the requisite level of expertise within the area of electromagnetic compatibility. Therefore, CE marking is not required.

The EC Directive (European Communities) governing CE marking applies solely to products which are brought onto the market. These products must comply with all relevant requirements, particularly the EMC Directive 2004/108/EC.

Test certificates for individual motors, issued in accordance with EU standards, are available on request.

5.3. Electromagnetic compatibility (EMC)

5.3.1 Definition

Electromagnetic compatibility is defined as the ability of a device, unit of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. [EMC Directive].

5.3.2 EMC Directives and Standards

Motion Controller MCLM 3006 S comply with the EMC Directive 2004/108/EG if used as intended. Proof of this has been furnished demonstrating compliance with the following Harmonised Standards:

- EN 61000-6-4:
  Generic standards – Emission standard for industrial environments
- EN 61000-6-2:
  Generic standards – Immunity for industrial environments

The aforesaid Generic Standards prescribe certain standardised tests for the emitted-interference and interference-immunity tests. The following tests are required due to the connections on the MCLM:

Generic Standard on Emitted Interference:

- EN 55011, Class A:
  Electromagnetic disturbance characteristics

Generic Standard on Interference Immunity

- EN 61000-4-2:
  Electrostatic discharge
- EN 61000-4-3:
  Radiated, radio-frequency, electromagnetic field
- EN 61000-4-4:
  Electrical fast transient / burst
- EN 61000-4-5:
  Surge immunity test
- EN 61000-4-6:
  Immunity to conducted disturbances, induced by radio-frequency fields
- EN 61000-4-8:
  Power frequency magnetic field immunity test

All these tests have been conducted and passed.

5 Appendix

5.3.3 Information on use as intended

Please note the following for the devices (see also Chapter 2 Installation):

Preconditions for use as intended:

- Operation in accordance with the technical data and the User Manual.

Restrictions:

- The device MCLM 3006 S is intended for use only in the industrial sector.
- If the devices are used in the home, in business or in commerce or in a small business, appropriate measures must be taken to ensure that the emitted interference is below the permitted limits!
- None of the connection leads, with the exception of the power supply, may exceed a length of 3 m.
- The connection leads between Motion Controller and motor must be shielded as of a length of 30 cm on MCLM.

Installation instructions:

- The power supply and motor supply leads must each be routed directly on the device (MCLM 3006 S), each with two windings, through a suitable ferrite sleeve (e.g. Würth Elektronik No.: 742 700 90 or FAULHABER, Item No.: 6501.00068).
- The signal leads of the MCLM 3006 S must be routed directly on the device with two windings through an interference-suppression ring (e.g. Würth Elektronik No.: 742 715 3, FAULHABER, Item No.: 6501.00069).
- There is a risk that damage may occur as the result of electrostatic discharges at the connection contacts (e.g. D-SUB connector and terminal strip). In order to avoid such discharges, these connectors should be covered by suitable protective caps.

Information on scope and frequency of maintenance:

- See Chapter 2.1.4 Maintenance

5.4 Configuration at delivery

The standard configuration parameters with which the units are delivered are listed below. These settings can also be reloaded at any time with the command FCONFIG, followed by a hardware reset

MCLM 3003/06 S:

FAULHABER Command	Description
CONTMOD	Normal operation
MOTTYP0	Special motor type
APL1	Position limits activated
SOR0	Velocity presetting via RS232
ERROUT	Fault pin = Error output
HP7	All inputs react to rising edge
HB0, HD0	No Hard Blocking limit switch defined
HOSP20	Homing Speed = 20 mm/s
SHA0, SHL0, SHN0	No FAULHABER homing sequence defined
ADR	Analog direction right
LPC1440	Peak current limitation = 1.44 A
LCC480	Continuous current limitation = 480 mA
AC30000	Acceleration = 30000 mm/s²
DEC4000	Deceleration ramp = 4000 mm/s²
SR1	Sampling rate = 100 µs
I10	I-term of velocity controller
POR20	P-term of velocity controller
PP80	P-term of position controller
PD10	D-term of position controller
CI40	I-term of current controller
SP500	Limitation of maximum velocity
LL1666	Upper positioning range limit
LL-1666	Lower positioning range limit
LPN16	Numeric value for pulse output
STW1	Step width for special operation
STN1000	Step number for special operation
ENCRES2048	Resolution of external encoder
DEV30000	Do not monitor deviation error
DCE200	Error delay 2 sec.
CORRIDOR20	Target corridor for positionings
SIN1	Do not permit block commutation
SETPLC	Digital inputs PLC-compatible
NET0	Multiplex mode deactivated
BAUD9600	Transfer rate 9600 baud
NODEADR0	Node number = 0
ANSW2	Asynchronous response activated
POHOSEQ0	No homing sequence after power-on
DIPROG	Sequence programs deactivated
DI	Power stage deactivated
LR0, M	Nominal position displacement = 0
KN635	Equivalent speed constant
RM13170	Terminal resistance

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