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Stepper Motor Power Stage with Indexer and Plain Text Display



GCD 93-70 MINI
Bipolar Stepper Motor Power Stage
with Indexer and Plain Text Display

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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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Manual GCD MINI

1 GCD 93-70 MINI

In this chapter you will find a brief description of the "intelligent power stage" GCD, and a short introduction into its menu system. A schematic diagram will show you the high integration level of this product.

1.1 Short Overview

GCD is a stepper motor power stage with an axis controller (or indexer). That means, GCD is a compact stepper motor controller to drive two-phase stepper motors.

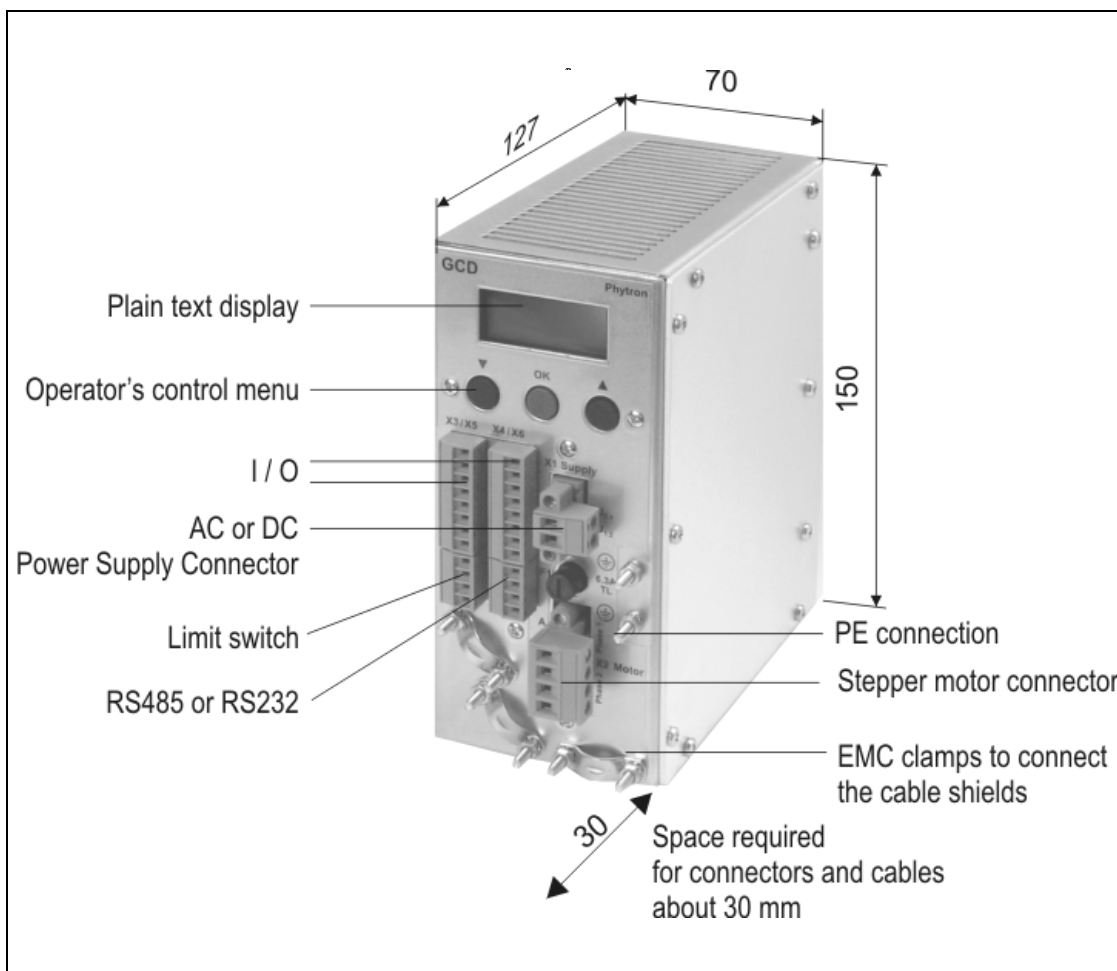


Fig. 1: Controls and dimensions (mm)

The power stage is directly controlled by a microcontroller, which receives motion commands from an overriding controller, for ex. a PC or a PLC.

The GCD can be connected to the controller either by means of a serial interface type RS232 or RS485 (different GCD design) or a parallel interface with 24 V process I/Os.

For service and test, you can manually operate the GCD. It is easy to do with the menu control buttons and the built-in plain text display.

Ministep power stage for two phase stepper motors

The GCD takes advantage of Phytron's well tried stepper motor power stage technology, which could be improved again with the 4 quadrant precision current control. This technique, also found in the CCD pulse/direction power stage, has been combined with the well known controller used in the GSP stepper motor control.

The step resolution is dynamically adapted to the speed. At low speed, the GCD will use 1/8 steps and full steps at high speed.

With the overdrive function, the GCD uses a dynamic current compensation for higher torque in the upper frequency range independent of the type of stepper motor.

Wide motor current ranges from 0.1 to 6.3 A_{r.m.s.}

In the SETUP menu, run current, stop current and boost current can be individually set in 0.1 A steps. The maximum motor current is 6.3 A_{r.m.s.} resp. 9 A_{Peak}.

Supply voltage AC or DC

Rectifier, load capacitor and logic supply circuit are already included, so you have only to connect an external supply with DC 20 to 70 V_{DC} or AC 17 to 50 V_{AC}.

Auxiliary process supply voltage 24 V_{DC}

The power circuit is insulated from the process I/Os and all other inputs and outputs.

You need an auxiliary 24 V_{DC} power to supply the process I/Os, limit switches and the serial interface.

Inputs

The inputs are driven with 24 V level enabling a direct connection to PLC outputs.

Outputs

The outputs are driven by the auxiliary power supply (24 V_{DC}). The outputs are compatible to standard PLC inputs and short circuit protected. Error messages can only be reset if the auxiliary power is off.

Limit switches

Two limit switches type PNP opener may be connected to the GCD. The limit switches are also supplied by the 24 V_{DC} auxiliary power. Of course, mechanical switches can be used as well.

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Serial interface

The GCD is equipped with an RS232 interface (3-wire point-to-point) or with an RS485 interface (4-wire bus topology).

To use the serial interface, the auxiliary supply voltage 24 V_{DC} has to be applied.

Plain text display with 2 * 8 characters



The plain text display has several functions.

In the manual mode: Operation parameter setting
Test of motor and wiring

In the normal mode, controlled by a master controller: Diagnostic information, as power stage temperature, short circuit, low voltage or overtemperature

Fig. 2: Plain text display with menu control

Easy to mount and EMC compliant

The GCD has been designed to be mounted in a switching cabinet. It is equipped with easy to mount screw type plug-in connectors.

The full metal housing is EMC compliant, a line filter for the supply voltage is integrated.

The GCD housing is prepared for mounting an external fan (24 V) at the bottom.

1.2 Extent of Supply

Before testing the GCD device, please check the delivery for completeness.

The standard package consists of:

- GCD with connector kit and mounting kit (rail mounting or wall mounting)
 - #2005758 GCD with RS232 interface / wall mounting
 - #2005759 GCD with RS485 interface / wall mounting
 - #2005789 GCD with RS232 interface / rail mounting
 - #2005790 GCD with RS485 interface / rail mounting
- Manual GCD containing setup, test and PLC operation
- Manual IPCOMM Protocol defining the serial interface functions
- CD with configuration software IPCOMM and toolset
- #2005740, connector kit for supply voltage, motor connector and digital I/O connector

Supplementary parts available are:

- #2005791, external fan 24 V_{DC} (type Papst) with mounting screws
- Toroidal transformer for mains voltage 115V_{AC} or 230 V_{AC} to drive GCD devices, secondary voltage rated 50 V / 4.5 A. The rated power of the transformer is 230 VA. The transformer is equipped with a temperature limiter with 130° C threshold temperature.
- Power supply: A ready-to-mount power supply with mains transformer, fuse and mounting kit for switching cabinets is being prepared.

1.3 Menu Function Test

In this chapter is explained how to use the menu control and how to drive the motor for test. The information in this chapter is only valid for performing tests with the menu control and the stepper motor. For normal operation, the GCD has to be mounted into a switching cabinet (chapter 4).

For test operation you only need a power supply (see chapter 5), a stepper motor (see chapter 2), and the corresponding cabling (see chapter 5.1).

In the manual test mode, you can drive the motor without a master controller connected to the GCD.



Please read the safety instructions in chapter 3.2 very carefully before turning the GCD into operation!

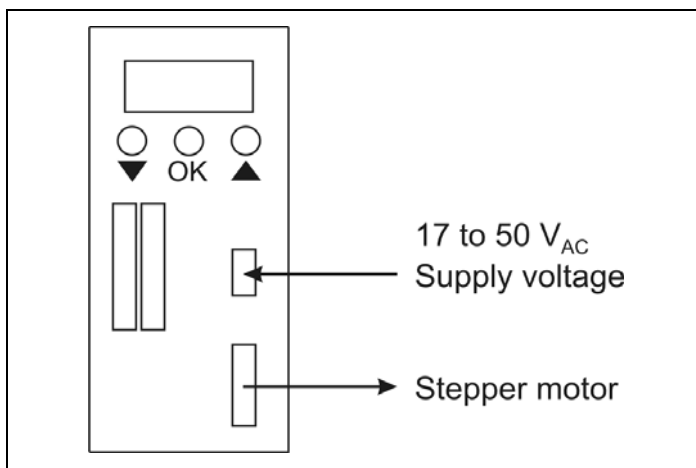


Fig. 3: Required wiring to test the GCD's menu system



1. First **only connect the power supply**.
2. Set the motor currents in the SETUP menu. Refer to the next page for details.

Warning! Excessively high motor currents may cause damage to the motor windings!

At delivery, 0.4 A run current and 0.2 A stop current are set.
The boost function is off (boost current = run current).

3. Switch off the power supply.
4. Connect the stepper motor.
5. Switch on the power supply.

After turning on the supply voltage, the following text will appear in the LCD display:

GCD 93-70 / SELFTEST.

After about two seconds, the display changes to:

GCD 93-70 / PHYTRON

The GCD will then display system information changing periodically, e.g. power stage temperature and supply voltage.

In the second line the actual state of operation is shown, for example BUSY if the motor is running or error messages.

Note: If you only connect the supply voltage as suggested on the page before, the error message **OutDrErr** will be displayed. This message says that digital I/Os and serial interface do not work, because the 24 V auxiliary supply is not connected. The basic menu and test functions with the menu buttons interface will work in spite of the error message.

After power on, the GCD is in one of two possible operation modes:

Online Mode or **PLC Mode**. By pressing the button **OK** for about three seconds the manual mode is entered. This mode switching is suppressed, if the motor is running.

As soon as the GCD changes to the manual mode, the display text changes to:

GD93-70 / Man.Mode.

Release the **OK** button. The GCD now displays the first item of the top menu level:

MENU / < BACK >. This main menu has three items, **< SETUP >** and **< TEST >** and **< BACK >** and **MENU / < BACK >**.

You can now switch to another menu item by pressing the buttons ▼ or ▲.

Having selected one of the items, you can enter the next menu level by pressing the **OK** button. The submenu **SETUP** defines GCD parameters, while the submenu **TEST** contains test functions to check the wiring. Selecting **BACK** will change to the top menu level with the items online mode or PLC mode.

In the SETUP-Menu

you can set the basic system parameters, for ex. motor currents and operating frequencies (please refer to chapter. 9.1.1).

In the TEST- Menu

you can perform basic checks of the motor and I/O wiring. You can also start the motor pressing a menu button. Some other test functions will show you the input and output states (chapter 9.1.2).

For a detailed explanation of the menu structure please refer to chapter 9.

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Menu functions and motor test	
Display after power on	GCD 93-70 SELFTEST
Display two seconds after power on	GCD 93-70 PHYTRON
Display in normal operation mode (<i>Online mode</i> or <i>PLC mode</i>). First display line will change between:	PHYTRON (Manufacturer) GCD 93-70 (Type of controller) PK 1.11 (Software version) U1 = 24V (DC bus voltage) Amp 34° (Amplifier temperature in °C)
Display in normal mode (<i>Online mode</i> or <i>PLC mode</i>). Second display line change between:	Curr.Err Overcurrent error Volt.Err Low voltage error Temp.Err Temperature error OutDrErr Digital I/O error LimSwErr Limit switch error Busy busy, e.g. motor is running
Press the OK button for more than 2 seconds	Manual mode will be activated (Man. mode) With the arrow buttons ▼/▲ you can select the items SETUP, TEST and BACK.
Release the OK button	Display changes to MENU / < SETUP>
Press the UP button ▲	Display changes to MENU / < TEST >
Press the OK button	Enters the next sub menu level (submenu TEST) First item displayed is > -FREE / < GO >
Press the OK button again	will start the motor as long as the button is hold down
Press the buttons ▲ or ▼	The menu items of the TEST submenu are scrolled once at a time
Return to main menu by pressing the button OK while the item < BACK > is shown	

1.4 GCD Schematic Diagram

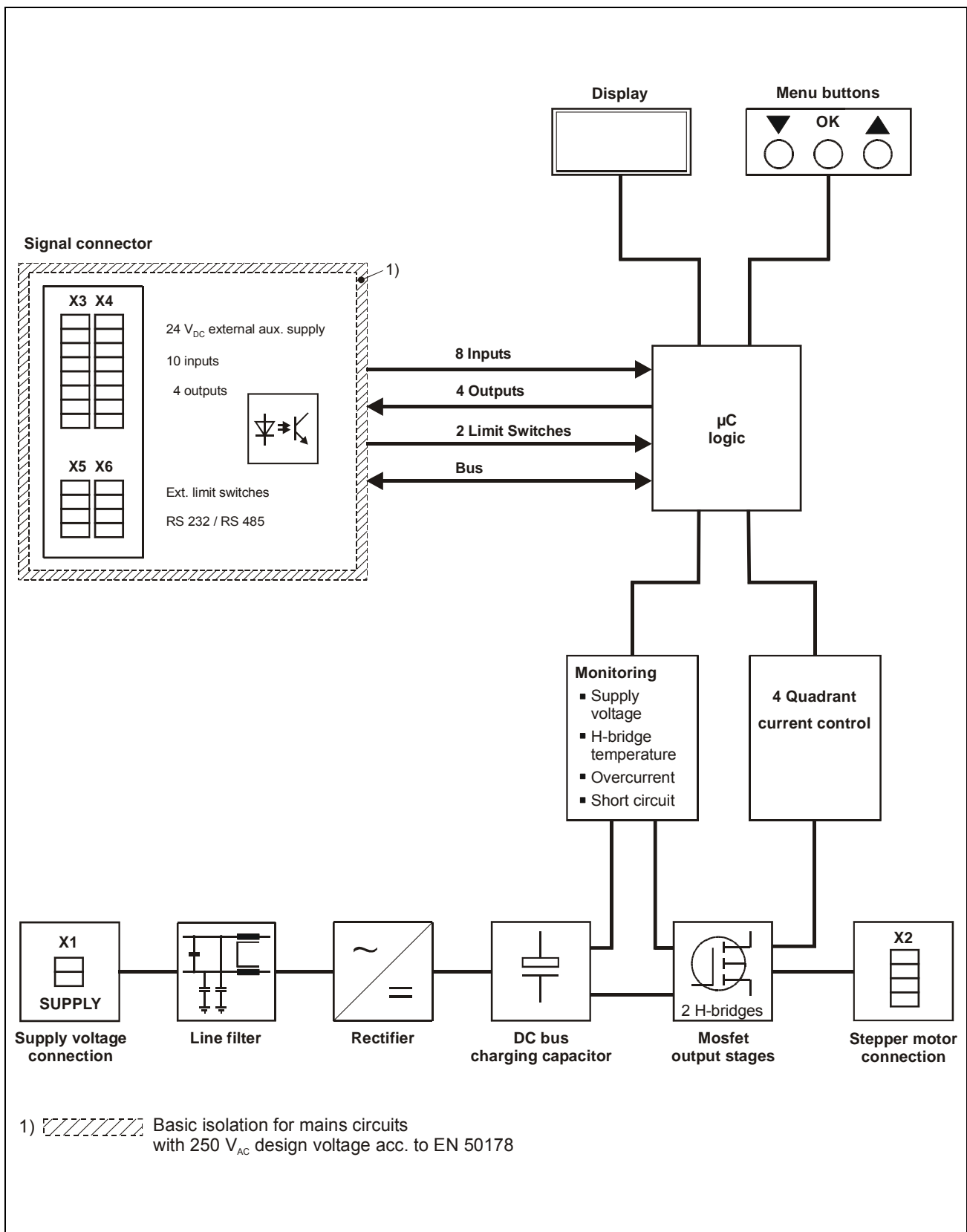


Fig. 4: GCD schematic diagram

2 Technical Data Table

Technical Data	
Control pulses	<p>Minimum step frequency : 1 Hz (referred to full step mode)</p> <p>Maximum step frequency : 10 kHz (referred to full step mode)</p> <p>This corresponds to 50 turns/sec if using a stepper motor with 200 steps / rev.</p>
Recommended Stepper Motors	<p>2-phase stepper motors with 4, 6 or 8 lead wiring scheme with 0.5 to 10 A phase current</p> <p>Winding resistance < 10 Ohm (for full power, small motors with higher resistance will also work)</p> <p>Winding inductance 0.5 to 10 mH per phase</p>
Step Resolution	<p>The step resolution will be automatically selected according to the motor speed:</p> <p>full step, half step, 1/4 step and 1/8 step.</p>
Phase Currents	<p>Run current, stop current and boost current can be set in the setup menu independent of each other in steps of 0.1 A_{r.m.s.}</p> <p>Current range: 0,1 A_{eff} up to 6,3 A_{eff}</p> <p>Select phase currents fitting to the motor !</p> <p>Factory setting: run current 0.4 A, stop current 0.2 A, boost deactivated (boost current = run current).</p>
Motor Cable Length	<p>Depending on motor current and winding resistance, refer to chapter 5.4 for details.</p>
Motor Cable Cross Section	<p>Recommended 1 mm² for full current, depending on peak current and cable length a smaller cross section may be acceptable. Refer to chapter 6 for details.</p>
Supply Voltage	<p>50 V_{AC} or 70 V_{DC}</p> <p>Admissible range: 17 to 50 V_{AC} or 20 to 70 V_{DC}</p> <p>Nominal current: 6 A_{r.m.s.}</p> <p>Short term limit: 7 A_{r.m.s.}</p>
Power Supply Transformer Requirements	<p>Basic insulation for mains supply circuits with a nominal voltage of 250 V_{AC} (accord. to the EN 50178 European Standard)</p> <p>Reinforced or double insulation between mains and secondary circuit</p>
Error Message Low Voltage	<p>Internal supply voltage less than 17 V_{DC}</p>
Fuse F1	<p>6.3 A slow</p>

Technical Data	
Mounting Environment	The GCD device is designed to be used in a switching cabinet. Depending on the operating voltage used and the safety standards to be applied other mounting environments may be applicable.
Mounting	Rail mounting or wall mounting depend on the mounting kit delivered with the device
Minimum Distances	Minimum horizontal distance to other devices: 30 mm Minimum vertical distance to other devices: 100 mm Required space for cabling and connectors: about 30 mm at the front side of the GCD
Ambient Temperatures	Operation: 4 to +50 °C Storage: -25 to +55 °C Transport: -25 to +70 °C
Ventilation	Operation without fan: Up to 40 °C ambient temperature with a phase current up to 4 A Operation with fan: With external fan (type Papst 614, 24 V _{DC}) the GCD can be operated up to 50 °C ambient temperature with full current and 100% duty cycle.
Mounting an External Fan	4 * mounting threads M3 (arranged in a square of 50 * 50 mm) to mount a 24 V fan at the bottom of the housing Warning: The mounting screws may penetrate maximum 3 mm into the device!
Weight	1.1 kg
Connector at the Supply Cable	Phoenix Combicon Screw Type Plug Connector Type MSTB 2,5/2-STF-5,08
Connector at the Motor Cable	Phoenix Combicon Connector, Type C 2,5/4-STF-5,08
Connector at the I/O Cables	2 * 8 pin Phoenix Mini Combicon screw type connector, Type MC 1,5/8-ST-3,81 2 * 4 pin Phoenix Mini Combicon screw type connector, Type MC 1,5/4-ST-3,81
Insulation requirements for I/O cables	Double or reinforced insulation for 160 V _{DC} against motor and supply voltages Note: Depending on the safety standards applied, the insulation requirements may be less strong for lower voltages.

Technical Data	
Digital Process Inputs	<p>All process inputs are optically insulated from the motor voltage.</p> <p>Nominal input voltage: 24 V with common ground</p> <p>The current limiting resistor (3.3 kΩ) reduces the current to a nominal value of 7 mA at 24 V driving voltage.</p> <p>Threshold voltage LOW: < 0.4 V</p> <p>Threshold voltage HIGH: 20 – 30 V</p>
Digital Process Outputs	<p>The outputs are optically insulated from the motor voltage.</p> <p>The outputs use smart power high-side-switches type BSP752R with internal protection against overcurrent and overtemperature. Nominal driver current is maximum 50 mA.</p>

3 To Consider Before Installation



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

3.1 Qualified Personnel

Design, installation and operation of systems using the GCD 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. Please observe the earthing instructions on page 30!
2. In case of supply voltages $> 24\text{ V}$:
The GCD must only be operated if GCD housing and motor housing are connected to protective earth.
3. The connectors „Supply“ and „Motor“ should be locked with the fixing screws.
4. 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. The secondary winding of the transformer shouldn't be grounded (SELV supply) (acc. to DIN VDE 0550 or DIN EN 60742).



5. If you need to open the GCD device:



Up to 3 minutes after turning off the supply voltage, dangerous voltages may still exist within the device.

6. **Be careful handling the connectors „Motor“ at the GCD and any motor cable coupling.**

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

7. **Up to 3 minutes after turning off the supply voltage, dangerous voltages may still exist at the GCD connectors.**



8. Do always switch off the supply voltage if you connect or disconnect any wires or connectors at the GCD.

Most important:

Do not disconnect the motor while powered.

Danger of electric arcing.

9. The digital inputs and outputs connected to X3, X4, X5 and X6 should be safely separated from mains. The maximum voltage against protective earth must not exceed 60 V_{DC} or 25 V_{AC}.

10. To switch off the drive safely, the voltage supply has to be safely switched off (by relay contact, for example).



11. The surface of the GCD may reach temperatures of more than 70 °C.

Danger of injury if touching the surface!

3.3 Protective Measure Options

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:

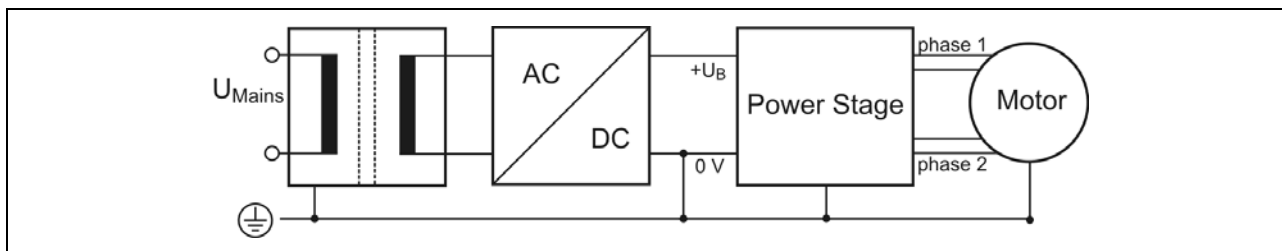


Fig. 5: PELV – Grounding: total

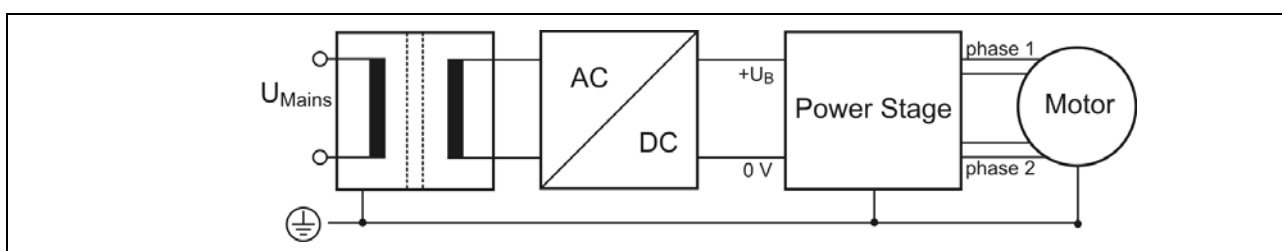


Fig. 6: PELV – Grounding: Power Stage and Motor. The secondary winding of the transformer (SELV supply) must not be grounded because the equipment is grounded.

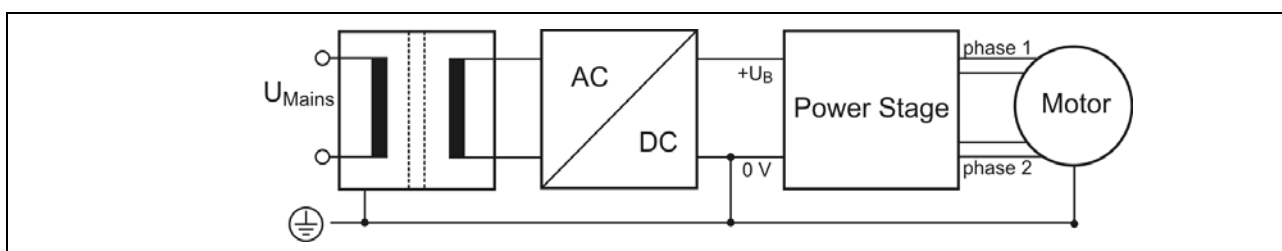


Fig. 7: PELV – Grounding: 0 V and Motor

If there is no PE clamp on the motor, the 0 V wire **must** be grounded to complete the protective measure PELV (Fig. 6 and Fig.7):

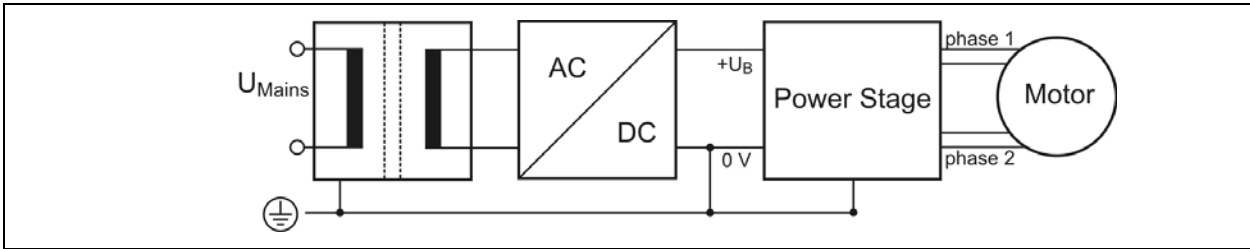


Fig. 8: PELV – Grounding: 0 V and Power Stage

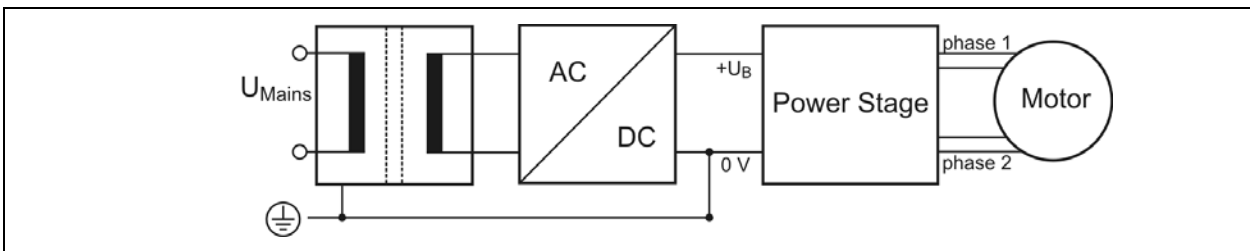


Fig. 9: PELV – Grounding: 0 V



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).

4 Mounting

In this chapter you will find all information about mounting the GCD inside a switching cabinet and mounting an external fan.

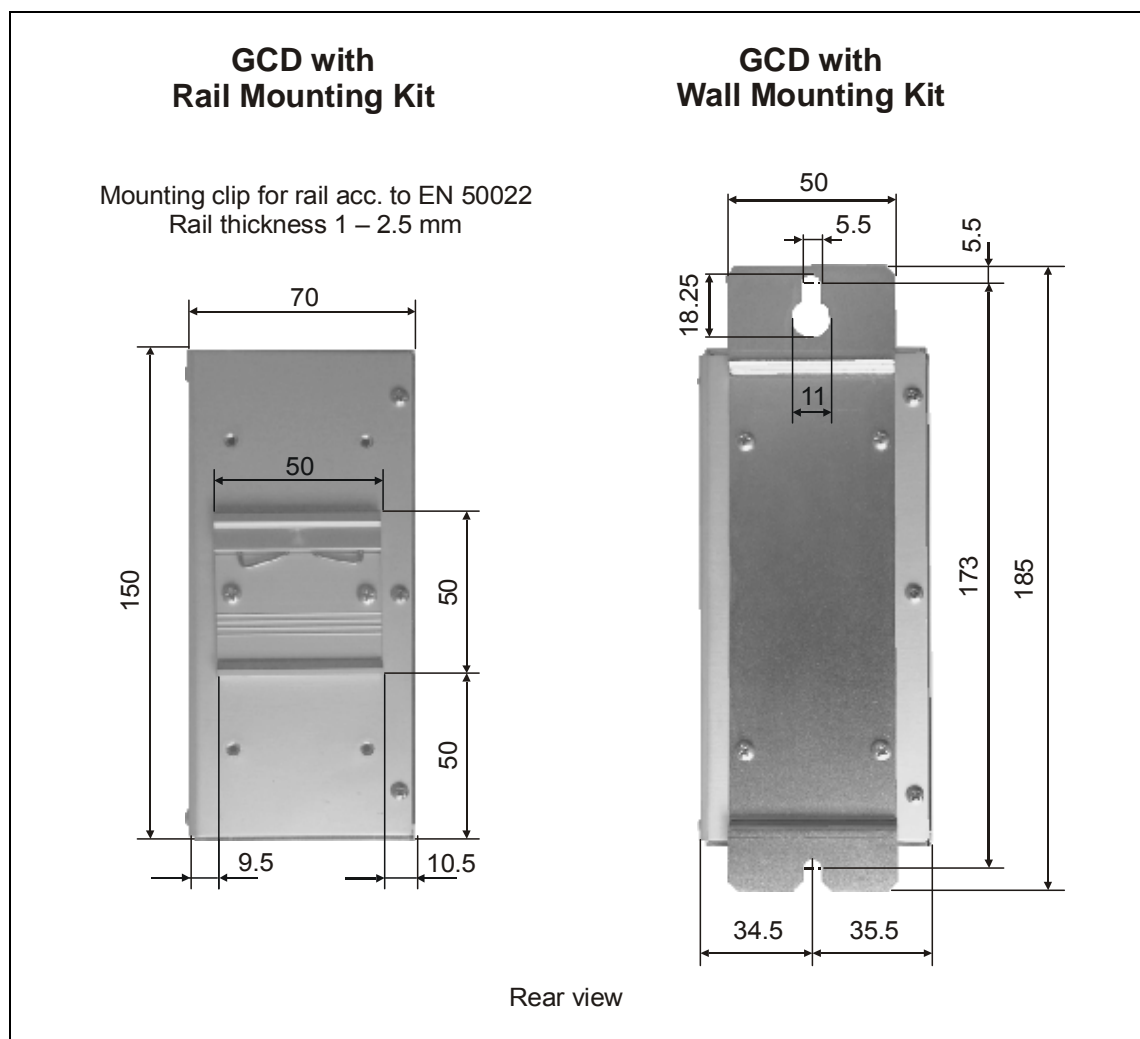


Fig. 10: Mounting kits available with the GCD

Mounting Instructions

- The GCD has been designed to be mounted inside a switching cabinet. Depending on operating voltage and applicable standards, other environments can also be permissible.
- The GCD should be vertically mounted.
- Mount the GCD at a plane surface with appropriate load capacity (device weight is about 1.1 kg).
- Use the mounting kit delivered with the device for rail mounting or wall mounting.
- You may also use the mounting threads in the devices back plate.



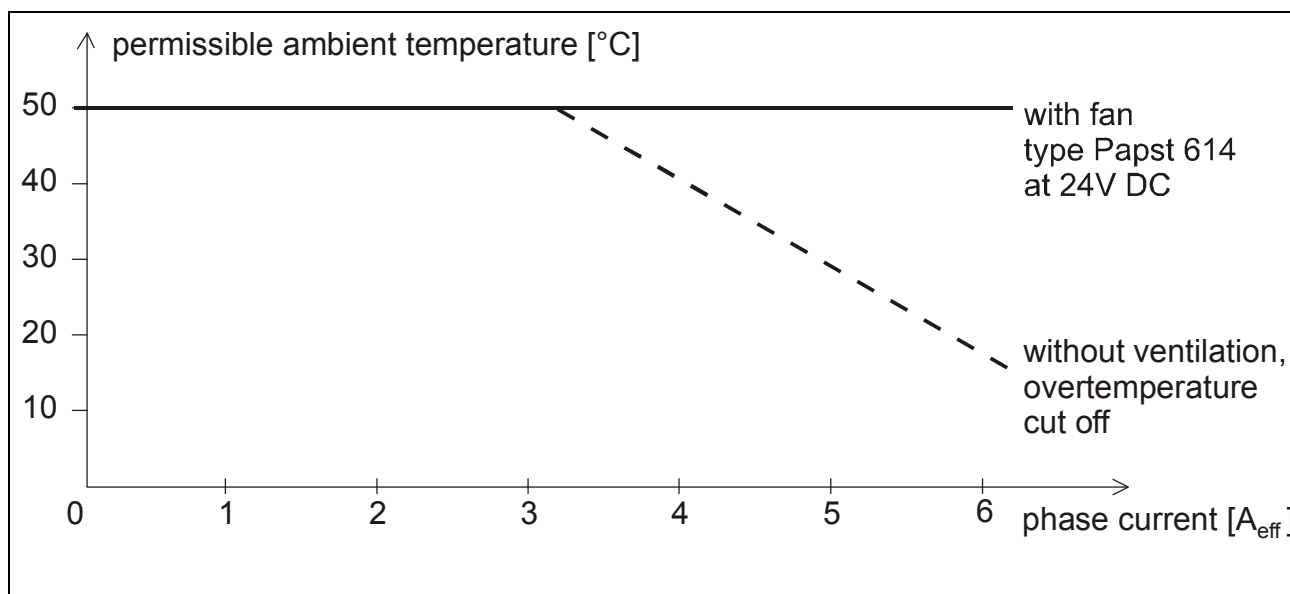
- **The mounting screws used must intrude not more than 3 mm into the GCD's interior!**
- Recommended free space below and above the device: 100 mm. Keep the air slots free to allow a convective air exchange!
- Recommended free space to other devices besides the GCD: 30 mm
- Recommended free space for cables and connectors before the front side of the GCD: 30 mm.
- The GCD has to be mounted and operated at a place free of shocks and vibrations.

4.1 Temperature and Cooling Air Flow

The heat production in the GCD depends on the motor current setting. At maximum current up to 45 W thermal power are produced in the device.

If mounting several GCD devices one upon another, be sure that the requirements for cooling air are met also at the topmost air inlet!.

- Refer to the derating diagram below for the acceptable ambient temperature depending on the motor current and type of air flow (forced or free).
- The curve „without ventilation“ is valid for 100% duty cycle.
- The GCD can be operated without an external fan with motor currents up to about 3 Amp, even at an ambient temperature of 50° C.
- Using an external fan (Papst type 614 operated at 24 V_{DC}) the GCD device can be operated with maximum phase current and 100% duty cycle even at an ambient temperature as high as 50 °C.



De-Rating

4.2 Mounting an External Fan

The GCD housing is prepared for mounting an external fan.

Recommended type:

Manufacturer Papst

Type 614

Air Flow 40 m³/h

Power supply: 24 V_{DC}

Mounting:

- For full cooling power dismount the air slot segment at the bottom side of the housing. Carefully cut the four metal bridges.

Metal scoops must not get into the GCD's housing!

- Mount the fan with four cylinder head screws M3*6.
- If you want to insert the screws into the holes on both sides of the fan's housing, four type M3*30 cylinder head screws should be used.
- The preferred air flow direction is from bottom to top. Check the mounting direction of the fan. The arrow on the fan's housing shows the air direction!



The mounting screws must not intrude more than 3 mm into the GCD housing! Risk of damage or injury!

5 Power Supply

The following chapters give information about the power supply types the GCD may be operated with. The supply voltage has to be connected to the connector X1 „Supply“.

To operate the GCD an external auxiliary voltage 24 V_{DC} is required.

5.1 Connector X1: Supply

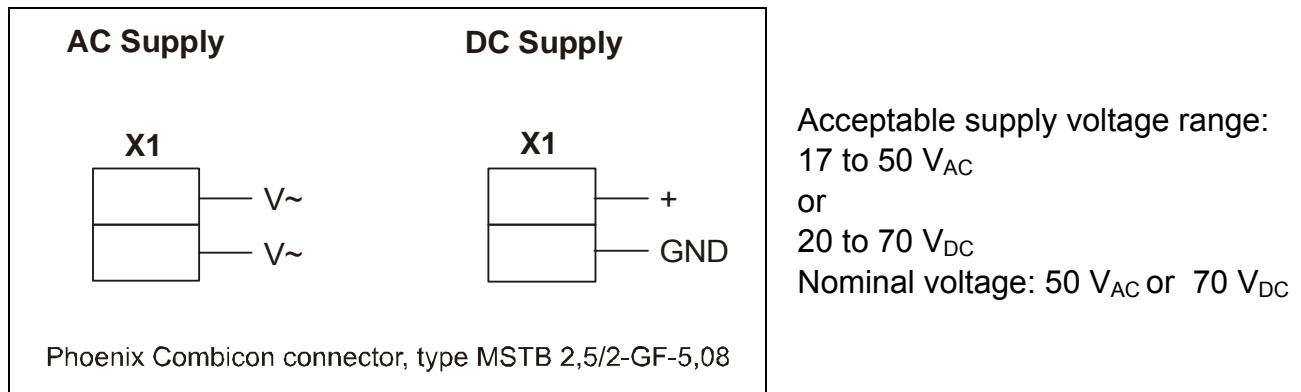


Fig. 11: Connecting the power supply voltage

The protective earth connection of the power supply has to be mounted to the bolts nearby the „Supply“ connector.

We recommend to fix the supply cable with the strain relief clamps.



The transformer should be constructed with reinforced or double insulation for safe operation of the GCD.

5.2 DC Supply Voltage

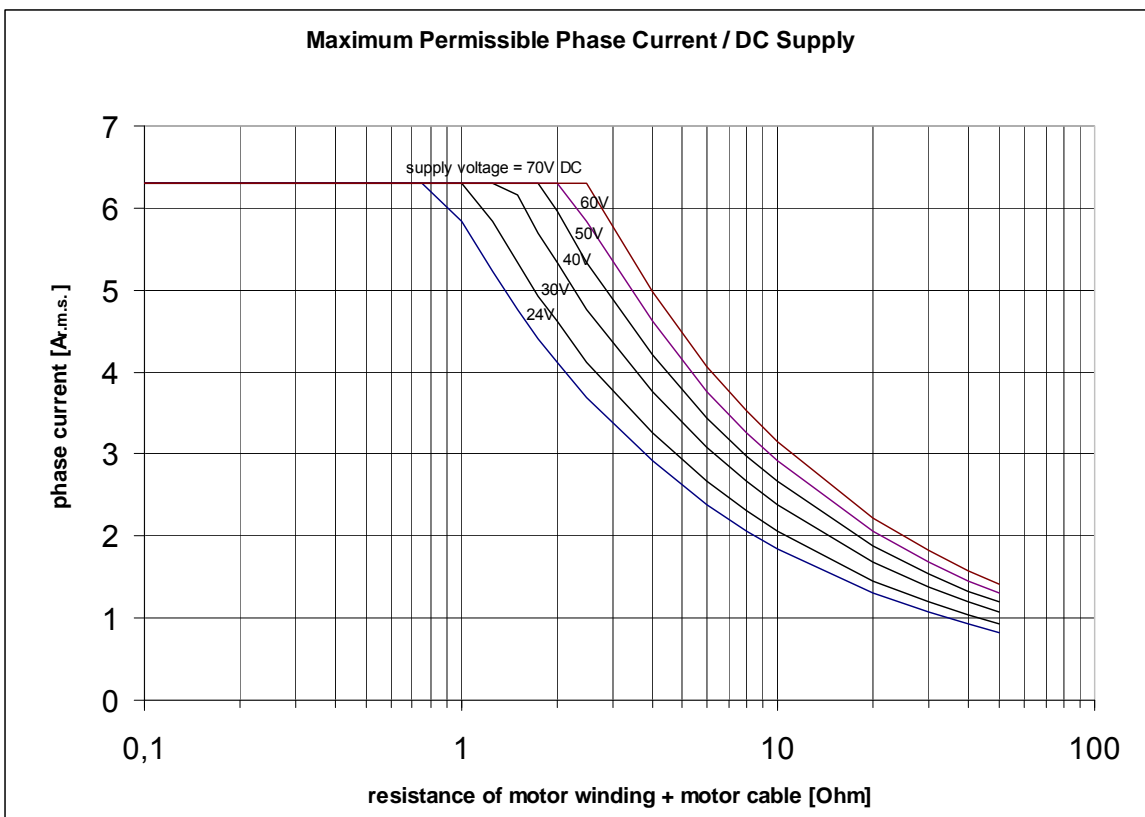


Fig. 12:DC supply mode

Acceptable supply voltage range if operated with smoothed direct current supply:
 $20 V_{DC}$ to $70 V_{DC}$.

The supply voltage must not drop under 17 V, not even for a very short period (> 1 msec).
 The GCD would recognize this as a low voltage error condition and switch off.

If you use not smoothed DC supply current, the recommended currents of the diagram
 above have to be reduced by a factor of 0.8.

Power supply design considerations: The following formula allows to estimate the
 current required, if the GCD device is supplied with rectified and smoothed DC current.
 The power supply should be able to deliver this current with 100% duty cycle. The
 maximum DC supply current is influenced by the value of the feed line's resistance.

$$I_{Supply DC} = \frac{2.7 * R_{ges} * I_{ph}^2}{U_{Supply DC}} + 4A$$

- where:
- I_{ph} : Phase current as set in the GCD menu
 - R_{ges} : Total resistance of motor winding and motor cable of one phase
 - $I_{supply DC}$: Supply current, effective value if power supply delivers direct current
 - $U_{supply DC}$: Effective value of the supply voltage if direct current supply is used.

5.3 AC power supply

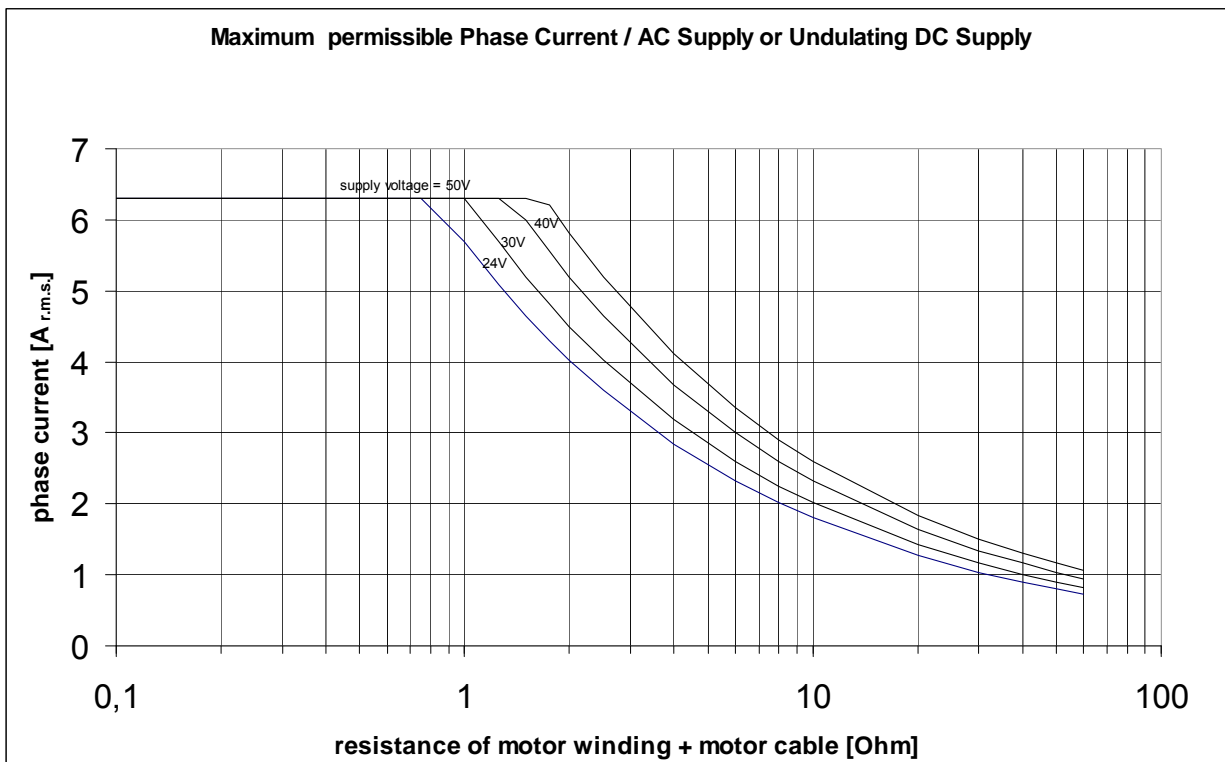


Fig. 13: AC supply voltage

The acceptable supply voltage range is 17 V_{AC} to 50 V_{AC} (effective voltage).

The peak voltage of the AC power supply must not be lower than 24 V (= 17 V_{AC} * √2), even with full load and voltage deviations of -10%.

Power supply design considerations: The maximum AC supply current is influenced by the value of the feed line's resistance. The following formula can be used to estimate the effective alternating current which has to be available at the connector „supply“, even if the system is operated with 100% duty cycle:

$$I_{Supply DC} = \frac{2.7 * R_{ges} * I_{ph}^2}{U_{Supply AC}} + 4.7 A$$

with:

I_{ph}: Phase current as set up in the GCD menu

R_{ges}: Total resistance of motor phase and cabling

I_{supply AC}: Effective value of the supply current if AC supply is used

U_{supply AC}: Effective value of the supply voltage if AC supply is used

5.4 Current Setting

Operating current, stop current and boost current can be set individually in steps of 0.1 A.



Set the currents fitting to the motor winding! Refer to motor data sheet.

Current range:	0.1 to 6.3 A _{eff}
Resulting peak current:	0.14 to 9 A _{Peak}
Supply current:	6 A _{r.m.s.}
Supply current, short time limit:	7 A _{r.m.s.}

Factory default settings:

Operating current:	0.4 A
Stop current:	0.2 A
Boost current:	0.0 A (boost function is de-activated)

The **maximum current consumption** depends on the supply voltage, the phase current selected and the ohmic resistance of motor winding and motor cable.

The mean current value at the terminals "Supply", evaluated over a period of 30 sec, must not exceed 6.3 A.

Note: The above phase current diagrams are based on the following assumptions:

- maximum duty cycle: 70%
- for the other 30%: stop current is less or equal of 50% of the run current
- cycle time maximum 30 sec

If the maximum current is switched on during more than 70% of the cycle time, or if the cycle time is longer than 30 seconds, the current has to be reduced by a factor of 0.8.

Example:

A stepper motor with 6.5 A nominal phase current is intended to be used with 6.3 A phase current. The motor winding resistance is assumed to be 0.5 Ω, and the supply voltage to be 50 V_{AC}.

According to the above diagram the resistance of each phase (winding and cabling) must not exceed 1.3 Ω .

The cable resistance (forth and back summed up) must therefore be less than 1.3 Ω – 0.5 Ω = 0.8 Ω . Assuming a cable cross section of 1mm² with a resistance per meter of 0.02 Ω/m the maximum cable length in this case would be limited to $\frac{0.8 \Omega}{2 * 0.02 \frac{\Omega}{m}} = 20 m .$

6 Motor Connection

The following chapter gives a description of how to wire different types of 2-phase stepper motors. GCD stepper motor controllers may be connected to stepper motors with 0.5 to 10 A phase current.

The stepper motor winding resistance should be less than 10 Ohm 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 the 6-lead stepper motors, wiring scheme (3) with serial windings is recommended. If wiring scheme (3) 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 (4). In this case the ohmic losses are higher, so the motor will deliver only about 70% of the nominal power due to thermal limitations.

Warning:

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

6.1 Motor Connector

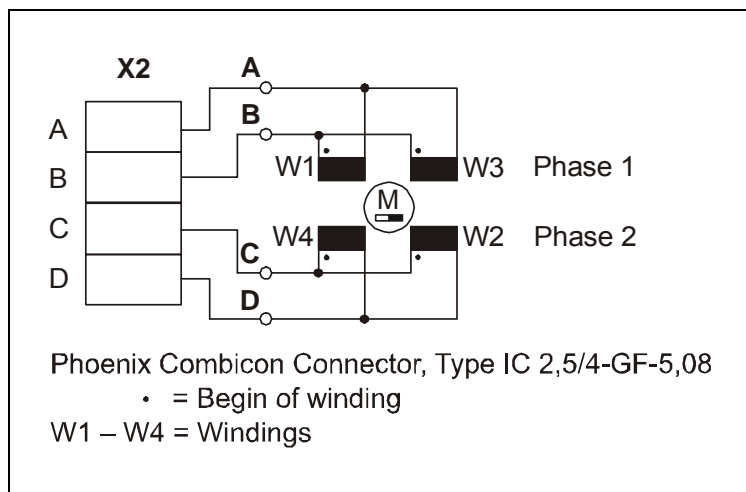


Fig. 14: Motor Connector X2

6.2 Wiring Schemes

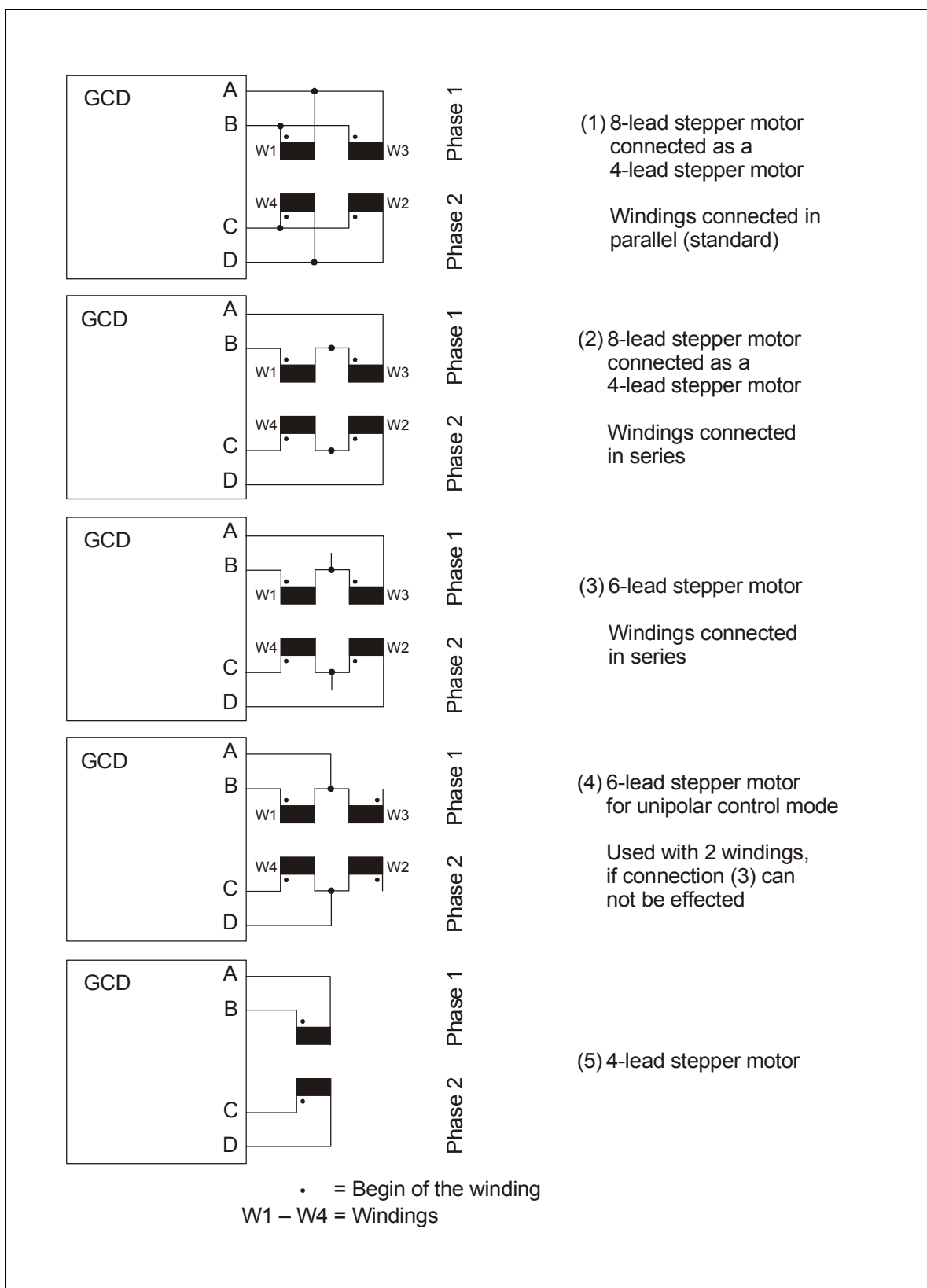


Fig. 15: Connection diagrams for 4-, 6- and 8-wire stepper motors

6.3 Motor Cables

We recommend to wire 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.

Recommended cable cross section: 1 mm² for full power

Acceptable motor cable length: depending on current setting, motor resistance and cable cross section (chapter 5.4).

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

If there is no earthing screw on the motor, the motor must be earthed by appropriate measures.

6.4 Shielding

To avoid disturbances affecting the wires and instruments installed close to the drive system, only shielded cables must be used.

Motor and power stage should be connected to ground by a central earthing tab.

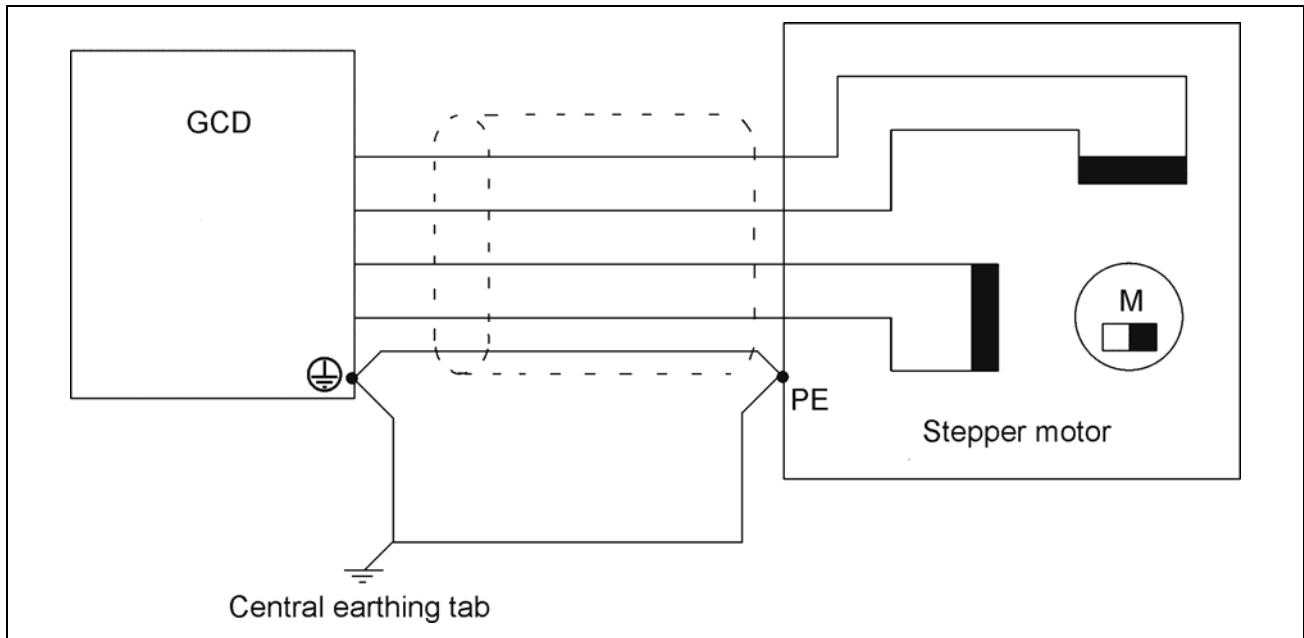


Fig. 16: Motor lead shielding and earthing



For best electromagnetic compatibility (EMC), you must connect the shielding mesh to the GCD housing. Use the cable clamps at the front side of the GCD. Free cable ends must be as short as possible.

The shielding mesh must also be connected on a large surface to the motor housing. Use EMC-type conduit fittings. All parts of the motor must be conductively connected with each other. 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 or 4)!

If the motor is connected in the required way, the fault-free operation is assured according to EN 61000-6-1/2.

The manufacturer of the equipment/machine is responsible for the adherence to limit values, required by the EMC legislation.

7 Input and Output Connectors

The I/O connectors X3 and X4 are used to connect the GCD with digital process control signals and an auxiliary power supply. Connector X5 is used to wire two limit switches, and the serial interface connector X6 is used for RS232 or RS485 (one of both).

7.1 Process Signal Connector

X3		X4	
prog. 0		0 V _{DC} (IN)	
prog. 1		Strobe	
prog. 2		Enable	
prog. 3		Out 0 (Ready in <i>PLC mode</i>)	
prog. 4		Out 1 (Error in <i>PLC mode</i>)	
prog. 5		Out 2	
prog. 6		Out 3	
prog. 7			
X5		X6	
– Limit Switch		RS232	RS485
24 V _{DC} (OUT)		RxD	RX +
+ Limit Switch		0 V _{DC}	RX –
0 V _{DC} (OUT)		TxD	TX +
		0 V _{DC}	TX –

Fig. 17: I/O connectors

Important:

- Do not plug in the I/O connectors inverse or wrong. Danger of damage to the GCD.
- The GCD voltage level (24 V) should fit to the control unit's process I/Os!
- Do not exchange X3 with X4 by mistake! Danger of damage to the GCD.
- Do not exchange X5 with X6 by mistake! Danger of damage to the GCD.

7.2 Digital Inputs

All digital inputs are optically insulated from the motor supply voltage. This assures best noise suppression between control and power circuit. The cathode pins of the optocouplers are connected to GND (of 24 V_{DC}). The nominal input level is 24 V.

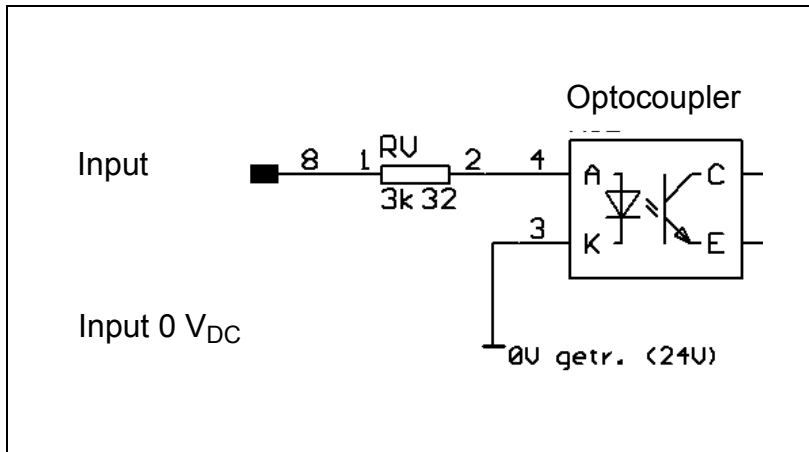


Fig. 18: Digital I/O input circuit, schematically

7.3 Digital Outputs

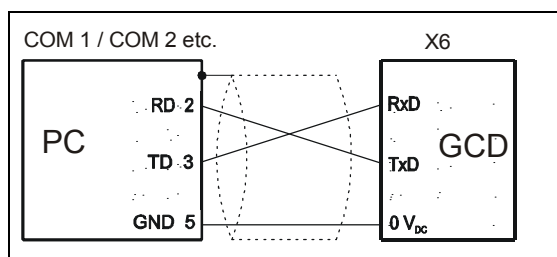
All output drivers are optically insulated from the motor supply voltage. The outputs use smart power high-side-switches type BSP752R. Each channel is protected against over-current and over-temperature. The rated output current is $I_{max} = 50 \text{ mA}$.

All digital outputs are connected with GND of the 24 V_{DC} auxiliary voltage.

In case of a fault condition the output driver will be locked to the off state. To reset an over-temperature or over-current error, the auxiliary voltage (24 V) has to be switched off and on again.

7.4 Interfaces

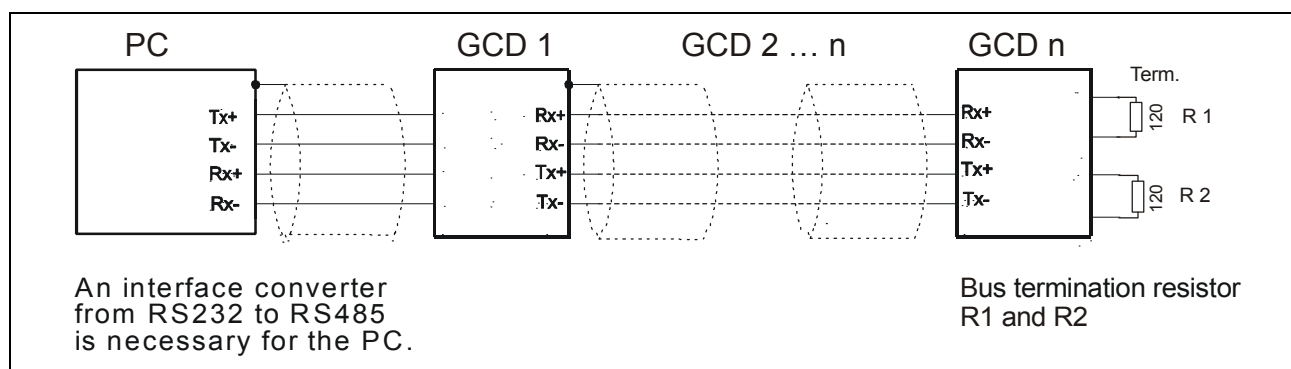
If operating one GCD device, the RS232 interface is used for communication between PC and GCD.



RS232 cable: 9 pole D-SUB connector female (PC) to 4 pole Phoenix Combicon connector (GCD)

If operating more than one GCD device (max. 16) at one serial interface, the RS485 field bus is best choice (bus connection, 4 wire operation). The unique axis ID for each GCD is selected by the *Manual Mode* (setup menu).

At the distant end of the RS485 bus, please use the bus termination resistors (120 Ω) at the very last GCD in the chain.



RS485 cable: PC connector to 4 pole Phoenix Combicon connector (GCD)

8 Basics of the GCD Functions

This chapter describes the GCD functions and explains, how to adapt the control parameters to a wide range of applications.

8.1 Control Software Structure

The GCD software consists of two modules called BIOS and SYSTEM, stored in a flash EPROM. The software can be reloaded via PC without opening the device. Please find detailed information in the appendix of the separate IPCOMM protocol manual.

8.2 Control Parameters

At delivery, all GCD control parameters are set to the BIOS-Default settings. In the following chapter you'll find an overview. In chapter 9 is described how to change the parameters.

In the GCD there are three copies of this parameter list: a table in the program memory (BIOS-Default), a table in the permanent data memory and a table in the working memory. After power on or reset, the data of the permanent memory will be copied into the working memory.

During operation, parameter changes are only valid for the working memory. Changes can be made non-volatile by saving the parameters, for example by means of IPCOMM.

Chapter 9.1.1 and 9.4 will show how to change the parameters.

Parameter	Menu Item	Unit	Default Value	Range
Start/stop frequency	F-OFFS	Hz	400	1 .. 1250
Run frequency	F-RUN	Hz	2,000	1 .. 10000
Acceleration ramp	RAMP	Hz/s	5,000	1,700 .. 164,000
Emergency stop ramp	E-STOP	Factor	0	0 .. 255
Stop current	I-STOP	A	0,2	0 .. 6,3
Run current	I-RUN	A	0,4	0.1 .. 6.3
Boost current	I-BOOST	A	0	0 .. 6.3
Recovery time	TDELAY	ms	20	0 .. 4,000
Axis limit	-	1/8-Step	1,000,000	0 .. $2 \cdot 10^9$
Offset to +limit switch	-	1/8-Step	0	0 .. $2 \cdot 10^9$

Parameter	Menu Item	Unit	Default Value	Range
Offset to –limit switch	-	1/8-Step	0	0 .. 2*10 ⁹
Play compensation	-	1/8-Step	0	-2*10 ⁹ .. 2*10 ⁹
Axis type (linear/rotational)	-	-	0	0 / 1
Control mode (Online / PLC)	-	-	0	0 / 1
Baud rate	BAUD	Bit/s	28800	9600 / 28800
LCD contrast*	CONTR.	%	50	0 .. 100
Device address*	AX-ID	-	0	0 .. 9, A .. F

* The last two parameters can only be changed in the manual mode (menu buttons).

9 Turning a GCD into Operation

The GCD has three basic operation modes: The **manual** or **test mode**, the **online mode** and the **PLC mode**, where the GCD is controlled by digital process I/Os.

After power on the GCD will start up in the **online mode** or in the **PLC mode**, as it is programmed in the internal parameter set. The actual operation mode is shown in the second line on the LCD display. To switch to the **manual mode**, press the OK button for more than three seconds.

In the **manual mode** the basic control parameters of the GCD can be changed, and you can easily test the wiring and the motor functions. This is also the best way to check the correct stepper motor wiring.

In the **Online mode** the GCD device is fully compatible with the stepper motor controllers type IPP and GSP. In this mode the GCD is controlled by means of the serial interface. With the GCD you will get a configuration software (IPCOMM), and a separate manual with the details of the serial IPCOMM protocol used with the GCD.

The IPCOMM software can be used to change the basic system parameters online. You can perform simple motion commands and test the dynamical behaviour of the stepper motor axis. Furthermore, with IPCOMM you can write the actual parameter set into the permanent EEPROM memory to store a new parameter set.

In the **PLC mode**, the GCD is controlled by means of digital process inputs and outputs. A supervisory PLC can select a predefined motion command and start this command to be handled by the GCD. The specific PLC mode command sets can be defined and edited by means of the IPCOMM software.

Manual GCD MINI

9.1 GCD in the *Manual Mode*

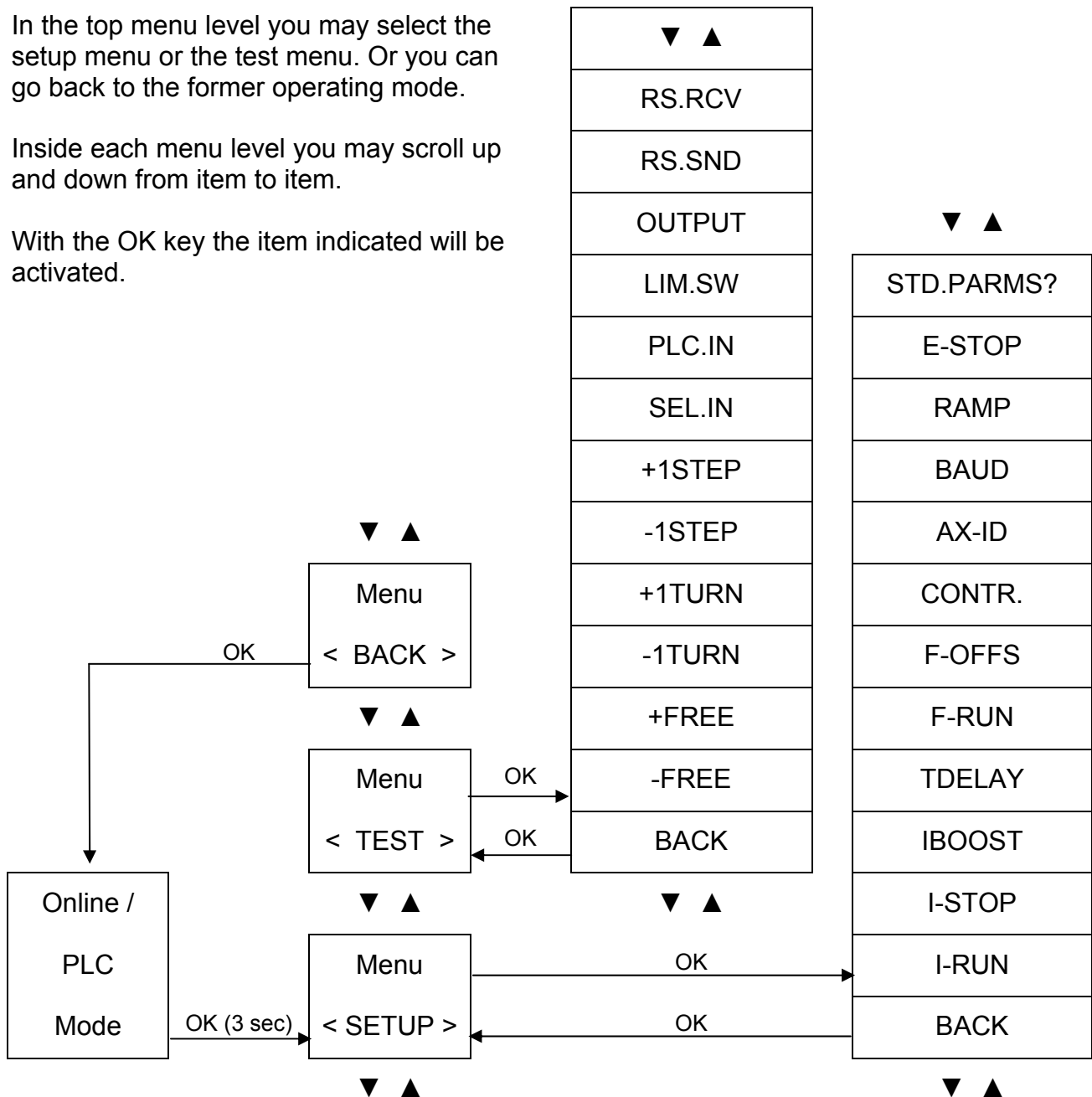
The **Manual Mode** should be used for a first configuration of the GCD.

The Manual Mode has the following menu structure:

In the top menu level you may select the setup menu or the test menu. Or you can go back to the former operating mode.

Inside each menu level you may scroll up and down from item to item.

With the OK key the item indicated will be activated.



9.1.1 The Setup Menu

The character '>', printed leftmost in the first display text line, shows that the second menu layer is active. Press the OK button to activate the edit function for the selected item. The active edit state is signalled with '>>' in the first display text line.

If the current value can be changed, the cursor is in the second line under the first figure. By means of the arrow keys you can change this figure. Confirm the value displayed by pressing OK. Now the cursor is under the next figure.

Confirming the change of the last figure will end the edit mode for this parameter value. The edit cursor will disappear, and in the first text line the state indicator changes from '>>' back to '>' again.

The GCD will now check the consistency of the user's input and display the new value (without preceding zeros as in the edit mode). If the value entered by the user exceeds the built-in parameter limits, the system will select the nearest acceptable value and display it.

Example to explain the edit functions:

Action	Display texts
Setup activated e.g. by OK	> I-RUN 3.0 A
1 * OK	>>I-RUN <u>3</u> .0 A
2 * ▲, 1 * OK	>>I-RUN 5. <u>0</u> A
3 * ▼, 1 * OK	> I-RUN 5.7 A
Changing value again, 1 * OK	>>I-RUN <u>5</u> .7 A
3 * ▲, 1 * OK	>>I-RUN 8. <u>7</u> A
1 * ▼	>>I-RUN 8. <u>6</u> A
1 * OK (limited to maximum value)	> I-RUN 6.3 A

If there are fixed parameter values defined in the software, no cursor is shown. In these cases the arrow buttons scroll through the predefined parameter values.

The above is valid for the baud rate (28,800 or 9,600 Baud) and for the ramps (only the programmed values are indicated).

The following table shows the available menu items:

Manual GCD MINI

Menu item	Comment
STD.PARMS?	Overwrite the actual parameter set with the predefined BIOS parameter set.
E-STOP	Emergency stop ramp correction factor. The emergency stop ramp is faster than the standard ramp by the factor E-STOP. The emergency stop ramp will be used, if a limit switch becomes active (=damped).
RAMP	This parameter defines the standard acceleration and deceleration ramp.
BAUD	This parameters selects a baud rate for serial communication with the master computer.
AX-ID	The axis ID is used during serial communication between master and controller. In RS485 bus systems with several controllers, each device address must be used for one GCD only.
CONTR.	The LCD contrast can be adjusted.
F-OFFS	F_{Offset} defines the start/stop frequency to be used. This is the motor speed (full steps/second) used for leaving the limit switch range. Furthermore, this parameter defines a limit speed for motion profiles. Below this speed the GCD uses a rectangular motion profile. Above this speed the GCD uses a trapezoidal motion profile.
F-RUN	Maximum speed for positioning (in full steps/second). If the free run command is given, the motor will be run with this speed.
TDELAY	After motor stop the GCD will wait this time, before the power stage is switched from RUN current to STOP current. The status bit „Motor runs“ is reset only after this time delay has elapsed.
IBOOST	Boost current used during acceleration and deceleration. If set to zero, the normal run current is used also during acceleration and deceleration.
I-STOP	Stop current, used during motor stand still.
I-RUN	Normal operating current, used during motor run.

9.1.2 The TEST Menu

The menu structure is as shown with the SETUP menu. The handling is also the same, use the arrow buttons for scrolling and the OK button for activating a menu item.

The items in the TEST menu are:

Menu item	Function
RS.RCV	RS Receive can be used to check the serial interface. Received telegrams will be written into the display.
RS.SND	RS Send will output a test string „<ETX> Hello World <CR> <LF> <ETX>“ to the serial interface. You may receive the text string on a PC with any interface monitor.
OUTPUT	The digital process control outputs (X4) can be switched individually. The cursor will blink on the most significant output bit (Out 3). Use the OK button to switch the output, and the arrow keys to select another output. Move the cursor to EXIT to finish this function. Note: The outputs will work only if the auxiliary +24 V supply is on.
LIM.SW	"Limit switch" shows the current state of the limit switch inputs (X5).
PLC.IN	„PLC Inputs“ shows the current state of the PLC control inputs Strobe and Enable (X4).
SEL.IN	„Select Inputs“ shows the current state of the PLC data inputs (X3).
+1STEP	One 1/8 step motion of the stepper motor in positive direction.
-1STEP	One 1/8 step motion of the stepper motor in negative direction.
+1TURN	One complete turn (200-step motor) in positive direction.
-1TURN	One complete turn (200-step motor) in negative direction.
+FREE	As long as you press the OK button, the motor turns in positive direction.
-FREE	As long as you press the OK button, the motor turns in negative direction.

9.2 GCD in the *Online Mode*

In the *Online Mode* (PD0), the GCD receives commands from a master computer (PC, PLC, overriding controller) via serial interface.

Data are exchanged by telegrams which should meet a rigid protocol. This "IPCOMM protocol" is explained in the manual MA 1086-Axxx delivered with each GCD.

9.3 GCD in the *PLC Mode*

The *PLC mode* (PD1) means: the GCD receives commands from a master controller via the digital inputs. In this operating mode the handshake with the master controller is performed via the digital outputs.

In order to ensure safe data exchange, a defined protocol has to be observed. The PLC has to wait for the GCD's READY signal. After that the PLC can prepare the program information which is subsequently activated by a STROBE signal. The GCD receives the program information and processes the command. During program execution READY becomes passive.

In the *PLC mode* the **digital inputs** have the following meanings:

STROBE: Activates the selected motion command.

SW-ENABLE: Release the axis. Without this signal the axis cannot be started.

By deactivation SW-ENABLE each positioning can be interrupted. The motor is stopped and decelerates with ramp. The positioning counter contains a valid value.

Prog x: With the eight program selection inputs, one out of 256 motion commands can be selected out of the PLC table. The input bits are interpreted binary. These inputs should be stable before the STROBE signal is triggered. We recommend to wait at least one idle cycle of the PLC.

The meaning of the **digital outputs** in the PLC mode is:

Output 0 READY
The GCD is ready to accept the next motion command. At motor start, this signal is set to zero. It is switched on again only after the motor stands still AND the STROBE signal is no longer active AND the recovery time TDELAY has elapsed.

Output 1 ERROR
There is an error condition which might have one of the following reasons:

- Selected motion command has not been programmed.
- Limit switch error
- Power stage error

Output 2 RUN
The stepper motor runs (is set also during the recovery time TDELAY).

Output 3 AMPLIFIER
The amplifier signals an internal fault. Possible reasons are over-current (short circuit), over-temperature or low voltage at the load capacitor.

The digital handshake between PLC and GCD can be graphically shown as follows. Please note the small but important delay between Prog.x and STROBE, which should be established to suppress noise effects due to different settling times of PLC outputs.

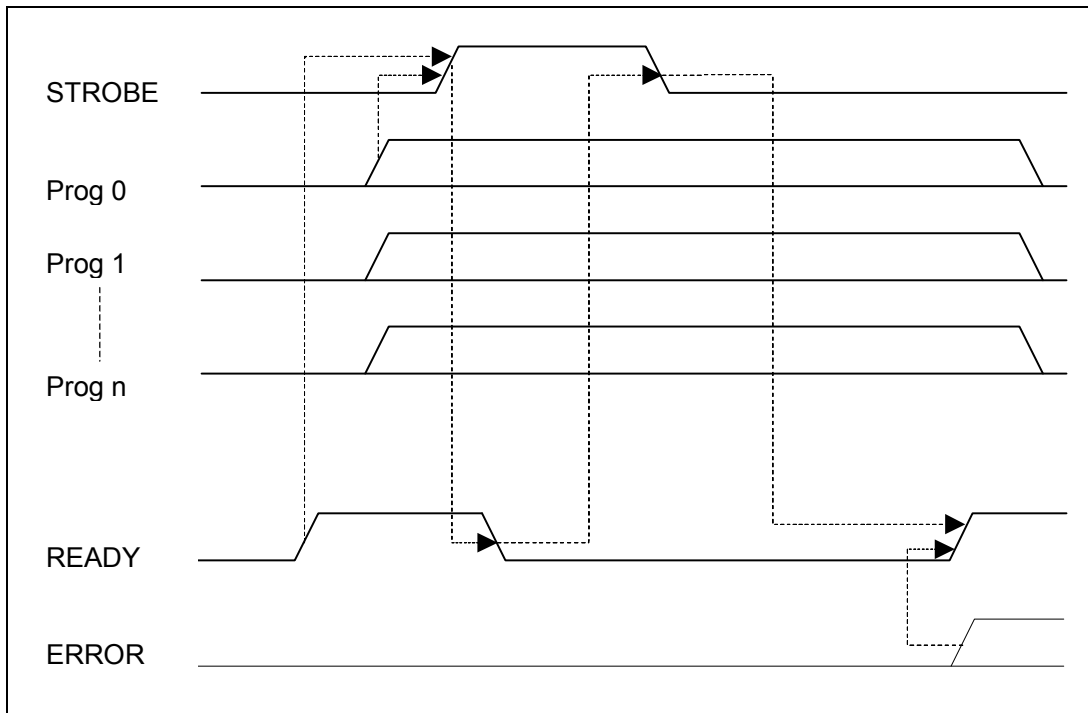


Fig. 19:Data exchange diagram

9.4 Configuring the GCD with IPCOMM

With the IPCOMM Phytron configuration software, all motion parameters can be set with the PC. PLC commands and command sequences can be set and tested as well.

The IPCOMM CD and the IPCOMM protocol manual are delivered free of cost with the GCD.

10 The LCD Display

The display contrast can be modified in the setup menu.

Note: If the LCD display is fading, this could be caused by high ambient temperature in the switching cabinet.

10.1 Error Messages

The GCD will show error messages in the second text line of the LCD display.

If there are several errors at the same time, the most important message will be displayed.

Error Message "Volt.Err"

(Voltage Error / Low Voltage)

The supply voltage at the internal load capacitor has dropped under 17 VDC. This error message will also occur if an external supply voltage of 24 V (AC or DC) breaks down under load for a short time.

If you use a standard transformer (and no high performance toroidal transformer), the voltage drops may occur due to a high resistance in the secondary transformer winding.

If you use a DC supply unit, typical reasons for low voltage error messages are internal load limiters in the power supply, or small load capacitors in the power supply.

Normal three phase power current supplies (6-way rectifiers for 24 V SELV supplies) are normally not suited to drive high load stepper applications due to the high time constant of the supply circuit, if these devices have no load capacitor.

Error Message "Curr.Err"

(Current Error / High Current or Short Circuit)

Short circuit from phase to phase, phase to ground or phase to other phase.

Check the connector wiring. Check the motor cable for short circuits. Please have somebody stressing the cable during the measurement, this will make cable faults by mechanical fatigue more obvious during the measuring period. Disconnect the motor and check it for any short circuits by measuring the insulation (phase to phase, phase to GND).

Error Message "LimSwErr"

(Limit Switch Error)

This error message appears, if the limit switch input shows an illegal signal pattern. If the GCD is configured as a linear axis, there must not be both limit switches active at the same time.

Error Message "OutDrErr"

(Output Driver Error)

This message signals an error of the digital I/O output driver or a missing auxiliary power supply voltage. The output driver has detected some overload condition. The chip is protected against overload, and it will switch off all outputs. You have to switch off the power supply voltages of the GCD and on again to reset this error signal.

10.2 Trouble-Shooting

The following list might help you to repair failures.

Problem: LCD display is bad to read.

Set up the contrast in the setup menu.

Problem: LCD display keeps being dark shaded.

Perhaps the the ambient temperature of the device is too high.

Problem: Error message over-temperature

Check ventilation (chapter.4.1) and current setting (chapter. 5.4).
Mount a fan.

Problem: Motor does not run.

Check the current settings. At delivery run current and stop current are set to 0.4 A.
Check the wiring. Use the test menu functions to eliminate other problem sources.

Problem: The stepper motor is inadmissibly hot.

Check the current settings.

For Boost current and run current settings please refer to the motor label or data sheet.

We recommend to set the stop current to 50% of the run current .

Phytron stepper motors are designed for a stop current of about 50% of the run current, with a duty cycle of up to 60%.

11 Appendix

11.1 Self-Adapting Overdrive

By the Overdrive function, the GCD power stages can compensate the phase current decrease in the upper speed range. Overdrive is self-adapting and therefore independent of the type of motor.

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

The stepper motor phase current decreases with increasing step frequency caused by the motor inductivity. Now the GCD increases the motor current by 20%. This turnover frequency is not fixed, as it is at other stepper motor power stages, but automatically adapted to the individual motor. If the frequency becomes lower again, the Overdrive is switched off again.

The benefit of this is a higher torque in the middle and high frequency ranges.

11.2 Warranty

The GCD devices are subject to Phytron's legal warranty as described in the terms of delivery. 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.

11.3 ESD Protection Measures

All the products which we deliver have been carefully checked and submitted to a longterm 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.

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