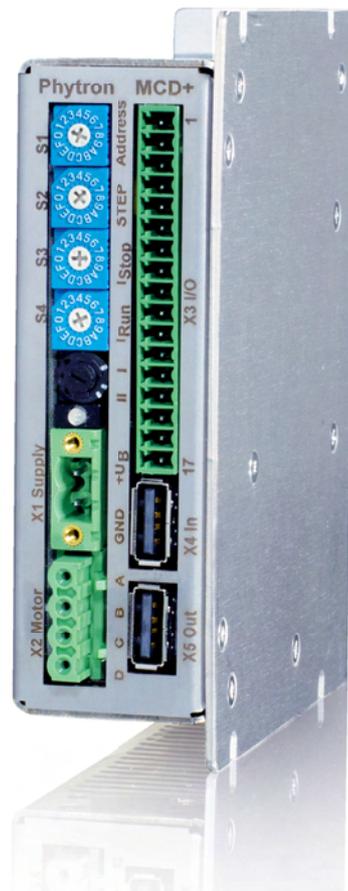


MCD+

Compact Stepper Motor Power Stage for Wall Mounting



MCD+

Compact Stepper Motor Power Stage

Manual MCD+

Version	Modification
8	Input wiring: input and $\overline{\text{input}}$

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Every possible care has been taken to ensure the accuracy of this technical manual. All information contained in this manual is correct to the best of our knowledge and belief but cannot be guaranteed. Furthermore we reserve the right to make improvements and enhancements to the manual and / or the devices described herein without prior notification.

We appreciate suggestions and criticisms for further improvement.

Please send your comments to the following e-mail-address: doku@phytron.de

You'll find the updated version of this manual on the website of www.phytron.de

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1 MCD+

In this chapter you'll find a brief description of the power stage MCD+ 93-70.

1.1 Short Overview

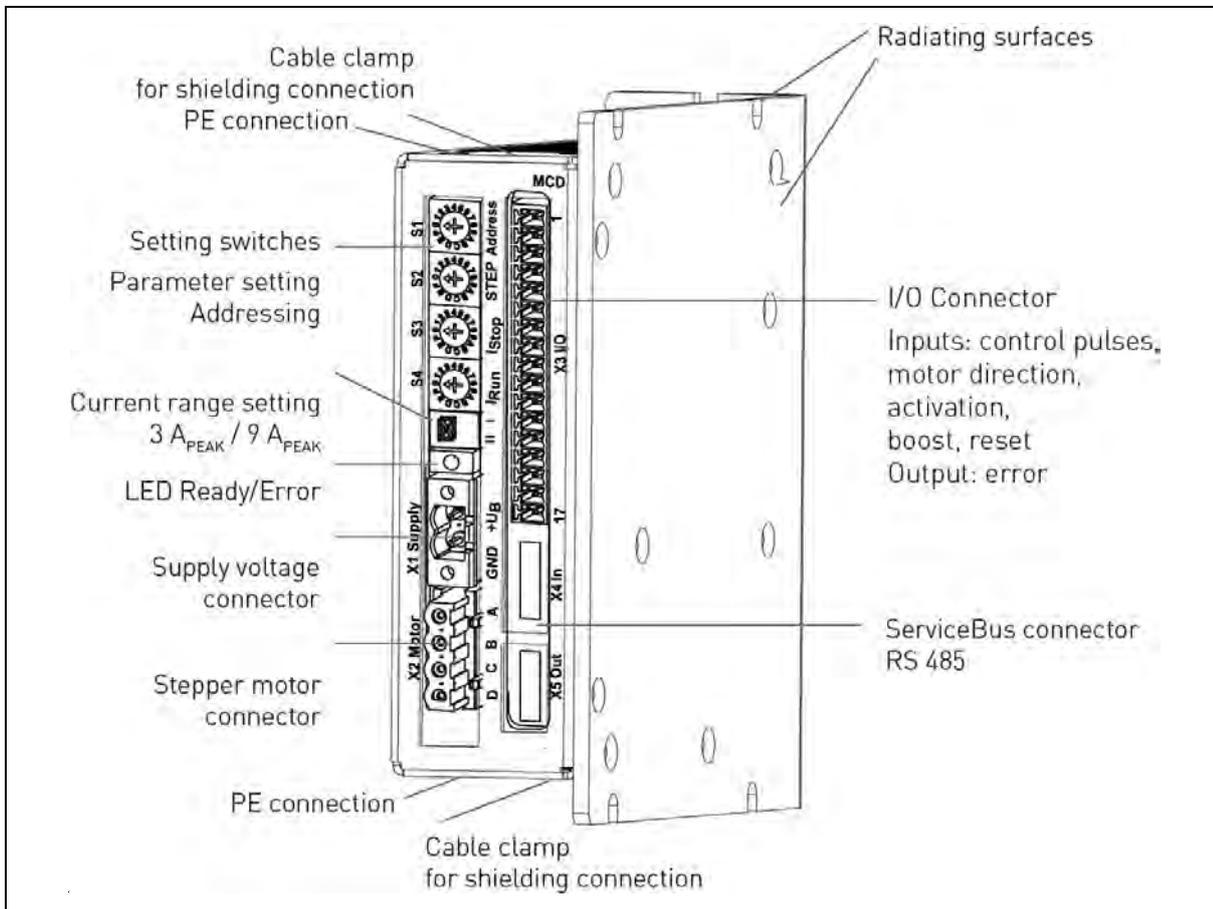


Fig. 1: Operator's controls

Ministep Compact Power Stage for 2-Phase Stepper Motors

The power stages type MCD are used for bipolar control of two-phase stepper motors with phytron's welltried technology, now with enhanced 4 quadrant chopper type current control.

The operating parameters – run and stop current, step resolution, current delay time and preferential motor direction – can be set either by rotary switches or by ServiceBus.

The ServiceBus allows configuration and programming via PC by software ServiceBus-Comm[®] for Windows[®].

In rotary switch mode the step resolution can be set to the following values: Full step, half step, 1/4, 1/5, 1/8, 1/10 and 1/20 step.

You can select further step resolution up to 1/512 step in ServiceBus mode.

With overdrive function, a dynamic boost function, the MCD offers a motor independent compensation of the torque decrease for higher frequencies.

In ServiceBus mode the current shaping function (CS) can be activated for phase current adaptation.

Motor currents from 0.3 to 9 A_{Peak}

Rotary switch mode:

Run and stop current can be individually set.

You can change between 2 ranges (I or II) by the rotary switch 'Current range setting':

Range I: from 0.3 to 3 A_{Peak} (0.2 to 1.6 A_{r.m.s.}, 100 mA steps)

Range II: from 1.1 to 9 A_{Peak} (0.6 to 5.0 A_{r.m.s.}, 300 mA steps)

ServiceBus mode:

Phase currents can be programmed in 100 mA steps.

Supply voltage DC

A DC voltage from 24 to 70 V_{DC} can be connected to the supply voltage connector.

Inputs

Two possibilities of input level: The MCD power stage can be controlled with 5 V or 24 V depending on the wiring.

The inputs Control pulse, Motor direction, Boost, Activation and Reset are designed for Push-Pull- or OC-Controlling. The inputs are optically insulated from the MCD power supply voltage.

ServiceBus

The ServiceBus offers the following possibilities:

- Power stage parameter programming:
e. g. Run, stop and boost current,
step resolution,
preferential motor direction and current delay time, etc.
- Configuration by software via 4-wire RS485 bus, optically insulated from the motor voltage
- Parameter memory to hold data safely in the power stage EPROM
- Activate or deactivate the functions Overdrive and Current Shaping

The power stage can easily and quickly be programmed by ServiceBus-Comm[®] for Windows[®] software (see manual ServiceBus-Comm[®]).

Manual MCD+

Easy to mount and EMC compliant

- Vario flat pack for wall or rail mounting
- EMC compliant metal housing (stainless steel and aluminum), cable clamps and PE screws at the top and bottom of the housing
- Built-in EMC filter and motor filter for power supply
- Easy mounting by means of screw-type connectors
- Mounting brackets for different mounting positions

1.2 Extent of Supply

The MCD is available in the following options (#: Item number):

- MCD Power stage for rail mounting with mating connectors X1 to X3 #10017754
- MCD Power stage for wall mounting with mating connectors X1 to X3 #10017755

Accessories:

- MCD Manual
- Phytron CD with ServiceBus-Comm[®] software
- ServiceBus-Comm[®] Manual

Supplementary parts are available:

- Rail mounting kit #10007882
- ServiceBus cable (connection A-A) 20 cm #10006857
- ServiceBus cable (connection A-A) 100 cm #10006880
- Phytron USB-RS485-converter #10012292 (chap. 8.2.1)
- USB cable (connection A-B) 200 cm #10006881
- Cable connection RS422/485-A 200 cm #10007255
- Power supply SPH240-4805-W (5 A, 48 V) for wall mounting #10015426
- Power supply SPH240-4805-H (5 A, 48 V) for rail mounting #10015427
- Power supply SPH240-2410-W (10 A, 24 V) for wall mounting #10015394
- Power supply SPH240-2410-H (10 A, 24 V) for rail mounting #10015320
- Mating connector set X1 to X3 #10007287:

Connector	Number of poles	Mating connector Phoenix	Identity number
X1	2	MSTB2,5/2-STF-5,08	#02005267
X2	4	IC 2,5/4-ST-5,08	#10005390
X3	17	MC 1,5/17-ST-3,5	#10006319

1.3 Signal Connector X3

The power stage is adapted for 5 V or 24 V input voltage. There are different pin assignments for both input voltages.

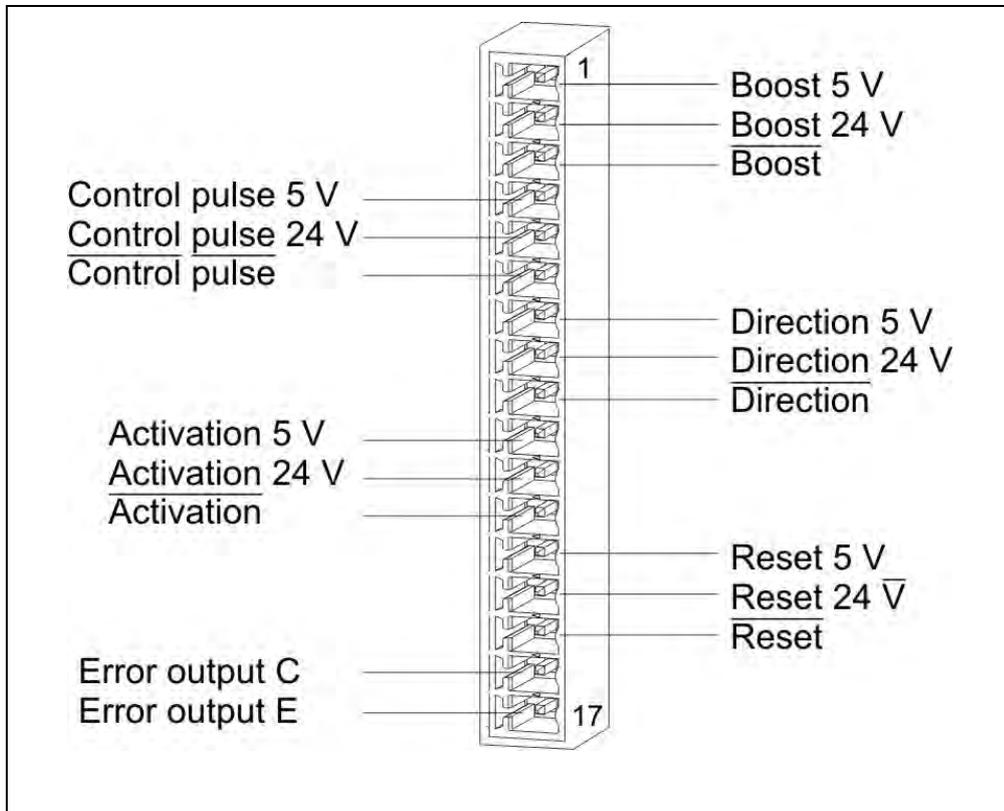


Fig. 2: 17-pole Phoenix Combicon connector MC 1,5/ 20-G-3,5



Please note that there are different pins for 5 V or 24 V inputs on X3!
Do not connect a 5 V input to 24 V voltage! Danger of damages!
See also chap. 7.1.

1.4 ServiceBus Connectors X4 and X5

The power stages MCD are connected to the 4-pole ServiceBus connectors in ServiceBus mode by A-A connection cables. See also chap. 8.2 in the ServiceBus-mode.

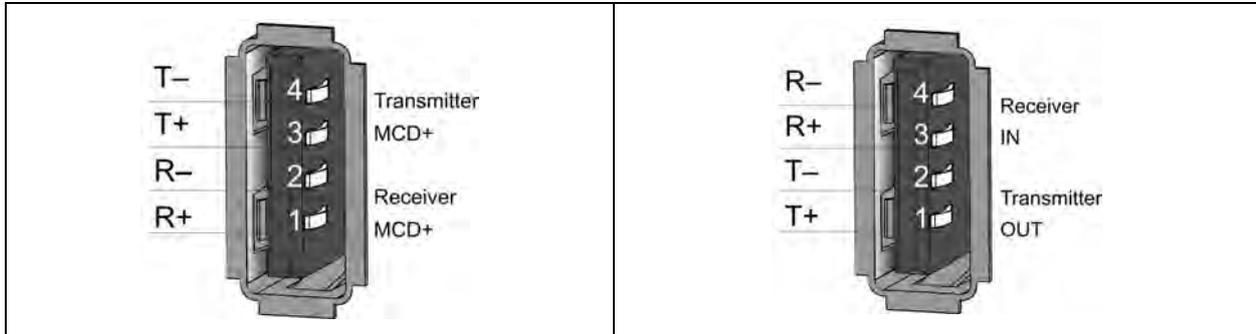


Fig. 3: 4-pole ServiceBus connector IN: X4 (DIN IEC 61076-3-107)

Fig. 4: 4-pole ServiceBus connector OUT: X5 (DIN IEC 61076-3-107)

1.5 Operating Modes

The MCD operating mode can be set by the 4 setting switches at the front panel:

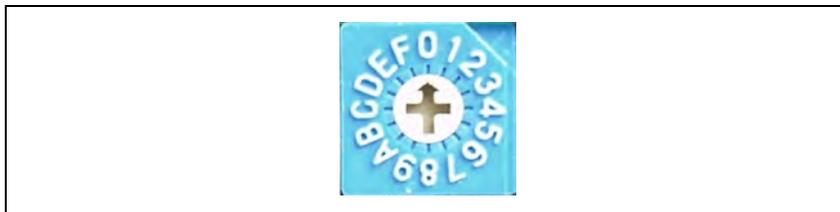


Fig. 5: 16-step setting switch: setting 0...F

Operating mode: Setting switch mode

Phase currents, Step resolution, preferential motor direction and device address are set by the rotary switches I_{Run} , I_{Stop} , STEP and Address.

Setting switch mode is selected, if the rotary switches **S1**, **S2**, **S3** and **S4** aren't set to ,0'.

Operating mode: ServiceBus mode

All settings are made on PC by ServiceBus-Comm[®] phytron software.

If the rotary switches **S2**, **S3** and **S4** are set to ,0', the MCD is in ServiceBus Mode.

The rotary switch **S1** addresses the device

Important: Each address must only be used once!

Remark:

If **only one** setting switch (S2, S3 or S4) is set to '0' in the ServiceBus mode, the MCD will be deactivated.

Operating mode: Bus mode exclusive

This operating mode is a special ServiceBus mode with safety locking. In Bus mode exclusive all settings at the rotary switches are ignored.

Important:

- In setting switch mode the rotary switch adjustments are only accepted after a Reset signal.
- Settings in the power stage also can be changed in setting switch mode by ServiceBus-Comm[®]. After Reset (and then only) the settings of the rotary switches are read.

1.5.1 Rotary Switch Mode

Run and stop current (I_{Run} , I_{Stop}), step resolution and preferential motor direction (STEP) to 15 positions (1...F), the device address (Address) to 16 positions (0...F) can be set by the four setting switches at the front side.

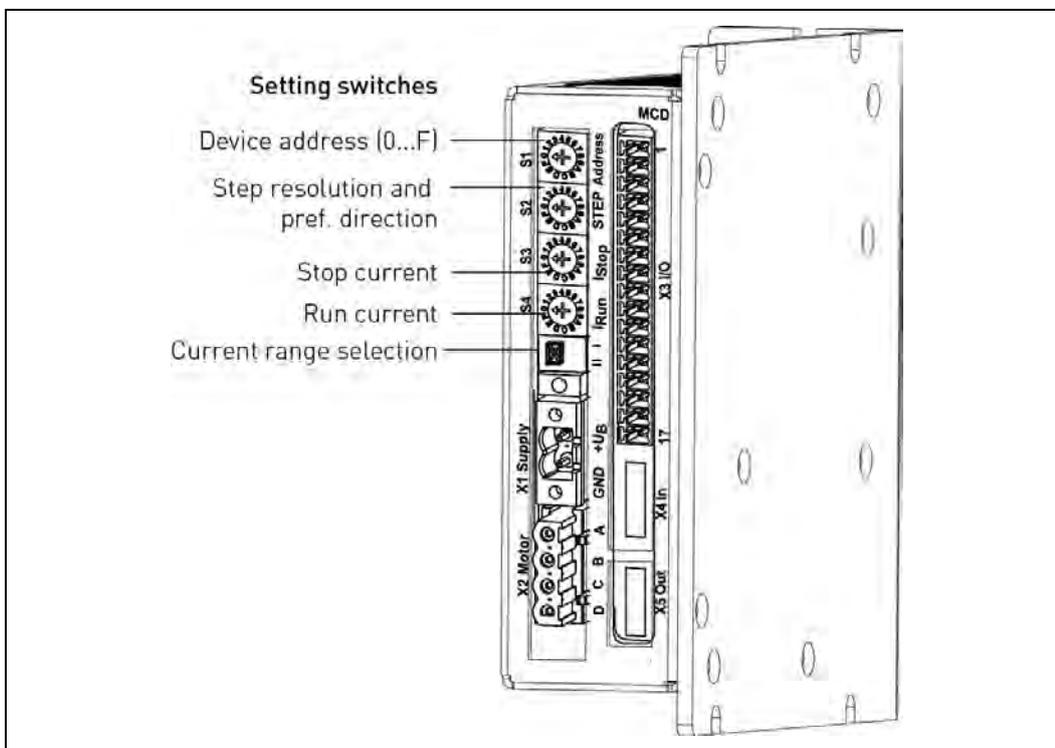


Fig. 6: Rotary switch mode – parameter setting by rotary switches

Manual MCD+

In the Rotary switch mode, you can be change between 2 ranges (I or II) by the rotary switch 'Current range setting':

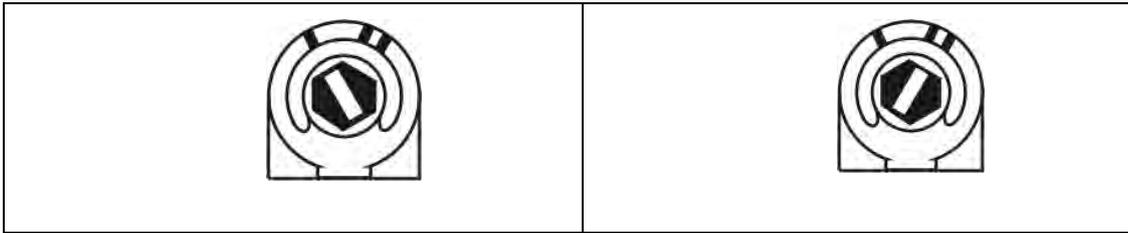


Fig. 7: Range I:
max. 1.6 $A_{r.m.s.}$ in 0.1 A steps

Fig. 8: Range II:
max. 5 $A_{r.m.s.}$ in 0.3 A steps

Remark:

The switch positions may be changed

- while the MCD is powered off or
- the power stage is deactivated. However, after changing the switch position the power stage should be reset by the input Reset.

1.5.2 ServiceBus Mode

The ServiceBus mode is only activated, if all three rotary switches S2, S3 and S4 are set to ,0'. The rotary switch S1 addresses the device (0...F).

Important: Each address must only be used once!

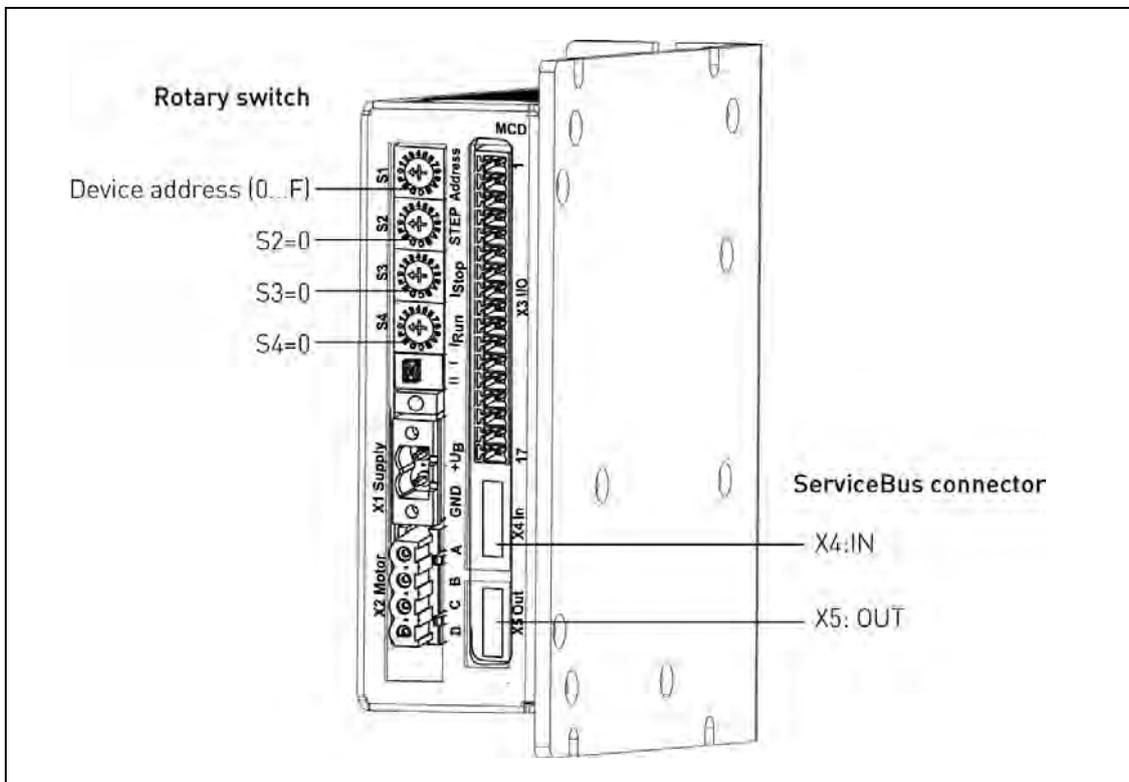


Fig. 9: ServiceBus Mode

The ServiceBus mode allows configuration and programming via PC by software ServiceBus-Comm[®] for Windows[®].

The step resolution can be programmed up to 1/512 step, the current delay time and the phase current in 100 mA steps.

The operating parameters are unconditionally set, i.e. the preset values are accepted **without** Reset.

Exception: The step resolution must be confirmed by Reset!

1.5.3 Bus Mode Exclusive

The Bus mode exclusive ensures safe operation in ServiceBus mode. If the power stage is set to Bus mode exclusive in ServiceBus mode by ServiceBus-Comm[®], all rotary switch settings are ignored.

1.6 LED

Bi-colour LED	Meaning	
green	Ready	LED is shining permanently: The MCD power stage is ready to operate and energized. LED is blinking by second cycle (0.5 Hz): Power stage is deactivated
red	Fault	Error in MCD: Overcurrent/Short circuit: LED is shining permanently Undervoltage: LED is blinking by second cycle (0.5 Hz) Overtemperature: LED is blinking fast (2 Hz)

2 Technical Data Table

Technical Data		
Stepper motor	2-phase-stepper motors with 4, 6 or 8 lead wiring scheme Winding resistance between 0.1 and 10 Ohm Winding inductance 0.5 to 10 mH per phase	
Step resolution Rotary switch mode	The step resolution can be set by the rotary switch: 1/1, 1/2, 1/4, 1/5, 1/8, 1/10, 1/20 of a full step.	
	ServiceBus mode The step resolution is programmable: 1/1, 1/2, 1/4, 1/5, 1/8, 1/10, 1/16, 1/20, 1/32, 1/64, 1/128, 1/256, 1/512 of a full step.	
Phase currents Rotary switch mode	Run current and stop current can be individually set by the rotary switches. Run current and stop current can be changed between 2 ranges by the rotary switch CURRENT RANGE SETTING (I and II). Factory settings: Rotary switch: I (= low range) All rotary switches: ,0'	
	Rotary switch position	
	 Range I Run and stop current	 Range II Run and stop current
	0.2 to 1.6 A _{r.m.s.} (without Boost) in 0.1 A steps 0.3 to 2.1 A _{r.m.s.} (with Boost) 0.4 to 3 A _{Peak}	0.6 to 5 A _{r.m.s.} (without Boost) in 0.3 A steps 0.8 to 6.3 A _{r.m.s.} (with Boost) 1.1 to 9 A _{Peak}
ServiceBus mode	Run and stop current can be set independently by program. Programmable from 0.1 to 5 A _{r.m.s.} in 100 mA steps	
Lead cross section of the motor cable	Minimum 1 mm ² is recommended at max. current.	
Supply voltage	Unregulated filtered DC voltage from 24 to 70 V _{DC} Nominal voltage 70 VDC Reinforced or double insulation between mains and secondary circuit.	

Technical Data			
Error message	Supply voltage < 20 V _{DC} or > 85 V _{DC} Overtemperature (T > 85° C) Overcurrent, short circuit The power stage is powered off in case of an error message.		
Mounting	The MCD housing is constructed with wall mounting brackets at two side panels. We recommend a vertical mounting (labeling readable) because of a better heat dissipation. The clip for rail mounting is mounted on the back side (35 mm acc. to EN550022).		
Weight	560 g		
Connector at the supply cable X1	Phoenix Combicon connector, type MSTB 2,5/2-STF-5,08		
Connector at the motor cable X2	Phoenix Combicon connector, type IC 2,5/4-ST-5,08		
Connector at the I/O cable X3	17-pole Phoenix Mini Combicon connector, type MC 1,5/17-ST-3,5		
Connector at X4: IN	4-pole ServiceBus connector, type DIN IEC 61076-3-107		
Connector at X5: OUT	4-pole ServiceBus connector, type DIN IEC 61076-3-107		
Inputs	The inputs are optically insulated from the motor voltage and can be controlled via push-pull driver or open collector, input level 5 V or 24 V		
	Signal level	5 V	24 V
	High	2.5 – 5.5 V	20 – 30 V
	Low	< 0.4 V	< 3 V
	Necessary driver current	10 mA minimum	
Control pulse	Maximum step frequency: 500 kHz Minimum pulse width: 1 µs The step is done with the rising flank of the control pulse.		
Motor direction	When the optocoupler is energized, the motor rotates in the reverse direction (as compared to the preferential motor direction selected). The direction of rotation signal should not be changed at least 1 µs before the rising flank and 4 µs after the falling flank of the control pulse!		

Technical Data		
Boost	In Rotary switch mode: When the optocoupler is energized, the MCD increases the run and stop current by 30%. Boost current is programmable in the ServiceBus mode.	
Activation	When the optocoupler is energized, the power stage is ready.	
Reset	When the input optocoupler is energized, all error messages are reset and the control circuit is initialized.	
Output	Optically insulated from the motor voltage, type open-collector $I_{\max} = 20 \text{ mA}$, $U_{\max} = 30 \text{ V}$, $P_{\text{total}} = 300 \text{ mW}$, UCE_{sat} at $20 \text{ mA} < 1 \text{ V}$	
Error	The output opens in case of the following error signals: short circuit, overcurrent, undervoltage, overvoltage, overheat. To avoid damages, the drive is deactivated at the same time.	
Ambient temperatures	Operation: 4 to +40 °C *) Storage: -25 to +55 °C Transport: -25 to +85 °C *) We recommend an additional cooling in case of higher operation temperatures.	
Ambient standards	EN 50178	<u>Electronic equipment for use in power installations</u> degree of pollution 2 should be observed
	EN 61000-6-2 (EN 55011)	<u>Immunity for industrial environments class A</u>
	EN 61000-6-3 (EN 55022)	<u>Emission standard for industrial environments class B</u> A line filter with 20 dB damping is necessary in the range from 0.15 to 1 MHz (e.g. Corcom 5VR1). Remark: If PS 5, phytron's power supply unit, is used, any line filter isn't required.
	EN 61000-6-4	<u>Emission standard for industrial environments class A</u>
	EN 61000-3-2	<u>Electromagnetic compatibility (EMC)</u>
Minimum free space	The MCD should be built-in vertically to ensure convection. Minimum free space to other devices: 30 mm Minimum free space below and above the device: 100 mm Required free space for cables and connectors: about 30 mm at the MCD front panel	

3 To Consider Before Installation



Read this manual very carefully before installing and operating the MCD. Observe the safety instructions in the following chapter!

3.1 Qualified Personnel

Design, installation and operation of systems using the MCD may only be performed by qualified and trained personnel.

These persons should be able to recognize and handle risks emerging from electrical, mechanical or electronical system parts.



WARNING !

By persons without the proper training and qualification damages to devices and persons might result!

3.2 Safety Instructions

1. The MCD must only be operated in accordance with the protective measure in chap. 3.3.

2. The connector power supply X1 should be locked with the fixing screws.



3. The transformer **must** be constructed with reinforced or double insulation to avoid dangerous touch voltages (50 V_{AC} and 120 V_{DC}) in case of isolation error in the transformer.



4. If you need to open the MCD device:
Up to 3 minutes after turning off the supply voltage, dangerous voltages may still exist within the device.

5. **Be careful handling the motor connectors X2 at the MCD and any motor cable coupling.**

As long as the MCD is connected to supply voltage, a hazardous voltage level is present at motor connector and motor cable, even if the motor is not wired.

6. Always switch off the supply voltage if you connect or disconnect any wires or connectors at the MCD.

Most important:

Do not unplug the motor connector while powered!

Danger of electric arcing.



7. The maximum voltage of the signal inputs and outputs must not exceed 5 V_{DC} and 24 V_{DC} (I/O connector X3).

Please note that there are different pins for 5 V or 24 V inputs! Do not connect a 5 V input to 24 V voltage! Danger of damages!

8. Clearing the inputs Activation or Reset is no safe separation in the emergency case.
The voltage supply has to be interrupted for switching off the drive safely.



9. Devices connected to MCD for control or communication should have reinforced or double insulation.



10. The surface of the MCD may reach temperatures of more than 85 °C during operation. Danger of injury if touching the surface!

3.3 Protective Measure Options for the Operation of Power Stages

The power stage must be operated by the protective measure PELV acc. to VDE 0100. Board and motor housing have to be grounded and/or connected to 0 V.

Various options are possible to achieve the protective measure PELV:

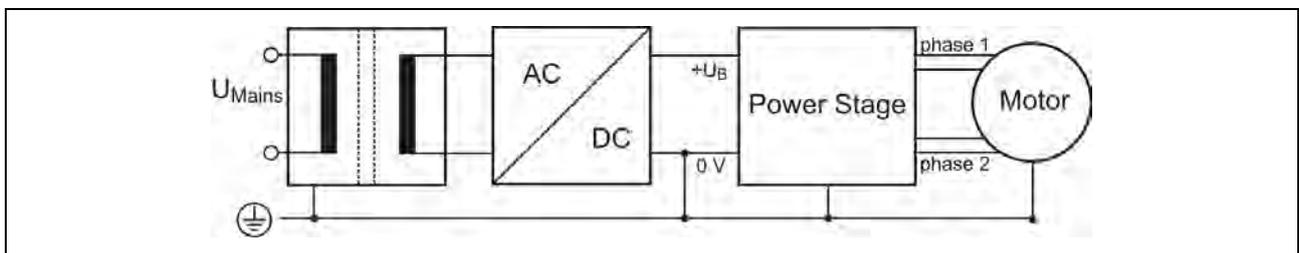


Fig. 10: PELV – Grounding: total

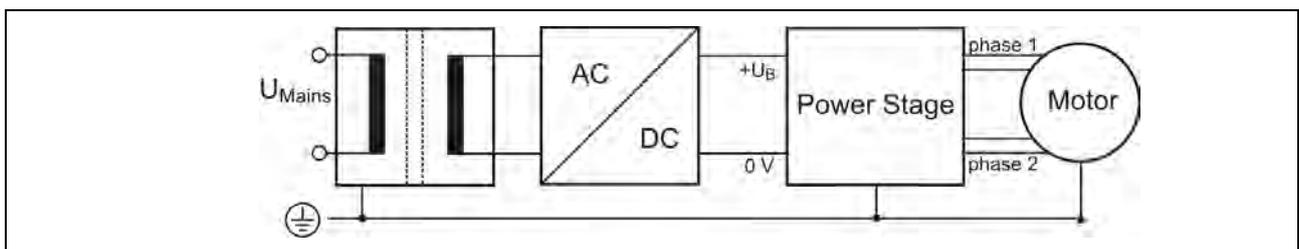


Fig. 11: PELV – Grounding: Power Stage and Motor. The secondary winding of the transformer (SELV supply) must not be grounded because the equipment is grounded.

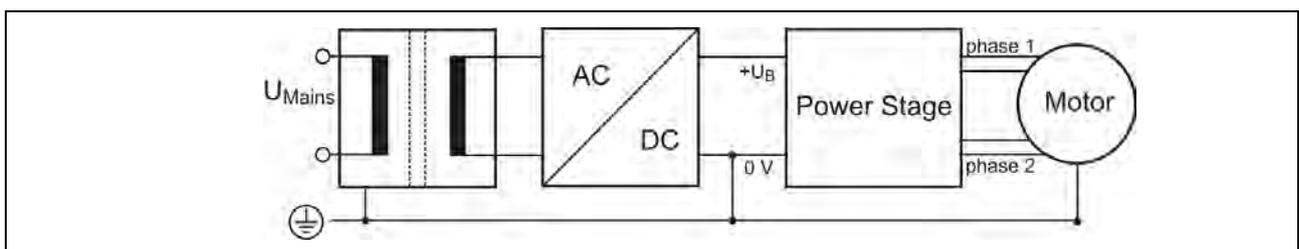


Fig. 12: PELV – Grounding: 0 V and Motor

If there is no PE clamp on the motor, the 0 V wire **must** be grounded to complete the protective measure PELV (Fig. 13 and Fig.14):

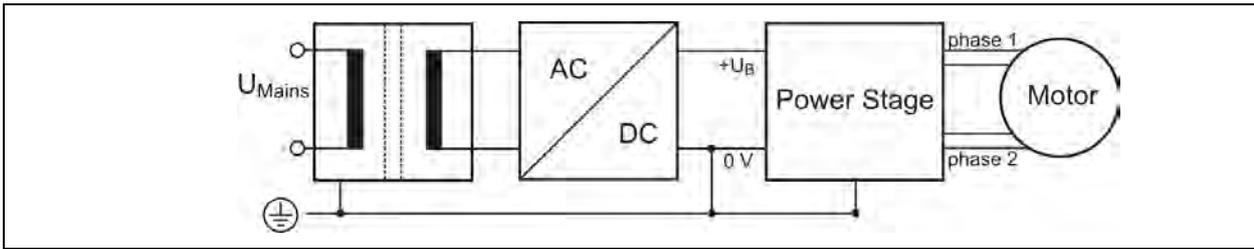


Fig. 13:PELV – Grounding: 0 V and Power Stage

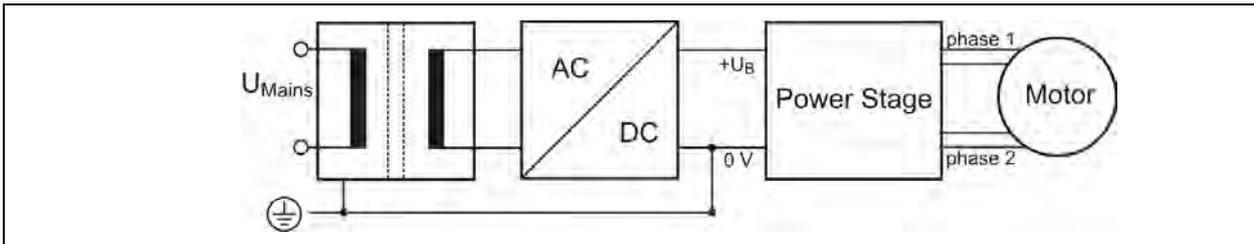


Fig. 14:PELV – Grounding: 0 V



Protective measure PELV for application of the $+U_B$ should not exceed $70 V_{DC}$ or $50 V_{AC}$ at dry environment (environmental conditions 3 acc. to IEC 61201).

The supply transformer must be constructed with reinforced or double insulation between supply and secondary winding (acc. to EN 61558).

Only use motors which are checked acc. to EN 60034-1 (500 V_{AC} /1 minute).

3.4 Putting into Service

3.4.1 For Rotary Switch Mode

Please follow the described order when you put into service the MCD power stage:

1. Connect the MCD acc. to protective measure in chap. 3.3.
2. Wire the **17-pole Phönix connector** (MC1,5/(17-ST-3,5)) with the required leads and connect it to the MCD (See fig. 2: male connector of the MCD (MC1,5/17-G-3,5)).
3. Connect the **motor** to the MCD. Use the Phönix connector called: IC2,5/4-ST-5,08. The equivalent male connector (IC2,5/4-G-5,08) is on the front panel of the MCD. Please note chapter 6.1 to 6.4.
4. Setting switch positions for **Rotary switch mode**
For rotary switch setting see table in chapter 8.
 - Set the rotary switch I_{Run} to the required run current. The phase current should not exceed the maximum admissible motor current.

- The stop current is set by the rotary switch I_{Stop} .
We recommend the following setting:
Stop current = 50 % of the run current.
 - Set the step resolution and preferred motor direction by the rotary switch STEP.
 - Connect the input signals to the Control pulse and Activation inputs.
5. Connect the **supply voltage** to the MCD. Use the 2-pole Phönix connector (MSTB2,5/STF-5,08). The equivalent male connector (MSTB2,5/2-GF-5,08) is on the front panel of the MCD (see chap. 5).
6. **Power on** the MCD.
The MCD is designed for voltages from 24 to 70 V. The nominal voltage is 70 V.
As soon as the MCD is powered on and there is no error, the green LED shines.

3.4.2 For ServiceBus Mode

Please follow the described order when you put into service the MCD power stage:

1. to 3. see chap. 3.4.1

4. Rotary switch setting for **ServiceBus mode**

- Set the **rotary switches S2, S3 and S4 to position 0**.
- Set the **rotary switches S1 to the required device address (0...F)**.
- **Using the USB-RS485-Converter:**
Connect an USB-port of the PC to the USB input of the USB-RS485-converter by an USB-cable, type A-B. Install the required USB drivers, see phytron CD. After a successful installation connect the USB-RS485-converter to the MCD (connector X4) (A-A connection of the 4-pole connector).
- **Using the RS422/RS485-Interface:**
Connect the PC to the first MCD (X4) with an adapted ServiceBus cable. Then, connect the bus output of the MCD (X5) to the next MCD (See fig. 29).
Continue until all MCD are connected in bus mode.
- Connect the input signals to the Control pulse and Activation inputs.

5. and 6. see chap. 3.4.1

4 Dimensions and Mounting

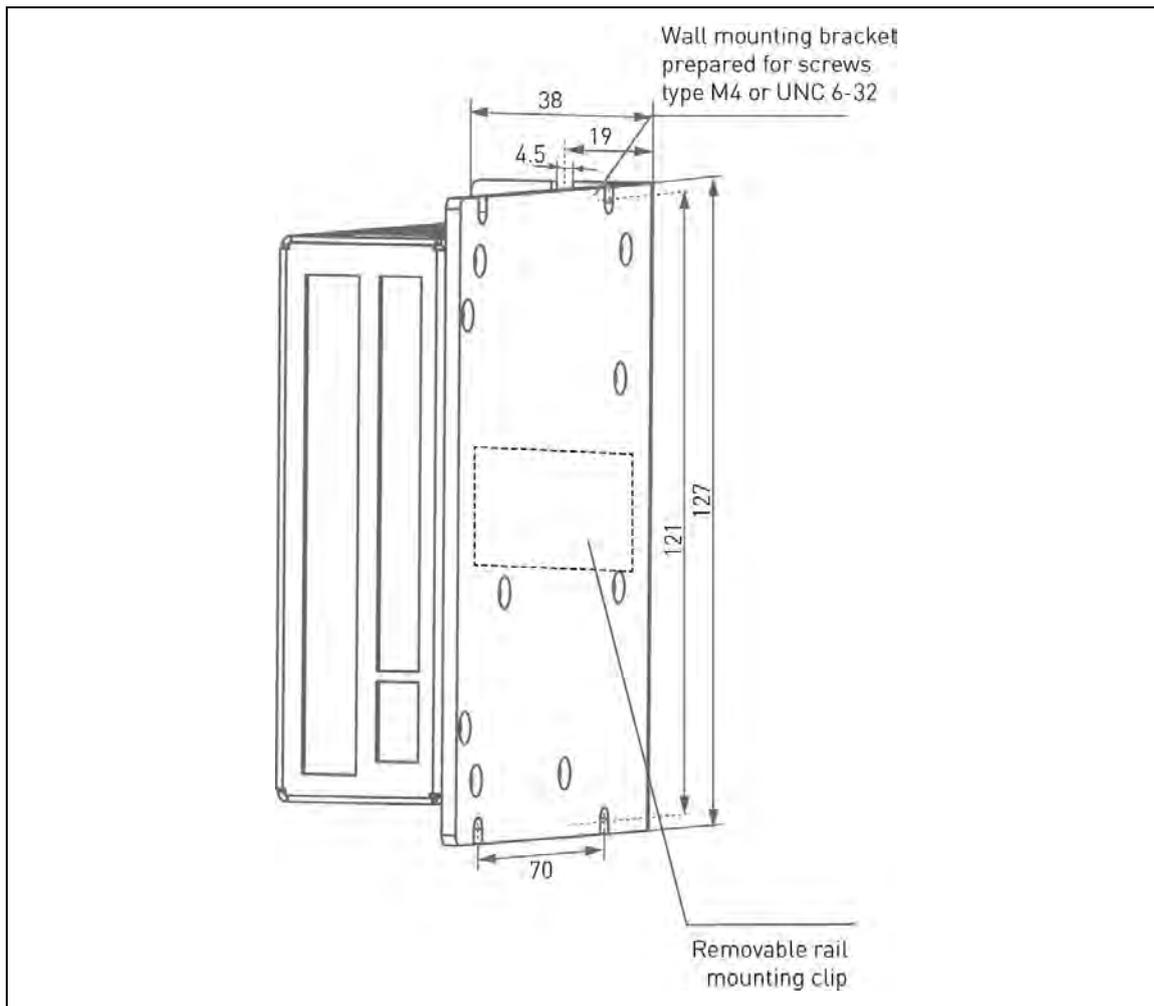


Fig. 15: Dimension in mm

Mounting instruction

The MCD should be built-in vertically to improve convection.

Minimum free space to other devices: 30 mm

Minimum free space below and above the device: 100 mm

Required free space for cables and connectors:
about 30 mm at the MCD front panel

Wall mounting

The MCD has been designed to be mounted in different mounting positions.

The power stage can be fixed at the lateral cooling surface with 4 screws M4 or UNC 6-32, at the rear side with two screws (see fig.15).

Rail mounting

The clip for rail mounting is mounted on the rear side.

Attention: screws admissible for mounting: M3 x 8

5 Mains Supply Unit

The MCD power stage can be supplied by means of an unregulated filtered DC voltage from 24 to 70 V_{DC}.

Admissible voltage range: 24 to 70 V_{DC}

Nominal voltage: 70 V_{DC}

The voltage must not drop under 20 V and rise over 85 V, not even for a short time (> 1 msec). If the external voltage breaks down below 20 V or rises above 85 V, the MCD detects undervoltage.

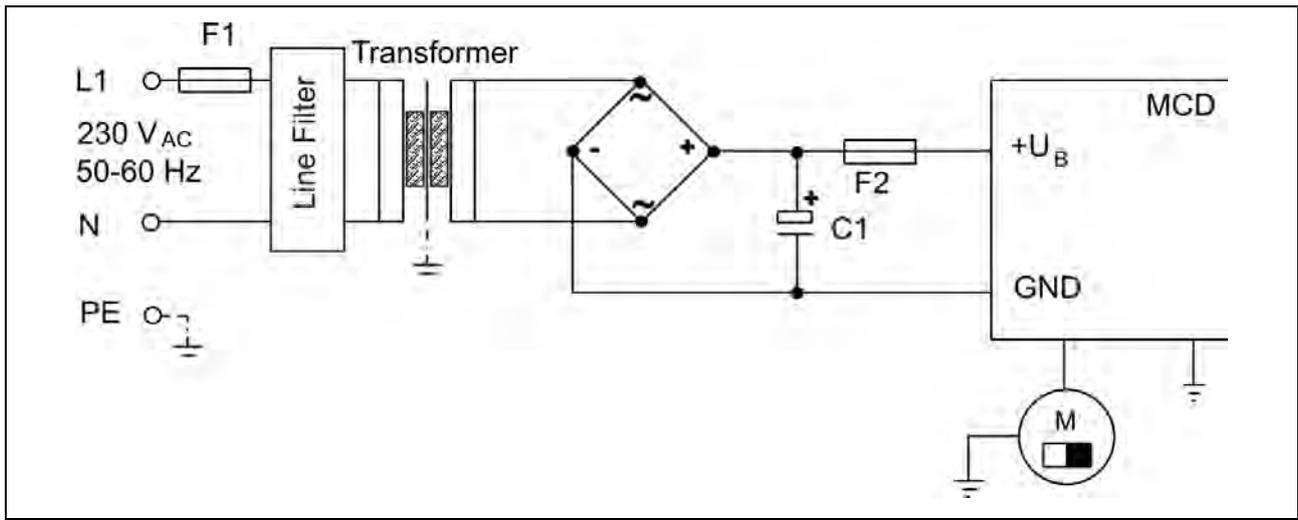


Fig. 16: Mains supply unit

For calculation and connection of the supply unit, the following instructions must be followed:

-  **The transformer must be constructed with reinforced or double insulation.**
-  The calculation of the F2 fuse depends on the preset phase current und the motor load:

Recommended values:

Phase current	Fuse
≤ 1 A	T2A
2 A	T4A
3 A	T6A
4 A	T8A
5 A	T10A
≥ 6 A	T12A

- For the load capacitor, a value of 1,000 μF per Amp of motor current should be calculated.
- Use shielded cables for DC supply.

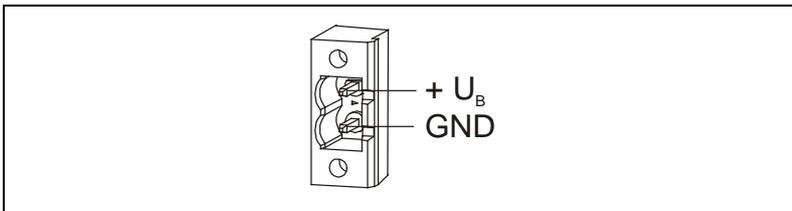


Fig. 17: 2-pole Phoenix connector MSTB 2,5/2-GF-5,08 X1

Attention: Do not interchange the connections! The MCD is **not** protected against reverse polarity.

5.1 Insulation Overview

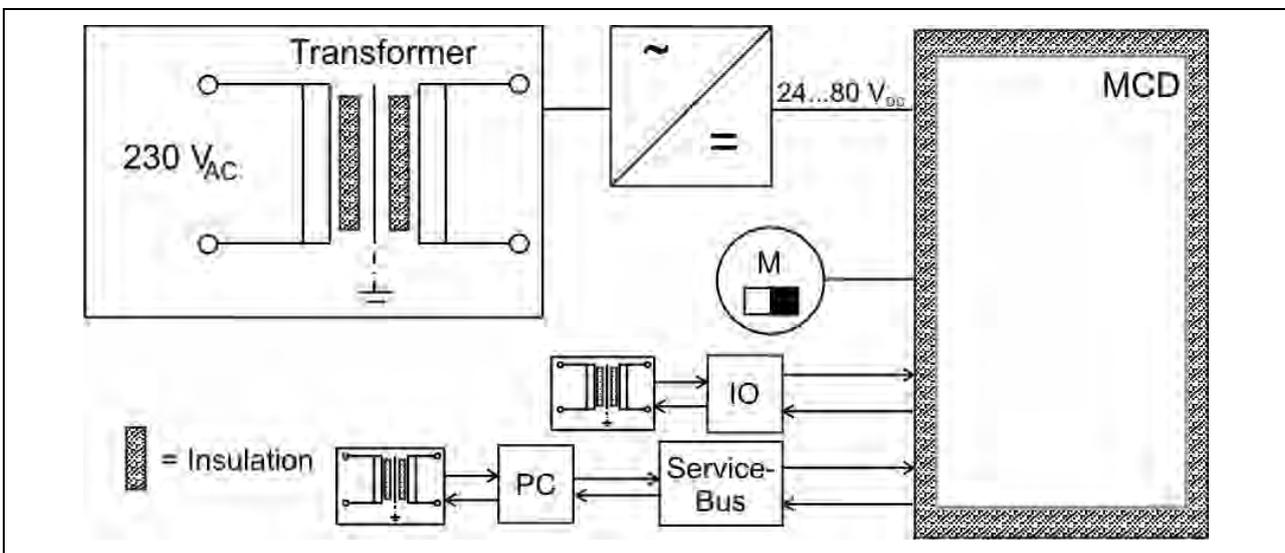


Fig. 18: Insulation MCD



The power stage must be operated with protective measure PELV.
The transformer should be constructed with reinforced or double insulation.

The insulation of the MCD fulfills the requirements of a basic insulation for non-mains-circuits for voltages up to 141 V acc. to EN 50178.

The device has been designed for degree of pollution 2 acc. to EN 50178.

The IO signals on connector X3 are optically insulated and safely insulated to withstand voltages up to 800 V_{DC}.

The signals RS485 on X4 and X5 ServiceBus connectors are electronically insulated from the motor voltage by a separate DC/DC-converter (withstand voltage 1000 V_{DC}).



Devices connected to MCD for control or communication should have reinforced or double insulation acc. to EN 50178.

6 Motor Connection

The following chapter describes how to wire different types of 2-phase stepper motors.

MCD stepper motor power stages may be connected to stepper motors with 0.3 to 9 A_{Peak} phase current.

The stepper motor winding resistance should be more than 0.1 Ω and less than 10 Ω for full power.

The winding inductivity of one phase should be in the range of 0.5 to 10 mH.

Stepper motors with 8 leads can be connected with the windings wired in parallel (1) or serial (2).

For 6-lead stepper motors, wiring scheme (3) with serial windings is recommended.

If wiring scheme (3) or (4) cannot be used because of the motor construction, the motor may be operated with only two of the four windings energized according to wiring scheme (5).

Warning:



5-lead stepper motors must **not** be connected to the MCD.
Both 5-lead stepper motor and MCD might be damaged.

Motor time constant τ:

$\tau = \frac{L}{R}$ applies to the electric motor time constant τ.

The total inductivity L_{total} is equal to the winding inductivity in a parallel circuit, because of interlinked inductivities.

L_{ges} = 4 x L applies to a serial circuit.

The result is an equal motor time constant τ for a serial and a parallel circuit:

Circuit	Serial	parallel
Resistance R _{total}	2 x R	$\frac{R}{2}$
Inductivity L _{total}	4 x L	L
Motor time constant τ	$\tau_{\text{serial}} = \frac{4 \times L}{2 \times R} = \frac{2 \times L}{R}$	$\tau_{\text{parallel}} = \frac{L}{R/2} = \frac{2 \times L}{R}$

6.1 Motor Connector

The figure shows the connection of a phytron 2-phase 4-lead stepper motor connected parallel.

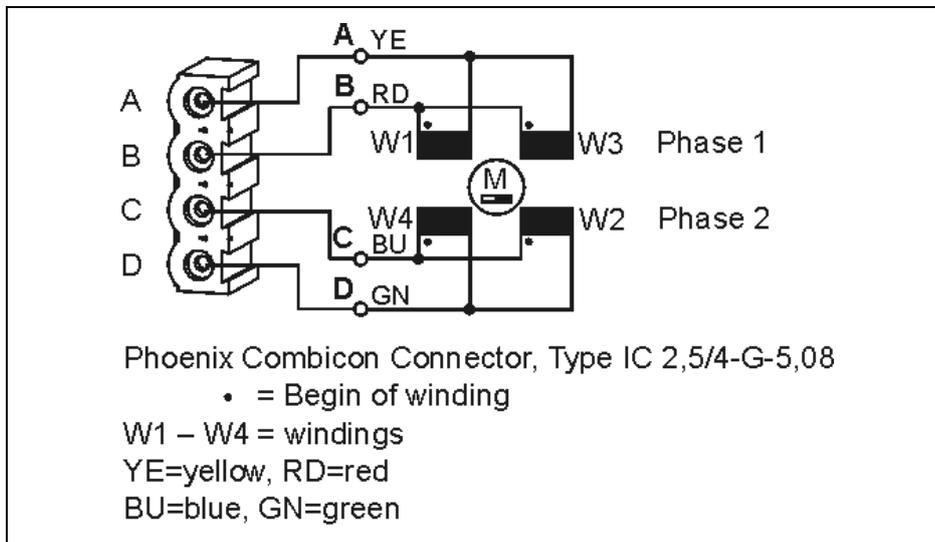


Fig. 19: Motor connector X2

Attention: Do not unplug the motor connector while powered.
 Danger of electric arcing.

6.2 Shielding

To avoid disturbances affecting the wires and instruments installed close to the drive system, we recommend using shielded cables.

The motor should be connected to the ground by a central earthing tab.

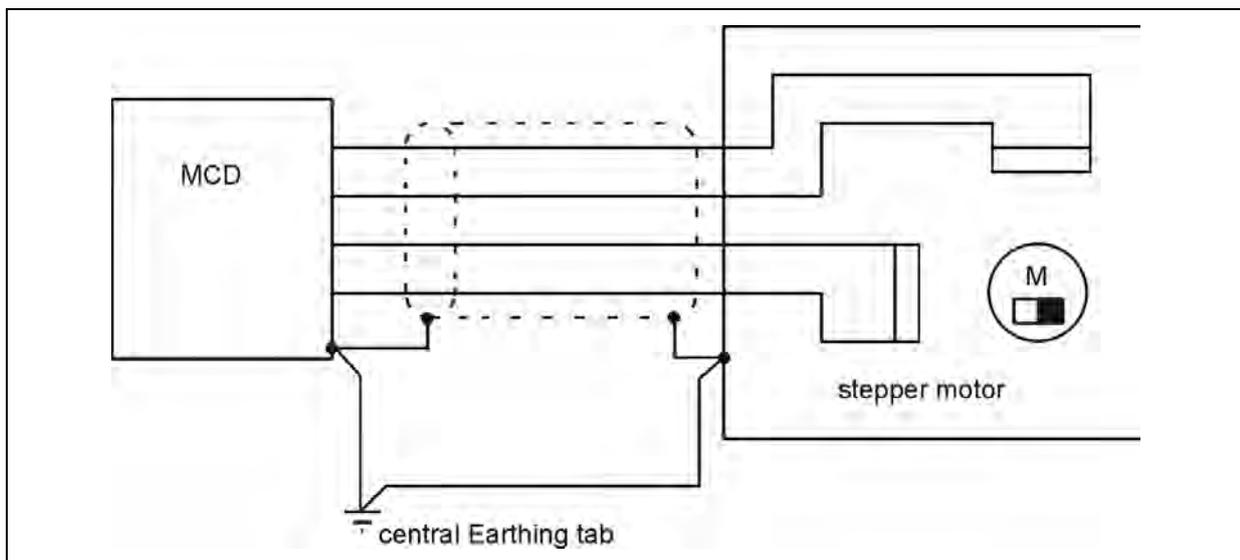


Fig. 20: Motor lead shielding

6.3 Wiring Schemes

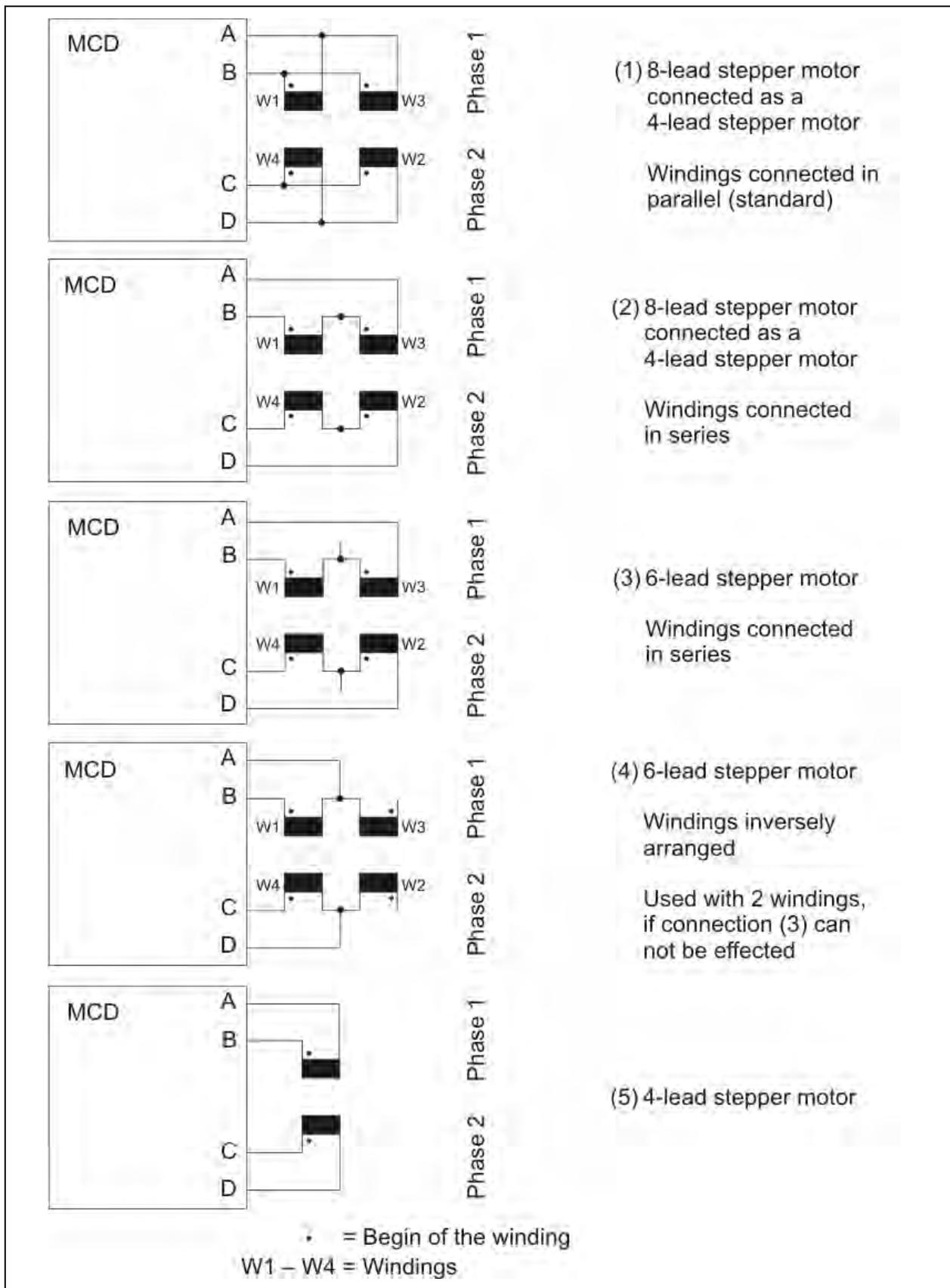


Fig. 21: Connection diagrams for 4-, 6- and 8-wire stepper motors

6.4 Motor Cables

We recommend wiring the stepper motor with a 5-lead cable with shielding mesh. For optimum electromagnetic compatibility (EMC), the cable should not be interrupted by additional connectors or screw terminals. We recommend using a short motor cable because of EMC. See chap. 6.1 and 6.2.

The protective earth wire (green/yellow) of the motor cable should be connected to the earthing screw near the MCD motor connector. At the other motor cable end, the green/yellow wire should be connected to the motor's earthing screw (if available).

For best electromagnetic compatibility (EMC), you should connect the shielding mesh to the MCD housing. Use the cable clamps at the bottom and the top side of the MCD.

The shielding mesh should also be connected on a large surface to the motor housing. Use EMC-type conduit fittings. All parts of the motor should be conductively connected with each other. We recommend using EMC conduit fittings at the motor side.

In case of motors without adapted conduit fittings the cable shielding must be connected as near to the motor as possible and has to be applied to PE.

Important:

Motor leads not used should be insulated separately (important if using wiring scheme 3,4 or 5)!

Motor cable:

Motor cable length	Min. lead cross section for phase currents	
	up to 3 A _{r.m.s.}	from 3 to 6.3 A _{r.m.s.}
up to 10 m	1.0 mm ²	1.0 mm ²
from 10 m to 25 m	1.0 mm ²	1.5 mm ²
from 25 m to 50 m	1.5 mm ²	2.5 mm ²

Cable between MCD and mains supply unit:

We recommend using a shielded cable, as short as possible (< 1 m):

Min. lead cross section for phase currents	
up to 3 A _{r.m.s.}	from 3 to 6.3 A _{r.m.s.}
1.0 mm ²	1.5 mm ²

7 Inputs and Error Output

The I/O connector X3 is used to connect the signal inputs and outputs.

Attention:

Please check the input level applied to the MCD: 5 V or 24 V!

Do not connect a 5 V input to 24 V voltage! Danger of damages!

Important: In ServiceBus mode the logic input signals Control pulses, Motor direction, Boost and Activation can be reversed (HIGH active or LOW active). The input logic of Reset remains unchanged (always HIGH active).

7.1 Inputs

There are 3 pins for every input signal (Control pulses, Boost, Motor direction, Reset, Activation). Therefore, separate inputs for 5 V or 24 V signals are available.

The signals are active, when current flows through the optocoupler. The controlling via push-pull driver confers optimum suppression of disturbances, because current always flows. Especially in case of long leads this kind of controlling should be preferred.

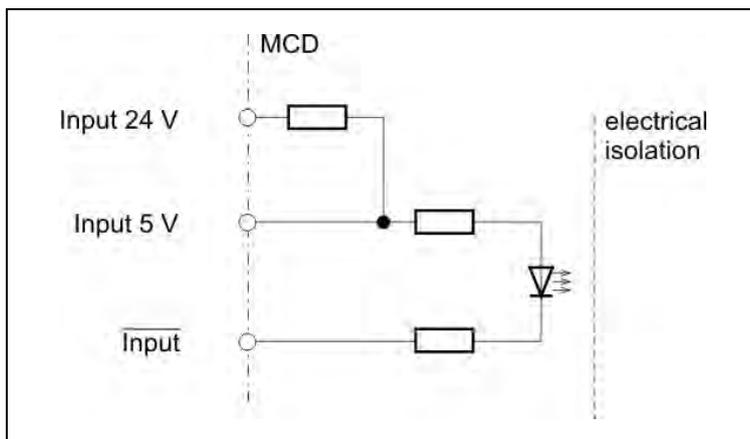


Fig. 22: Input wiring diagram

7.1.1 Push-Pull- or OC-Controlling

We recommend controlling the MCD inputs by push-pull drivers. This confers optimum suppression of disturbances.

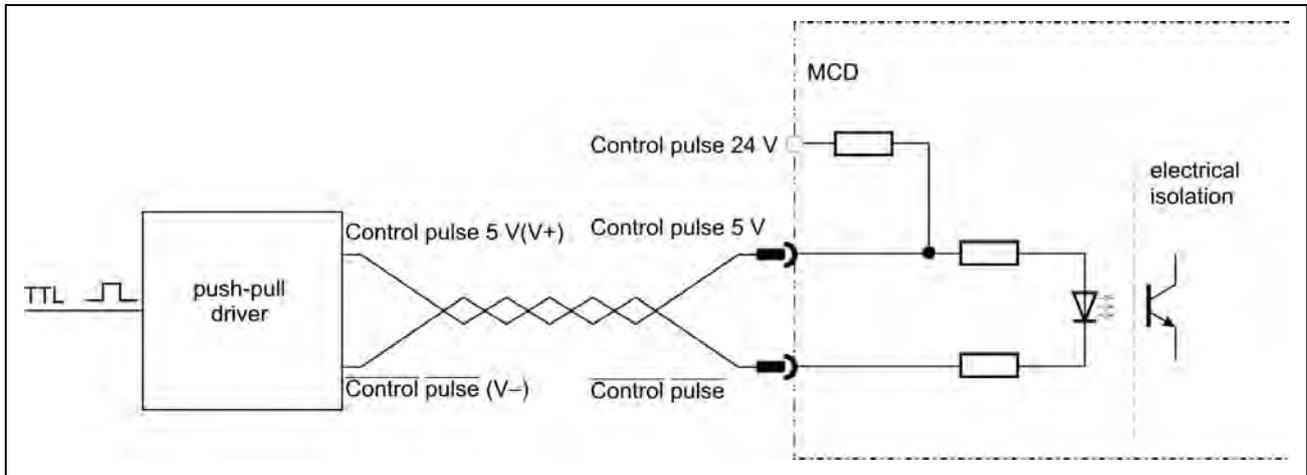


Fig. 23: Push-pull controlling

Alternatively a controlling via open-collector is possible.

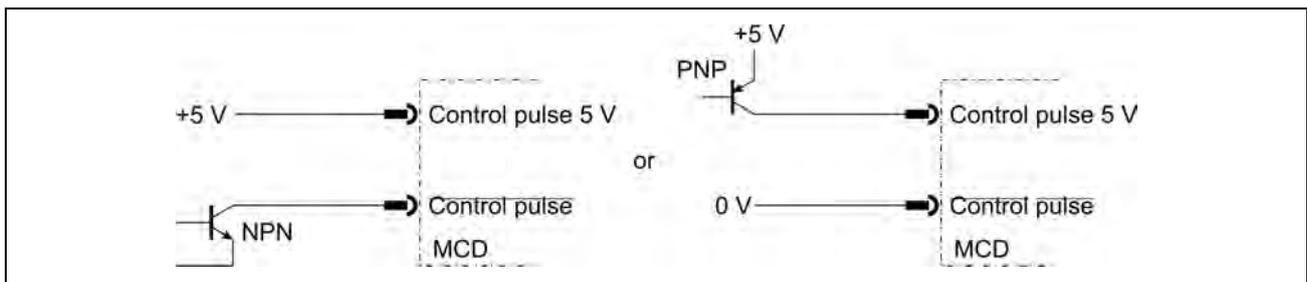


Fig. 24: Open Collector Controlling

7.1.2 Logic Level 24 V or 5 V

MCD power stages can be driven by input level 5 V or 24 V.

The different values depend on the input level:

Signal level	5 V	24 V
High	2.5 – 5.5 V	20 – 30 V
Low	< 0.4 V	< 3 V
Necessary driver current	10 mA minimum	

Attention:



Please check the input level applied to the MCD: 5 V or 24 V and connect the signals to the equivalent pins (see fig. 25)! Do not connect a 5 V input to 24 V voltage! Danger of damages!

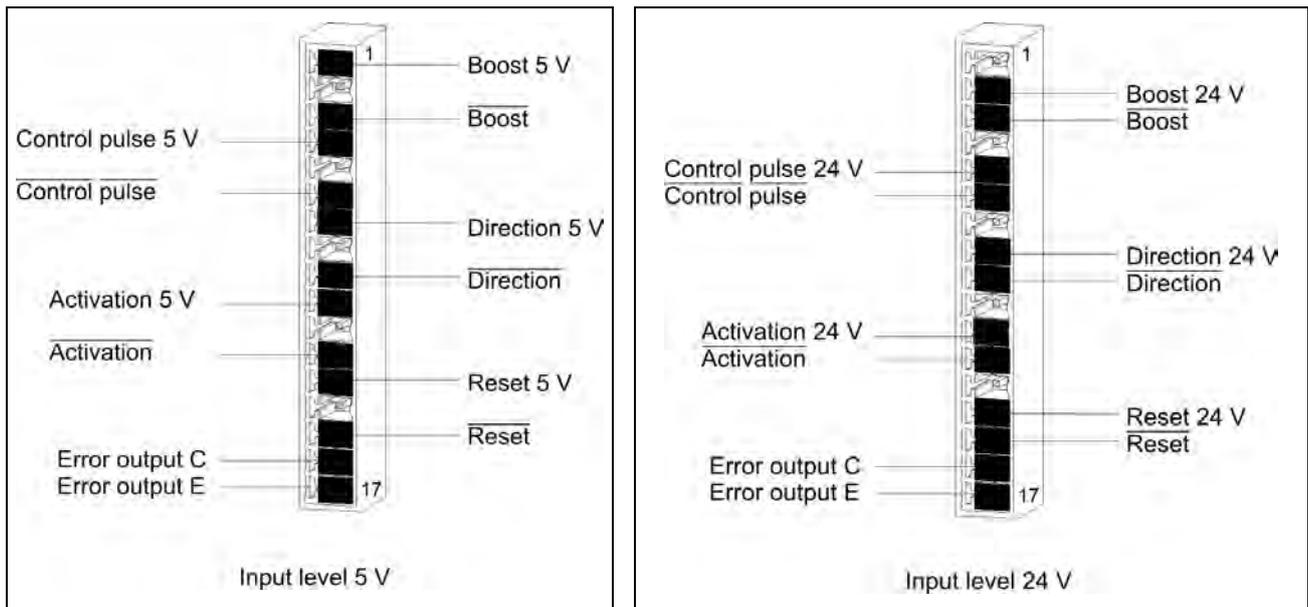


Fig. 25: Input level 5 V or 24 V connection

7.1.3 Control Pulse Input

Maximum step frequency: 500 kHz

Minimum pulse width: 1 μ s

The step is done with the rising flank of the control pulse.

The control pulse sequence must not suddenly start or stop, if the control pulse frequency is higher than the start/stop frequency^{*)} of the motor. Mispositioning of the drive would be the result.

^{*)} The start/stop frequency is defined as that frequency, from which a stepper motor can start from standstill without losing a step. Typical values for the start/stop frequency are 200 to 2000 Hz. The exact value depends on the load torque and the load inertia of the motor shaft.

If the motor is to be operated above the start/stop frequency range, the indexer has to generate frequency ramps to accelerate and decelerate the motor.

Current delay time:

After the last control pulse the stop current is activated after a waiting time. The waiting time after the last control pulse until the change to the stop current is called current delay time.

In Rotary switch mode the current delay time is set to 40 ms default value.

In ServiceBus mode the current delay time is programmed as parameter and saved in the MCD (see appendix A4).

7.1.4 Direction Input

This signal sets the direction of rotation of the motor.

If the input optocoupler is not energized, the motor drives in the preferential direction. If the input optocoupler is powered, the selected motor direction of rotation is reversed.

The signal must only be modified when the motor is at a standstill or turns with the frequency within the start/stop frequency. Don't change the signal 1 μ s before the control pulse and 4 μ s after the control pulse!

Changing the motor direction when the motor is running will cause step losses and/or stop the motor.

In Rotary switch mode the preferential motor direction can be changed by the rotary switch STEP (see table in chap. 8).

In ServiceBus mode the preferential motor direction can be programmed (see chap. 9.2.).

7.1.5 Boost Input

If the input optocoupler is energized the MCD changes to Boost current.

The power stage increases the run and stop current by 30 % in Rotary switch mode. As long as the Boost input is energized, the run and stop current will always be 30 % higher.

The boost current can be programmed by the user in ServiceBus mode from 0 to 6.3 A_{r.m.s.}.

Thus, a higher torque can be reached during the acceleration and deceleration time of the motor by changing to boost current.

Also see appendix A2.

7.1.6 Activation Input

If the input optocoupler is energized, the power stage is ready.

This input is useful, for instance, during maintenance operations to switch the power stage off, without having to disconnect it physically from the mains. It is possible now to slowly rotate the motor by hand.



WARNING!

The Activation input is not in conformance with the professional emergency stop circuit requirements.

The input Activation may also be used to avoid the inevitable electrical noise emissions of the power stage, e.g. if you have to perform sensitive electrical measurements in the environment of the device.

7.1.7 Reset Input

If the input optocoupler is energized, all error signals and the ring counter are reset. Then, the ring counter is in basic position. Both motor phases are energized by the same current value in basic position independent of the step resolution.

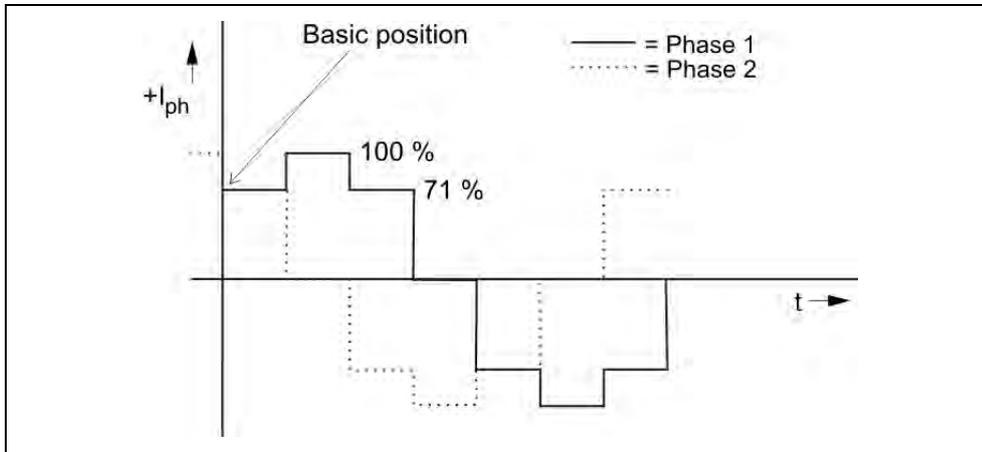


Fig. 26: Motor phases in basic position (half step)

After cut-off the reset signal, the power stage will enable the ready signal after approximately 500 ms.

7.2 Error Output

Open-Collector-Darlington output insulated by means of optocoupler.

$I_{max} = 20 \text{ mA}$, $U_{max} = 30 \text{ V}$, $P_{total} = 300 \text{ mW}$, $U_{CE\ sat} \text{ at } 20 \text{ mA} < 1 \text{ V}$

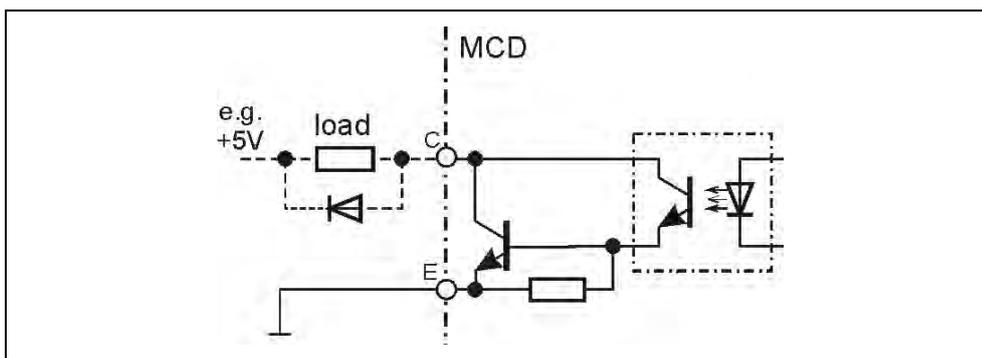


Fig. 27: Output wiring diagram

Remark: If inductive loads (e. g. a relay) are connected, a protective diode must be mounted.

This output opens at the error messages: undervoltage, overcurrent/short circuit, overtemperature. At the same time the driver is deactivated to avoid damages.

An error message can be reset after error elimination or cooling. The MCD can be reset by the input Reset on X3 or in ServiceBus mode.

Error Messages:

Undervoltage/Overvoltage

The red LED blinks by second cycle in case of undervoltage/overvoltage.

Reasons:

- The supply voltage at the internal load capacitor has dropped under 20 V.
- An electronic current limitation or a not adequate smoothing of the DC voltage can be the reason for a short time break of the supply voltage.
- The rotator energy is supplied back as electric energy to the power stage like a generator. Raising in the internal load capacitor will be the result. The error message 'overvoltage' is caused off by operation with maximum power supply (70 V), by motor mass inertia ($> 1.3 \times 10^{-4} \text{ kgm}^2$) and high revolutions per minute ($> 20 \text{ rev/s}$).

Overcurrent/Short circuit

The red LED shines permanently in case of overcurrent/short circuit.

Reason:

- A short circuit has occurred phase to phase or phase to ground.



Short circuit phase to phase and phase to ground is detected from a current setting of $0.7 A_{r.m.s.}$!

- The ohmic resistance of the motor winding is too less. See chap. 6.0

Overtemperature Power Stage

The red LED blinks fast.

Reason:

- The temperature at the heat sink of the transistors is too high ($> 85^\circ \text{ C}$).
The power stage is powered off.

Resetting is possible under 70° C .

8 Rotary Switches

8.1 Rotary Switch Mode

Run and stop current can be individually set by rotary switches. Step resolution and preferred motor direction can be set by rotary switch, too.

For fine run and stop current settings you can change between 2 ranges (I or II).
Run and stop current are increased with Boost by 30 %.

Rotary Switches				
Position	Run/stop current [A _{r.m.s.}] without Boost I _{Run} / I _{Stop}		Step resolution/ pref. motor direction (s. appendix A1)	
	Current range setting			
				
0	ServiceBus mode activated			
1	0.2	0.6	Full Step	+
2	0.3	0.9	Half Step	+
3	0.4	1.3	1/4	+
4	0.5	1.6	1/5	+
5	0.6	1.9	1/8	+
6	0.7	2.2	1/10	+
7	0.8	2.5	1/20	+
8	0.9	2.8	not used	
9	1.0	3.1	Full Step	-
A	1.1	3.4	Half Step	-
B	1.2	3.8	1/4	-
C	1.3	4.1	1/5	-
D	1.4	4.4	1/8	-
E	1.5	4.7	1/10	-
F	1.6	5.0	1/20	-
Factory settings				

Important: The current values of this table have been verified with the phytron stepper motor ZSH 87.2/200.6.5. Deviation is possible for other motors.



Set up phase currents correctly fitting to the motor winding's design current!

- The stop current is normally set to 40-50% of the run current, to keep the motor temperature as low as possible.
- The table values refer to current values, if both motor phases are activated. The current in one phase is calculated as: table value $\times \sqrt{2}$
- Max. run /stop current in Rotary switch mode: range I : $1.6 \text{ A} \times \sqrt{2} \times 1.3 = 3 \text{ A}$
range II : $5 \text{ A} \times \sqrt{2} \times 1.3 = 9 \text{ A}$
- **Important:** The run and stop current values, which are set by the rotary switches, depend on the selected current range, that means

	Run current (without Boost)	Stop current (without Boost)
Range I	0.2 to 1.6 A _{r.m.s.}	0.2 to 1.6 A _{r.m.s.}
Range II	0.6 to 5 A _{r.m.s.}	0.6 to 5 A _{r.m.s.}



The switch positions may be changed

- while the MCD is powered off or
- the power stage is deactivated. However, after changing the switch position the power stage should be reset by the input Reset.



Short circuit phase to phase and phase to ground is detected from a current setting of 0.7 A_{r.m.s.}!

8.2 ServiceBus Mode

If more than one MCD is operated (max.16), the RS485 field bus is best choice (4 wire operation).

The ServiceBus Mode setting:

The ServiceBus Mode is activated by the rotary switches S1 to S4 on the MCD. The rotary switches S2, S3 and S4 must be set **all** to '0'. The rotary switch S1 is used for device address setting (0...F). Therefore, up to 16 MCD power stages can be connected by the connectors X4 and X5 and addressed.

Two possibilities for MCD connection acc. to RS485 (4-wire operation):

1. MCD connection to PC by an USB-RS485 converter:

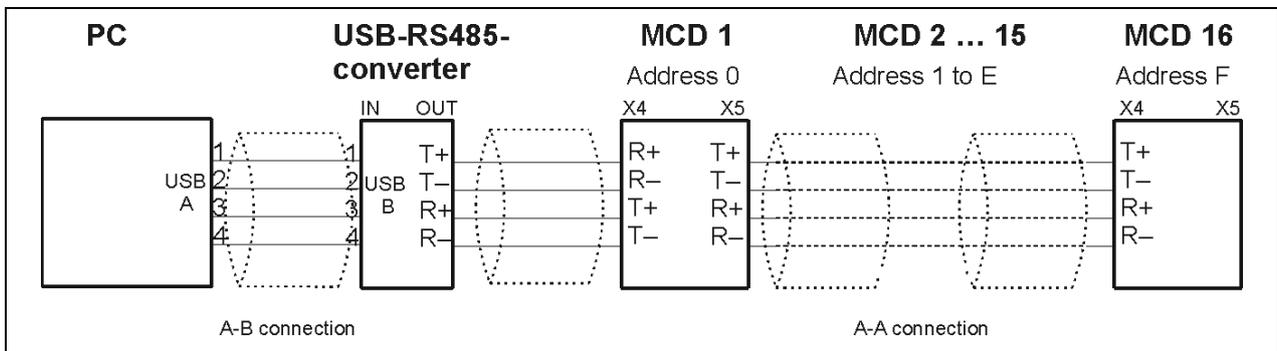


Fig. 28: Connection PC → MCD by USB-RS485-converter

2. The power stage is connected to the RS422/RS485 interface of the PC:

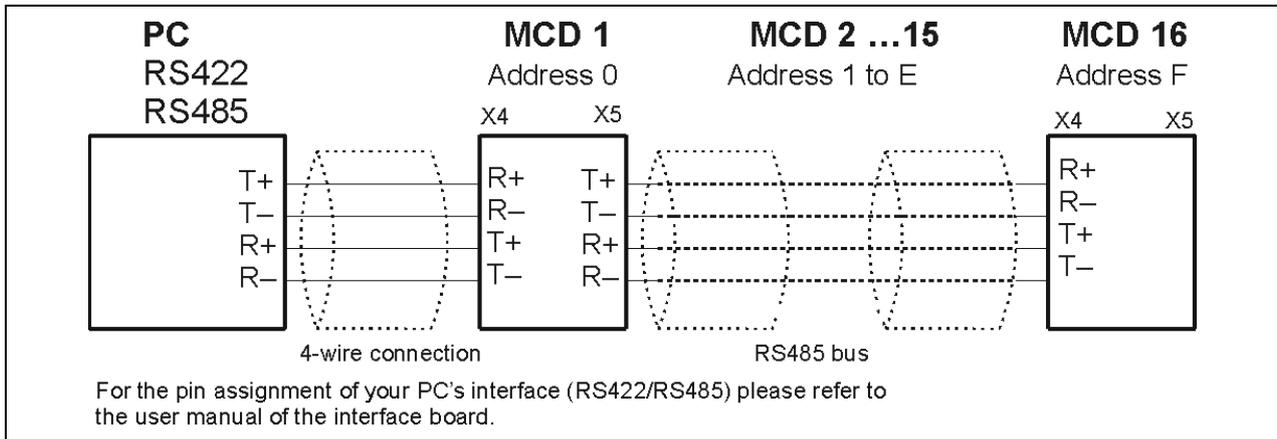


Fig. 29: Connection PC → MCD by RS422/RS485-interface

8.2.1 USB-RS485-Converter

The phytron USB-RS485-converter is connected to X4 (IN) by a short A-A cable (20 cm). The first of several MCD axes is addressed by 0, to which the USB-RS485-converter is plugged. All other power stages are addressed continuously (fig. 30).

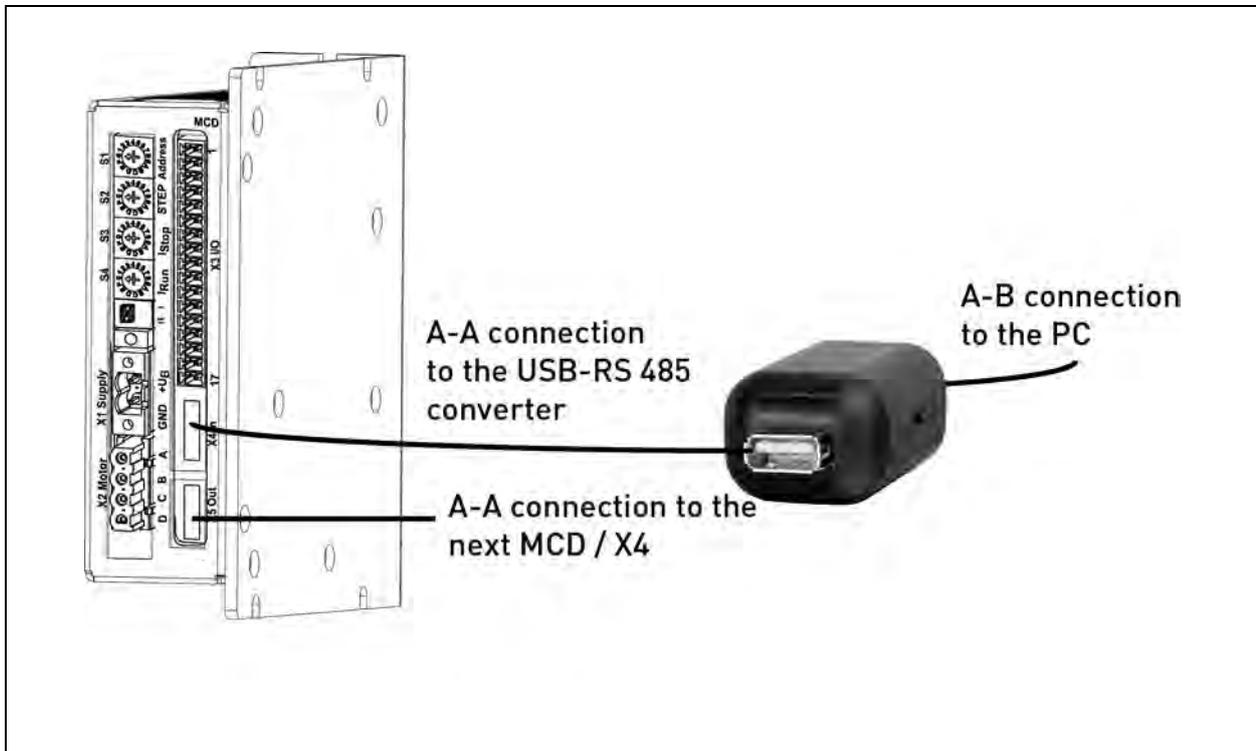


Fig. 30: Power stage MCD with phytron USB-RS485-converter

Important: When the MCD is connected to the PC by USB-interface, USB drivers, available at the phytron CD, have to be installed on the PC.

8.2.2 USB-Driver Installation

Important: Administrator authorizations are required for the driver installation.

- Power on your PC. When the desktop is ready, insert the phytron CD and open the folder **USB Treiber** by the Windows Explorer. Select the **.exe** program which goes with your system software and start it by double click. The following window is shown on desktop after a successful installation:



- Connect the power stage directly or via USB converter to the USB port of your PC by USB cable.

Important: Use a USB cable with a maximum length of 2 m!

- For checking the correct USB driver installation, continue as follows:

Start the device manager by clicking **Start→Settings→System control** and double-click on **System**. Then select the **Device manager** tab. The USB components can be found in **Computer→Ports** and in **Universal Serial Bus Controller**. Here the new USB-component is shown: **USB Serial Port (Com X)**

- **Important:** If you want to test several USB devices, which are identical in construction, you should use the same USB port on the PC. Thus, you avoid changing the COM port number.
- You'll also find information about the driver installation for the chip FT232R on <http://www.ftdichip.com>.

9 Bus Connection Configuration

If operating more than one MCD device (max. 16) at one serial interface, the RS485 field bus is the best choice.

Many parameters in the MCD can be set by the serial bus connection. Thus, a safe stepper motor operation with correct preset parameters is assured.

9.1 Definition

The bus connection is defined as follows:

- RS485: 4 wire connection, also point to point connection possible
- Signal input: R+ R-
- Signal output: T+ T-
- insulated from the motor voltage by means of optocoupler

A well-defined protocol should be followed to assure a safe data exchange:

Asynchronous transmission, 8 bits/byte, 1 stop bit, 1 parity bit

Transmission rate: 57600 Baud

Permanent telegram format:

<STX> <address_H><address_L> <instruction> <value> : <csh> <csi> < ETX>

<STX>	Start-of-text character, 02 _H
<address_H>	High-order byte of the power stage address 00 _H ...0F _H , 0 _D ...15 _D ; Admissible characters: 0...F
<address_L>	Low-order byte of the power stage address 00 _H ...0F _H , 0 _D ...15 _D ; Admissible characters: 0...F
<instruction>	Instruction byte: A...Z
<value>	Data byte
:	Colon as separator, to distinguish between usable data and checksum
<csh>	Upper byte of the 8 bit checksum value
<csi>	lower byte of the 8 bit checksum value
< ETX>	End-of-text character, 03 _H

The checksum is defined by summing up all bytes, beginning with the address byte and including the separator (:) in an exclusive-OR-operation (\oplus):

$$CS = \text{address_H address_L} \oplus \text{data byte 1} \oplus \text{data byte 2} \dots \oplus \text{data byte n} \oplus \text{separator}$$

The checksum is calculated as one 8-bit binary value (00_h to FF_h). This byte is taken apart in its upper and lower byte (nibbles). After the HEX values of the two nibbles have been transferred to the corresponding two ASCII characters (0 to 9 instead of 0_H to 9_H and A to F instead of A_H to F_H, that means to each nibble 30_H or rather 37_H is mathematically added), the checksum is written into the telegram.

The power stage also calculates (Exclusive OR) the checksum of the received data. The telegram will be rejected if a difference to the received checksum is detected.

If there is no need to validate the contents of the telegram, the checksum monitoring can be set off. Instead of the checksum bytes, two X characters will be accepted by the power stage. As well, telegrams without checksum and also without : (separator) will be accepted, e.g.:

Example: <STX> | 1 | R | 4 | 0 | : | X | X | <ETX> or

Example: <STX> | 1 | R | 4 | 0 | <ETX>

9.2 Operating Parameters

The operating parameters are stored in a permanent memory of the power stage.

In the following table the operating parameters are defined with

W for **w**rite,

R for **r**ead and

X for **e**xecute.

For current values reading or writing is applied:

Integer value x 1/10 = valid current or voltage value

Example: 48 x 1/10 = 4.8 (A_{r.m.s})

The MCD instruction set mostly consists of one-byte-instructions, this means, that from the second byte the data for the instruction will follow.

The instructions for additional parameters with instruction code **P** are two byte instructions.

The data will begin on the 3rd byte in these instructions.

By **L** or **U** input after the instruction code the maximum permissible instruction limits, by **I**

input after the instruction code the function of the instruction are displayed. By **S** and **E**

scale and unit (**E**inheit) of current and time values can be read.

The following table gives an overview:

Additional input to the instruction code	Function	Example	Description	Answer
I	Information about the instruction	FI	Information about the instruction F	f,R/– MCD status'
U	Upper limit of the number range	SU	Stop current: highest value	S63
L	Lower limit of the number range	RL	Run current: lowest value	r1
S	Scale of current or temperature values: 1=1:1 10=1:10	SS	Read scale value of the stop current	s10
E	Unit of current- and time values: A, mA, ms, s	SE	Read unit of the stop current	eA
?	Read the preset value	R?	Display run current: 2.5 A	r25
<value>	Set the value	S5	Stop current 0.5 A	s5

Important:

- If the instruction input values are faulty, the actual preset value will be the answer.
- If an instruction code is entered which is not implemented, the instruction code is answered by a minuscule with –character.
Example: Enter K → Answer: k–

Instruction code	Parameter name	Type	Value	Description	Default values																			
A	Boost	R/W	0 to 63	Boost current from 0.1 to 6.3 A _{r.m.s.}	0																			
B	Software version	R	<String>	Read power stage software version	–																			
C	Reset	X	–	Power stage reset	–																			
E	Delete EPROM	X	–	Delete user's parameters in the EPROM	–																			
F	MCD status	R	Read the MCD status (0001 to FFFF)		–																			
			<table border="1"> <thead> <tr> <th>Hex.⁺⁾</th> <th>Dec.⁺⁾</th> <th>Va- lency</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0001</td> <td>1</td> <td>0^{*)}</td> <td>Error under-/overvoltage</td> </tr> <tr> <td>0002</td> <td>2</td> <td>1^{*)}</td> <td>Error overtemperature /short circuit</td> </tr> <tr> <td>0020</td> <td>32</td> <td>5</td> <td>Power stage is in basic position</td> </tr> <tr> <td>0040</td> <td>64</td> <td>6</td> <td>Error checksum</td> </tr> <tr> <td>0080</td> <td>128</td> <td>7</td> <td>Reset in MCD</td> </tr> </tbody> </table>	Hex. ⁺⁾		Dec. ⁺⁾	Va- lency	Description	0001	1	0 ^{*)}	Error under-/overvoltage	0002	2	1 ^{*)}	Error overtemperature /short circuit	0020	32	5	Power stage is in basic position	0040	64	6	Error checksum
Hex. ⁺⁾	Dec. ⁺⁾	Va- lency	Description																					
0001	1	0 ^{*)}	Error under-/overvoltage																					
0002	2	1 ^{*)}	Error overtemperature /short circuit																					
0020	32	5	Power stage is in basic position																					
0040	64	6	Error checksum																					
0080	128	7	Reset in MCD																					
G	Pref. direction	R/W	0 or 1	1=preferential direction 0=contrary to pref. direction	0																			
J	Zero position	X		Enforce the basic position	–																			
LA LB LD LT	Input logic level for: Activation Boost Direction Control pulse	R/W	0 or 1	Define input logic level: 0 = HIGH active 1 = LOW active	0																			

⁺⁾ Status can be read as dec. or hex. number. See chap. 9.2.2

^{*)} If both error bits are set, the status means "short circuit in power stage".

Instruction code	Parameter name	Type	Value	Description	De- fault values																		
M	Step width	R/W	0 to 12	<table border="0"> <tr> <td>0= 1/1</td> <td>7=1/20</td> </tr> <tr> <td>1= 1/2</td> <td>8=1/32</td> </tr> <tr> <td>2= 1/4</td> <td>9=1/64</td> </tr> <tr> <td>3= 1/5</td> <td>10=1/128</td> </tr> <tr> <td>4= 1/8</td> <td>11=1/256</td> </tr> <tr> <td>5=1/10</td> <td>12=1/512</td> </tr> <tr> <td>6=1/16</td> <td>step</td> </tr> </table>	0= 1/1	7=1/20	1= 1/2	8=1/32	2= 1/4	9=1/64	3= 1/5	10=1/128	4= 1/8	11=1/256	5=1/10	12=1/512	6=1/16	step	9				
0= 1/1	7=1/20																						
1= 1/2	8=1/32																						
2= 1/4	9=1/64																						
3= 1/5	10=1/128																						
4= 1/8	11=1/256																						
5=1/10	12=1/512																						
6=1/16	step																						
O	Output logic level Error (open collector)	R/W	0 or 1	Define output error logic level: 0 = Transistor opened 1 = Transistor locks	0																		
P	Extra parameters	R/W X		1st byte of the instructions ,Extra parameters', to define security functions See chap. 9.2.1	–																		
Q	Error inquiry	R	0 to 3	0=no error 1=undervoltage/overvoltage 2=overtemperature 3=overcurrent	–																		
R	Run current	R/W	0 to 63	Run current values from 0 to 6.3 A _{r.m.s.}																			
S	Stop current	R/W	0 to 63	Stop current values from 0 to 6.3 A _{r.m.s.}																			
T	Delay time	R/W	0 to 15	<table border="0"> <tr> <td>0= 1</td> <td>8= 16</td> </tr> <tr> <td>1= 2</td> <td>9= 20</td> </tr> <tr> <td>2= 4</td> <td>10= 40</td> </tr> <tr> <td>3= 6</td> <td>11= 60</td> </tr> <tr> <td>4= 8</td> <td>12= 100</td> </tr> <tr> <td>5=10</td> <td>13= 200</td> </tr> <tr> <td>6=12</td> <td>14= 500</td> </tr> <tr> <td>7=14</td> <td>15=1000</td> </tr> <tr> <td></td> <td>ms</td> </tr> </table>	0= 1	8= 16	1= 2	9= 20	2= 4	10= 40	3= 6	11= 60	4= 8	12= 100	5=10	13= 200	6=12	14= 500	7=14	15=1000		ms	10
0= 1	8= 16																						
1= 2	9= 20																						
2= 4	10= 40																						
3= 6	11= 60																						
4= 8	12= 100																						
5=10	13= 200																						
6=12	14= 500																						
7=14	15=1000																						
	ms																						
U*	Power stage deactivation	R/W	0 or 1	0 = activated 1 = deactivated	1																		

*) Remark for ServiceBus mode: Please deactivate the power stage only by U=0, if it isn't still deactivated by the input Activation (connector X3).

Manual MCD+

Instruction code	Parameter name	Type	Value	Description	Default values
W	Write EPROM	X	–	Write parameter into EPROM	–
Z	Motor test	X	+ or –	Self test: one motor rotation with preset run current	–

9.2.1 Extra Parameters

Instruction code	Parameter name	Type	Value	Description	Default values
PB	Operation mode	R/W	0 or 1	Set operation mode 0 = Bus 1 = Stand alone	1
PC	Current Shaping	R/W	0 or 1	Define Current Shaping CS 0 = On 1 = Off	0
PH	Overdrive upper switching frequency	R/W	225 to 225,000	Define Overdrive upper switching frequency unit: Hz	
PN	Axis name	R/W	<String	Assign or read an axis name (max. 40 characters) into the EPROM	–
PO	Overdrive	R/W	0 or 1	Define function Overdrive 0 = Off 1 = On	1
PX	Bus mode eXclusive	R/W	0 or 1	Rotary switch 0= Don't ignore rotary switches 1= Ignore rotary switches	0

9.2.2 Examples

Instruction code	Action	Answer
A? A40	Read Boost current Set Boost current to 4.0 A _{r.m.s.}	e. g. a50 (= 5.0 A _{r.m.s.}) a40
B?	Read power stage software version	b<String> (e. g. bMCDV1.0)
C	Reset power stage	c1
E	Delete EPROM	e1
F? FH?	Read MCD status in decimal mode Read MCD status in hexadecimal mode	e. g. f1 e. g. f01 (= Error undervoltage/ overvoltage)
G? G1 or G0	Read preferential direction Set preferential direction	g0 or g1 g1 or g0
J	Enforce the basic position	j1
LB? LT0 or LT1	Read input logic level Boost Set input logic level Control Pulse	lb0 or lb1 lt0 or lt1
M0....M12 M?	Set step width Read step width	M0...m12 m0...m12
O? O0 or O1	Read output logic level Set output logic level	O0 or O1 O0 or O1
PB? PB0 or PB1	Read operation mode Set operation mode	pb0 or pb1 pb0 or pb1
PC? PC0 or PC1	Read current shaping CS Set current shaping CS	pc0 or pc1 pc0 or pc1
PH? PH725	Read overdrive switching frequency Set overdrive switching frequency to 725 Hz	e. g. ph500 ph725
PN? ^{*)} PNAxis7 PN/	Read the axis name Store the axis name Delete the axis name	pn<String> (e.g. Axis4) pnAxis7 pn0

^{*) Remark:} pn0 is also the answer of PN?, if no name is saved.

Manual MCD+

Instruction code	Action	Answer
PO? PO0 or PO1	Read function Overdrive Set function Overdrive	po0 or po1 po0 or po1
PX? PX0 or PX1	Read bus mode eXclusive Set bus mode eXclusive	px0 or px1 px0 or px1
Q?	Error inquiry	q0...q3
R? R150	Read run current Set run current to 1.5 A _{r.m.s.}	e. g. r18 (= 1.8 A _{r.m.s.}) r15
S? S240	Read stop current Set stop current to 2.4 A _{r.m.s.}	e. g. s18 (= 1.8 A _{r.m.s.}) s24
T? T10	Read delay time Set delay time to 40 ms	e. g. t9 (= 20 ms) t10
U? U0 or U1	Read deactivation of the power stage Set deactivation of the power stage	e. g. u0 or u1 u0 or u1
W	Write EPROM	w1
Z+, Z-	Do the motor self test	z1

Appendix A: Technical Details

A stepper motor can be used with different step resolutions, which are described in the first part of this chapter. The functions Boost, Overdrive, Current delay time and the Current Shaping you'll find in the second part.

A1 Full Step / Half Step / Ministep

Full step (FS)

The FULL STEP mode is the operating mode in which a 200-step motor, for example, drives 200 steps per revolution. In the full step mode, both stepper motor phases are permanently energized.

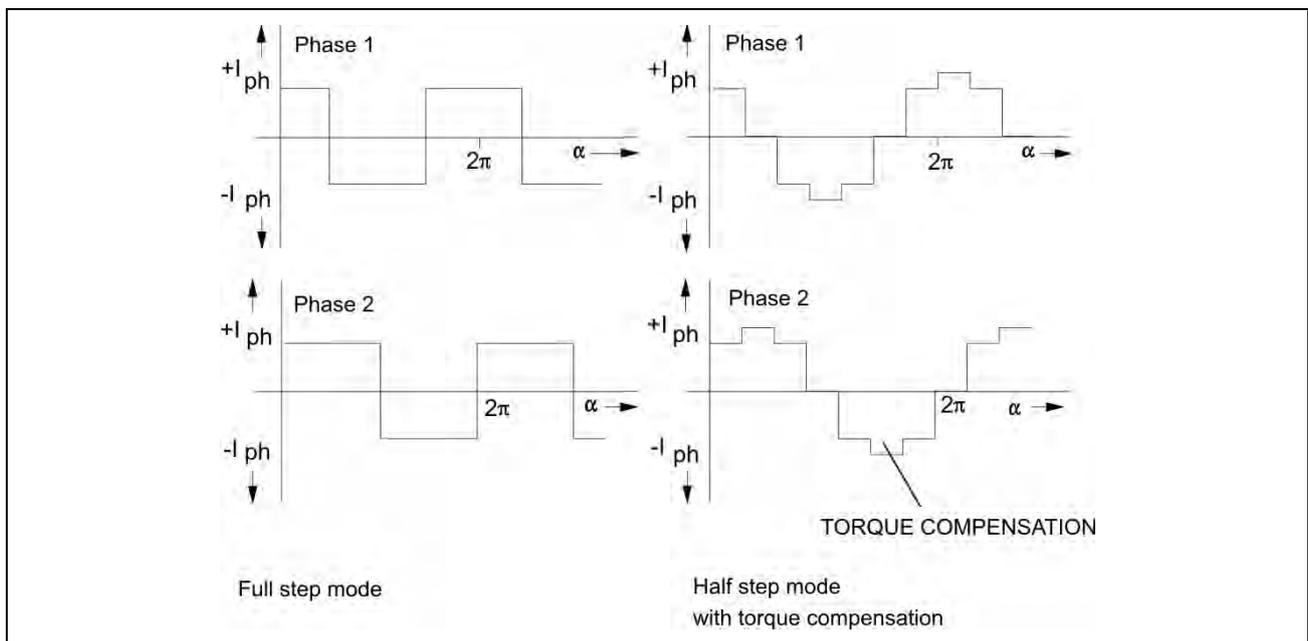


Fig. 31: Phase current curves

Half step (HS)

The motor step resolution can be electronically multiplied by 2 by alternately energizing the stepper motor's phases 1, 1+2, 2 etc. This is the HALF STEP mode. The torque, however, is reduced in the half step mode, compared to the full step mode.

To compensate this lack of torque, the operating mode HALF STEP MODE WITH TORQUE COMPENSATION was developed: the current is increased by $\sqrt{2}$ in the active phase. Compared to the full step mode, the torque delivered is almost the same. Most of the resonance is suppressed.

The following diagram shows extent and direction of the holding torques of a 4-step motor during one revolution without and with torque compensation. In the full step position two phases, in the half step position only one phase is energized. The total moment is the result of superpositioning both phase moments.

Manual MCD+

The moment in the full step mode, M_{FS} , as compared to the moment in the half-step mode, M_{HS} is: $|M_{FS}| = |M_{HS}| \times \sqrt{2}$

This means, when a single phase is energized, the current must be increased by a $\sqrt{2}$ factor to obtain an identical torque.

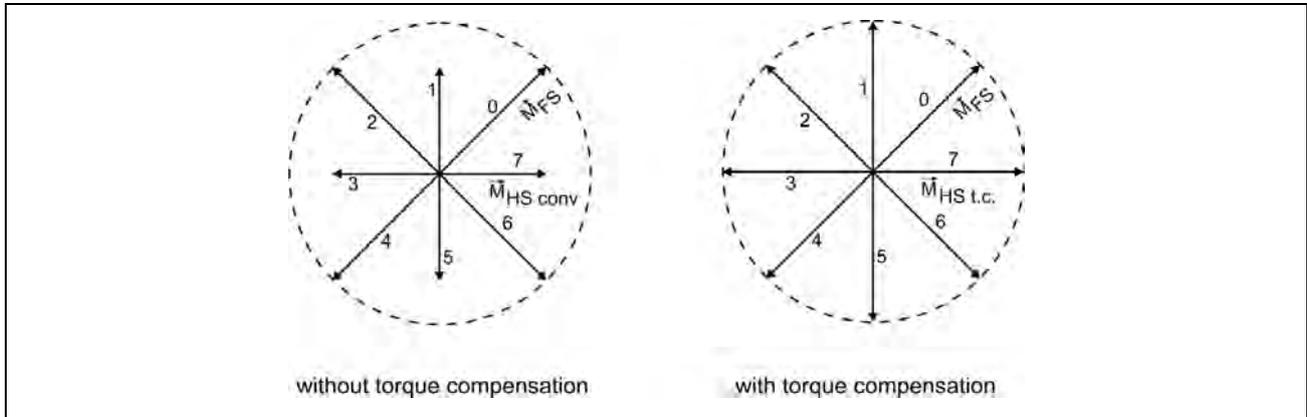


Fig. 32: Holding torques without/with torque compensation

Ministep/ Microstep

In Rotary switch mode the power stage MCD increases the step resolution by a factor 2, 4, 5, 8, 10 or 20 of a full step – MINISTEP MODE.

In ServiceBus mode the step resolution can be increased by a factor 2, 4, 5, 8, 10, 16, 20, 32, 64, 128, 256 or 512 of a full step – MICROSTEP MODE.

Various advantages are obtained by the MINISTEP MODE:

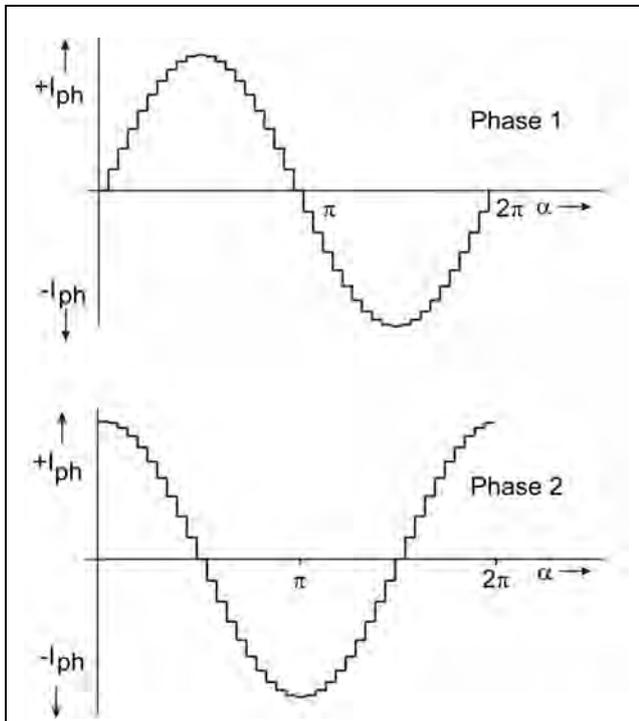


Fig. 33: Ministep 1/10 of a full step

- The torque undulation drops when the number of ministeps is increased.
- Resonance and overshoot phenomena are greatly reduced; the motor operation is almost resonance-free.
- The motor noise also drops when the number of ministeps is increased.

A2 Boost

The motor torque required during acceleration and deceleration is higher than that required during continuous motor operation (f_{max}). For fast acceleration and deceleration settings, (steep ramps), the motor current is too high during continuous operation and results in motor overheating. However, a lower phase current results in too flat acceleration and deceleration ramps.

Therefore, different phase currents should be used:

- Continuous operation: run current
- During acceleration and deceleration: Boost current

The Boost signal is activated by the superior controller. While input Boost is energized, a 30 % higher current is flowing.

In the ServiceBus mode the boost value is programmable from 0 to 6.3 $A_{r.m.s.}$.

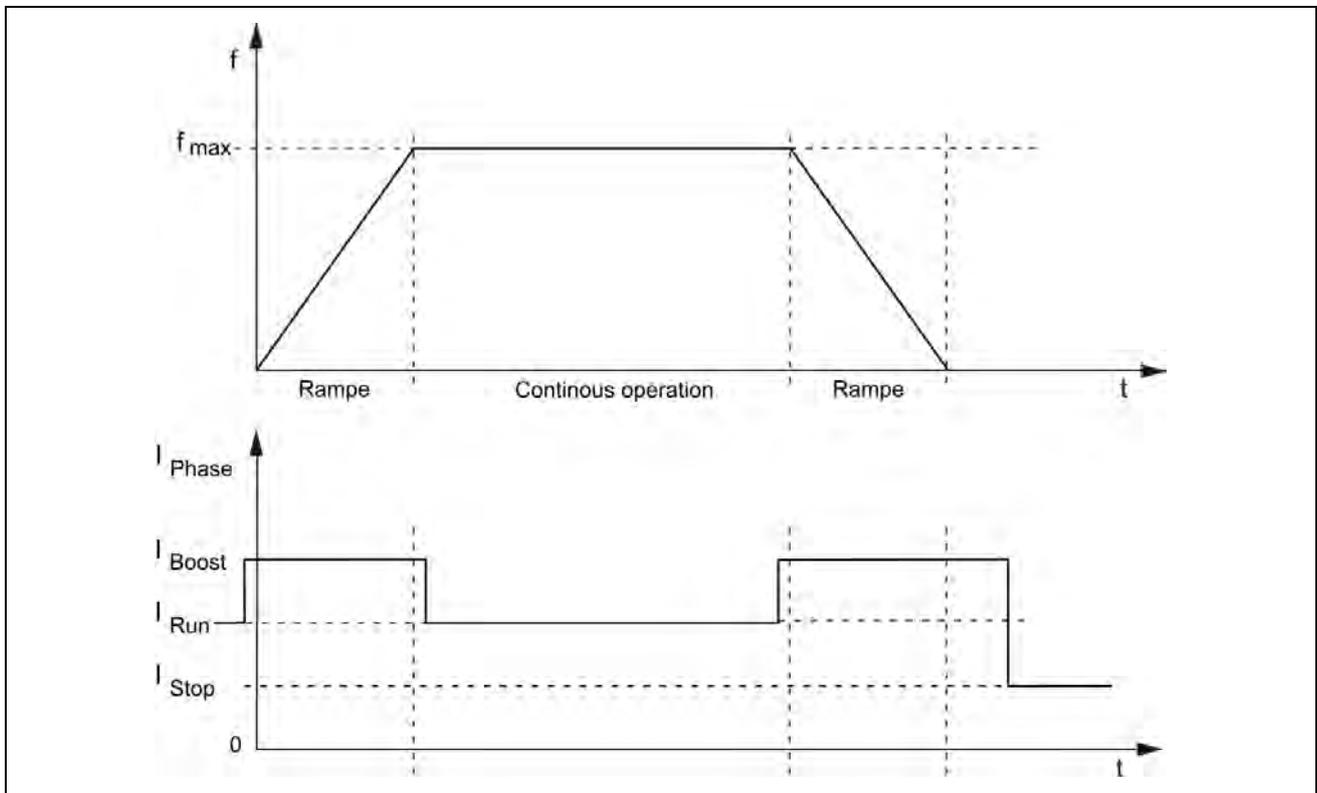


Fig. 34: Boost

After the last control pulse the stop current is activated after a waiting time. The waiting time after the last control pulse until the change to the stop current is called current delay time (see appendix A4).

A3 Overdrive Function

The MCD power stages can compensate the phase current decrease in the upper speed range by the Overdrive function. Overdrive is independent of the motor type.

Overdrive is a dynamic boost function, which will be automatically switched on if this makes sense in regard of the current shape:

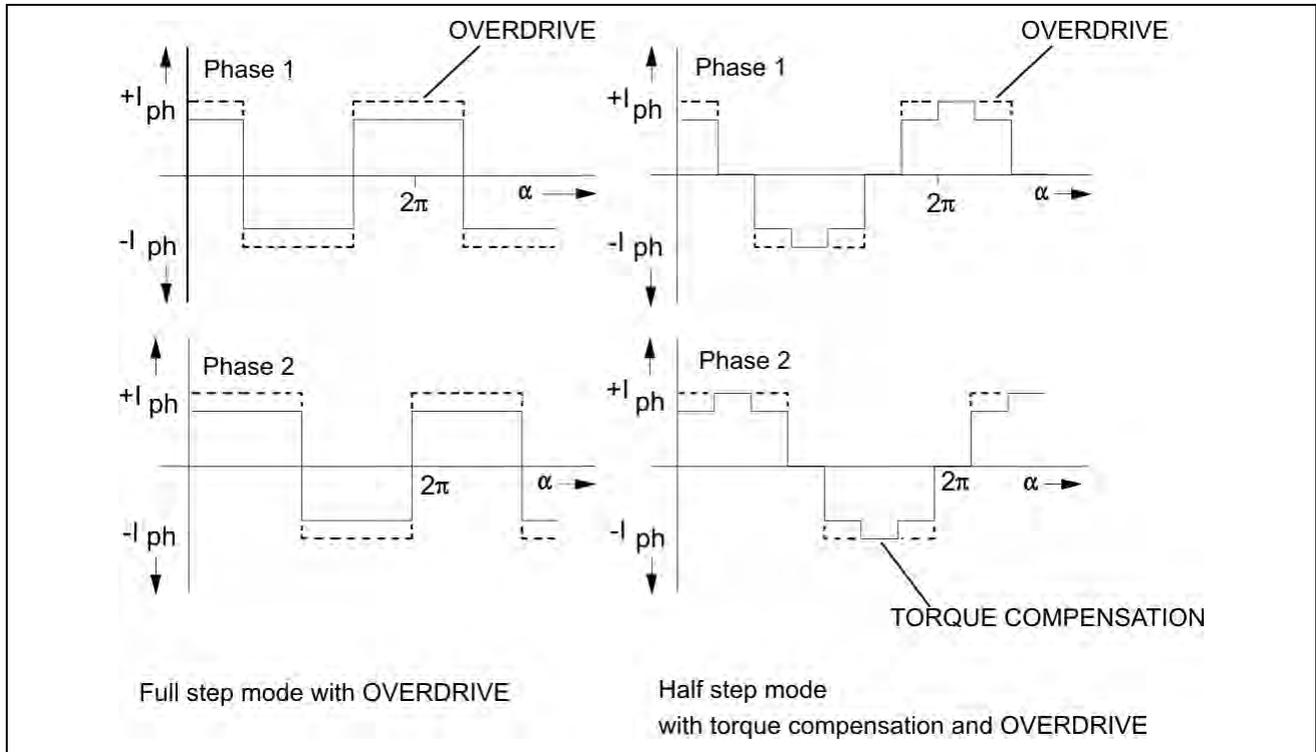


Fig. 35: Phase currents with Overdrive

The stepper motor phase current decreases with increasing step frequency caused by the counter-electromotive force of the motor.

The Overdrive function compensates the decrease of current and torque. The phase current is increased by about 20 % in Overdrive function. The switching frequency based on FS can be selected from 225 Hz to 225 kHz. This switching frequency is set to 1,000 Hz input control pulse by default. The switching-off frequency is 10 % lower than the switching-on frequency for producing a hysteresis.

The stepper motor torque decreases by increasing of the rotation speed.

The Overdrive function works against the reducing of the torque at middle and high rotation speeds.

The function Overdrive is activated on delivery and can be switched off in the ServiceBus mode by ServiceBus-Comm®.

The parameterization is done by the ,PH' instruction code.

Step resolution	Input control pulse frequency		PH ServiceBus parameter Default
	Overdrive on at >	Overdrive off at <	
1/1 = VS	1 kHz	0.9 kHz	1 kHz
1/2 = HS	2 kHz	1.8 kHz	1 kHz
1/4	4 kHz	3.6 kHz	1 kHz
1/5	5 kHz	4.5 kHz	1 kHz
1/8	8 kHz	7.2 kHz	1 kHz
1/10	10 kHz	9.0 kHz	1 kHz
1/16	16 kHz	14.4 kHz	1 kHz
1/20	20 kHz	18.0 kHz	1 kHz
1/32	32 kHz	28.8 kHz	1 kHz
1/64	64 kHz	57.6 kHz	1 kHz
1/128	128 kHz	115 kHz	1 kHz
1/256	256 kHz	230 kHz	1 kHz
1/512	512 kHz	460 kHz	1 kHz

Example for 500 Hz switching frequency during VS operation:

Step resolution	Input control pulse frequency		PH ServiceBus parameter
	Overdrive on at >	Overdrive off at <	
1/1 = VS	0.5 kHz	0.45 kHz	500 Hz
1/2 = HS	1 kHz	0.9 kHz	500 Hz
1/4	4 kHz	1.8 kHz	500 Hz
1/5	2.5 kHz	2.25 kHz	500 Hz
1/8	4 kHz	3.6 kHz	500 Hz
1/10	5 kHz	4.5 kHz	500 Hz
1/16	8 kHz	7.2 kHz	500 Hz
1/20	10 kHz	9.0 kHz	500 Hz
1/32	16 kHz	14.4 kHz	500 Hz
1/64	32 kHz	28.8 kHz	500 Hz
1/128	64 kHz	57,6 kHz	500 Hz
1/256	128 kHz	115.2 kHz	500 Hz
1/512	256 kHz	230.4 kHz	500 Hz

A4 Current Delay Time

After the last control pulse the stop current is activated after a waiting time. The waiting time after the last control pulse until the changing to the stop current is called current delay time.

We recommend to specify t_{Delay} so that the motor's oscillations are dying out after the last motor step and mispositioning is avoided.

In Rotary switch mode the current delay time is set to 40 ms.

In ServiceBus mode the delay time can be programmed from 1 to 1000 ms in 15 steps.

Automatic change from run to stop current:

The ratio between both phase currents remains equal in the respective current feed pattern. Changing from run to stop current is synchronously.

In the following figure the next motor step follows after every **rising** control pulse edge:

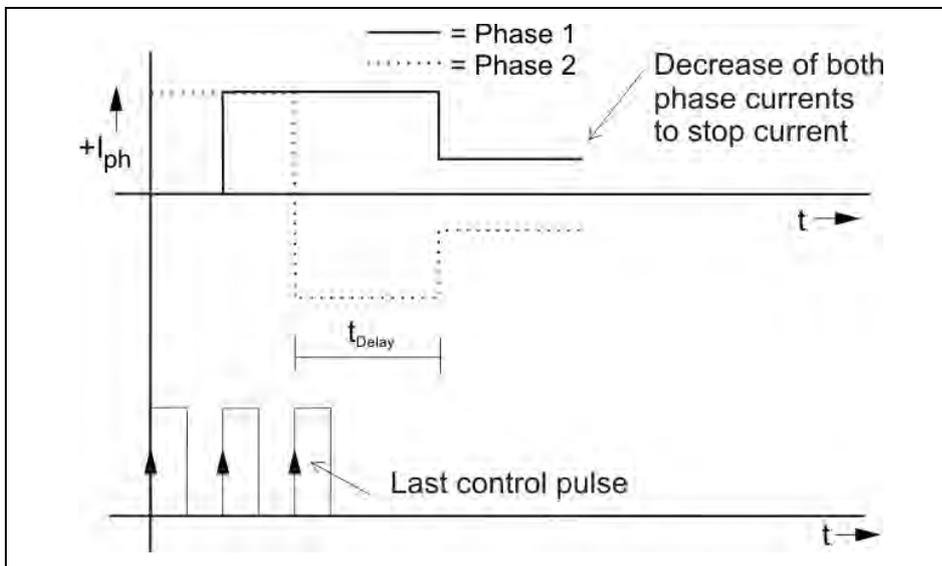


Fig. 36: Decrease to stop current after the last control pulse (full step)

Decreasing to stop current takes the following advantages:

- Motor and power stage heating is reduced.
- EMC is improved because of smaller current values

A5 Current Shaping CS

Current Shaping (CS) is a circuitry method for delivering a true phase current which corresponds for a wide range of frequencies to a selected current shape.

If the stepper motor is driven without CS, the true current differs from the specified current, even in the lower speed frequencies.

The 1/20 sine wave mode results in a current deviation as shown in fig. 37, for average speed:

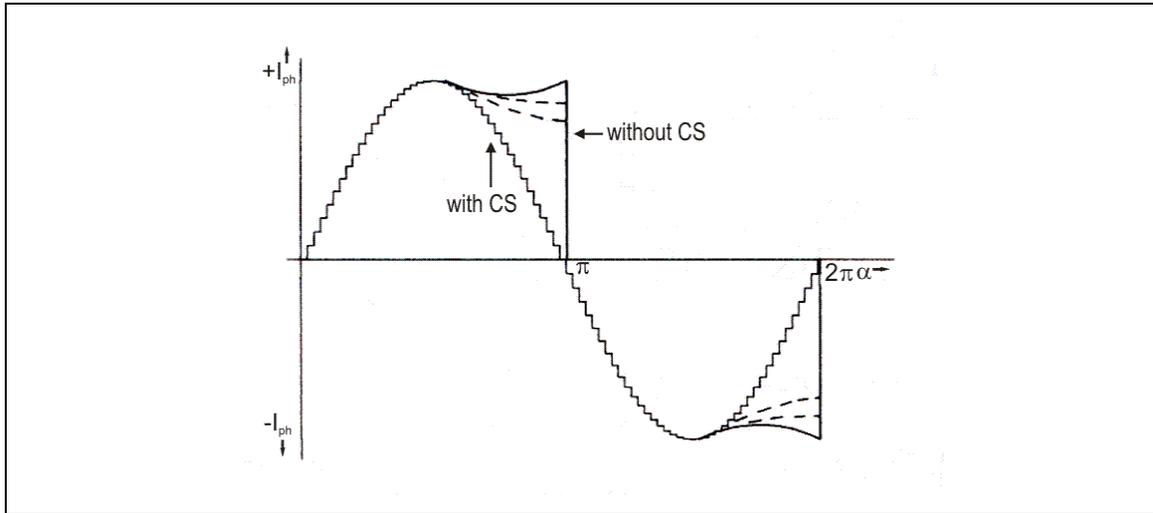


Fig. 37: Current Shaping CS

These typical deformations can be observed for all types of curves. They are caused by the stepper motor inductance and the generator feedback which increases with the motor speed.

The resulting ,current queue' makes precise current regulation possible by Current Shaping (CS= 4 quadrant current regulation), only. The amplitude of the ,current queue' varies strongly remarked during one revolution and may provoke a motor resonance effect which causes step losses or desynchronisation of the motor.

If the CS function is activated, the ,current queue' disappears and the resulting current is close to the ideal shape.

We recommend to use CS in higher current and speed frequency ranges.

In ServiceBus mode CS can be activated by a button in ServiceBus-Comm[®].

Appendix B

In this chapter warranty, trademarks and ESD protective measures are described.

B1 Warranty

The MCD power stages are subject to legal warranty. phytron will repair or exchange devices which show a failure due to defects in material or caused by the production process. This warranty does not include damages which are caused by the customer, as there are, for example, not intended use, unauthorized modifications, wrong treatment or wrong wiring.

B2 Trademarks

In this manual several trademarks are used which are no longer explicitly marked as trademarks within the text. The lack of this signs may not be used to draw the conclusion that these products are free of rights of third parties. Some product names used herein are for instance

- ServiceBus-Comm is a trade mark of the Phytron GmbH.
- Microsoft is a registered trade mark and WINDOWS is a trade mark of the Microsoft Corporation in the USA and other countries.

B3 ESD Protective Measures

All the products which we deliver have been carefully checked and submitted to a long-term test. To avoid the failure of components sensitive to electrostatic discharge (ESD), we apply a great number of protective measures during manufacturing, from the component input check until the delivery of the finished products.

Warning:

Manipulation of ESD sensitive devices must be effected by respecting special protective measures (EN 61340–5). Only return the modules or boards in adapted packaging.

phytron's warranty is cancelled in case of damages arising from improper manipulation or transportation of ESD modules and components.

Appendix C: Declaration of Incorporation



Declaration of Incorporation
 according to EC directive 2006/42/EC on machinery (Annex II B)
 for partly completed machinery

Name and address of the manufacturer:

Phytron GmbH,
 Industriestr. 12
 82194 Gröbenzell

Representative in EU, authorized to compile the relevant technical documentation:

Rainer Gareis
 Phytron GmbH,
 Industriestr. 12
 82194 Gröbenzell

Description of the partly completed machinery:

Product denomination: Compact Stepper Motor Power Stage
Model/Type: MCD+ 93/70, Part.-No. 10008200, 10006576, 10008201, 10006861, 10017754, 10017755, 10012292, 10017754, 10017755

From serial number 1410xxxxx

We declare that the product complies with the following essential requirements of the Machinery Directive 2006/42/EC:

1.1.2.; 1.1.5.; 1.3.4.; 1.5.1.; 1.5.2.; 1.5.4.; 1.5.5.; 1.5.6.; 1.5.16.; 1.6.3.; 1.6.4.; 1.7.2.; 1.7.3.; 1.7.4.

In addition the partly completed machinery is in conformity with the following EC Directives:

EC Directives 2004/108/EC relating to electromagnetic compatibility.

We declare that the relevant technical documentation is compiled in accordance with part B of Annex VII.

We commit to transmit, in response to a reasoned request by the market surveillance authorities, relevant documents on the partly completed machinery.

Important note! The partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of Directive 2006/42/EC on Machinery, where appropriate, and until the EC Declaration of Conformity according to Annex II A is issued.

Gröbenzell, 2014-10-22

Christian Klaus
 Management Board

AP QS-0670-6
 CE 7044 Rev. 1

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 IBAN DE670169464000096610 – BIC GENODEF3307
 Sparkasse Fürstenfeldbruck – Kto. 1801265 – BLZ 70053070
 Oberbank München – Kto. 1941021021 – BLZ 70120700
 Volksbank Fürstenfeldbruck – Kto. 712531 – BLZ 70163370
 Postbank München – Kto. 0286001800 – BLZ 70010080

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