PAB+ MICRO

phytron

Stepper Motor Power Stage with Service-Bus

Manual 2098-A005 GB

customized solutions in motion

PAB^{+} MICRO

Stepper Motor Power Stage with ServiceBus

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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: info@phytron.de.

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

Contents

1 PAB+ MICRO Power Stages

In this chapter you'll find a brief description of the PAB power stage with TEO temperature monitoring module via CAN connection.

1.1 Short Overview

Fig. 1: Operating elements and dimensions (mm)

Microstep power stage for two-phase stepper motors

The PAB power stages are used for bipolar control of two-phase stepper motors. A very fine step resolution up to 1/256th step enables an optimum stepper motor control.
The power stages type PAB use Phytron's welltried technology, now with enhanced 4 quadrant chopper type current control.

The + of PAB stands for 'particular user-friendly' by ServiceBus-Comm for Windows®, the delivered configuration and user software, which sets the power stage via the ServiceBus interface.

Programming and diagnostics can be easily managed via PC by the ServiceBus configuration.

The Step resolution, Activation, Reset and Motor direction functions can be programmed via RS485 interface.

Adjustable step resolutions: 1/1, 1/2, 1/4, 1/5, 1/8, 1/10, 1/20, 1/32, 1/64, 1/128, 1/256 of a full step.

Run, stop and boost current can be individually programmed.

Factory settings

Boost current	0.6 $A_{r.m.s}$
Run current	0.4 $A_{r.m.s}$
Stop current	0.2 $A_{r.m.s}$
Step resolution	1/256 step
Current delay time	20 ms
Signal activity	High active

Motor currents from 0 to 9 A_{PEAK}

Run, stop and boost currents can be individually programmed on PC via RS485 interface.

DC supply voltage

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

Control inputs

Controlling via RS422 push-pull driver ensures high immunity against disturbances. Open-Collector controlling (OC) is also possible. The inputs are optocoupler-isolated from the PAB's supply voltage. The input function is programmable by software.

The PAB power stages can be controlled by different control units with stepper motor interface.

Output

The Open-Collector output is optically insulated from the motor voltage. The output function is programmable by software.

ServiceBus inputs

The service bus offers the following possibilities:

- Power stage parameter programming
- Online diagnostics for safe operation and easy maintenance
- Configuration by software via 4-wire RS485 bus, optically insulated from the motor voltage
- Parameter memory to hold data safely
- Status information via LED display

The power stage can be user-friendly programmed by ServiceBus-Comm software. (See manual ServiceBus-Comm).

CAN bus

The 9-pole D-SUB connector on the front panel is used for connection of the TEO temperature monitoring module via CAN bus.

Address switch

Up to 16 power stages can be addressed by the rotary switch.

Easy to mount

The power stage PAB is designed for mounting in 19"/3U racks (or with fan 4U).
All wiring is connected to one 48-pin rear connector according to DIN 41612, version E.

1.2 Extent of Supply

PAB ID-Number (#): #10003560

Accessories:

- PAB Manual
- Phytron CD with ServiceBus-Comm® software
- ServiceBus-Comm® Manual

Supplementary parts are available:

- Front panel (8 HP) with handle #10003562
- G-PAB V1.0 adaptor board for easy connecting the PAB with connectors for motor cable, signal leads and supply voltage #10001979
- TEO temperature monitoring module #10003566 with front panel (#10003564)

1.3 Connectors

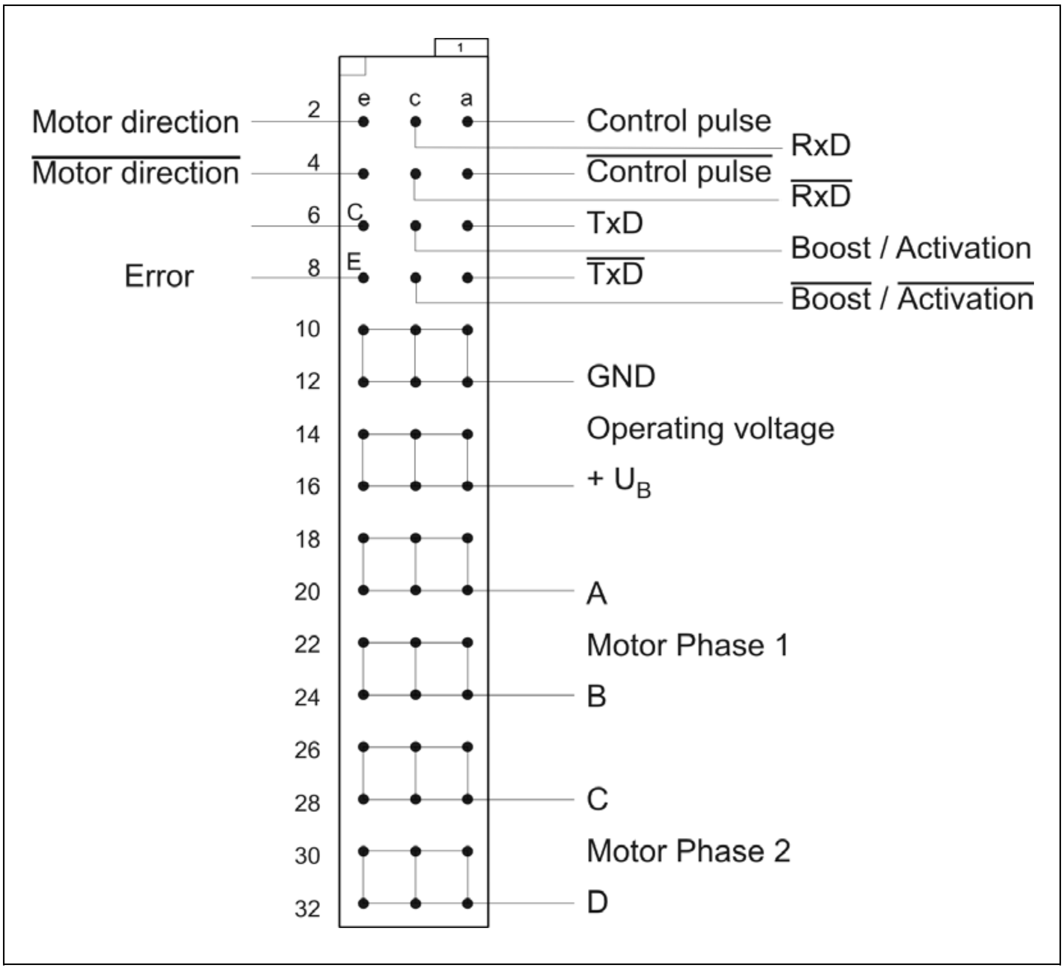


Fig. 2: 48-pole connector according to DIN 41612, version E

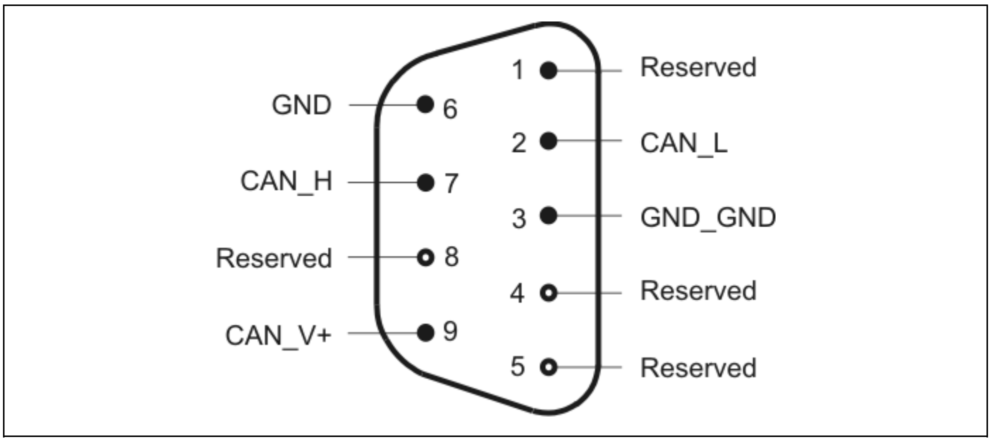


Fig. 3: RS CAN bus, 9pole D-SUB male connector on the front panel

1.4 Address Switch

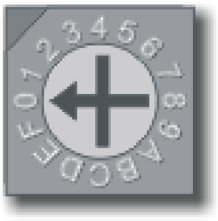


Fig. 4: Address switch 0...F

The logical axis address is fixed by the address switch behind the front panel. The rotary switch can be set from 0...9 and A...F. If every power stage is defined by another address, up to 16 power stages can be used with the bus connection.

1.5 LEDs

The function of the green LED can be set by software.

LED	**Setting by ‚K‘ Instruction Code**	**Meaning**
green	K=0	LED is shining in basic position
	K=1	LED shines permanently (except error) If the PAB is deactivated, the LED shines with the frequency, which is set by instruction code Y.
	K=2	shines permanently; except error and when PAB is deactivated
red	Fault	Error in PAB: Overcurrent / Short circuit, Undervoltage / Overvoltage Overtemperature Error in deadman monitoring Error TEO Temperature error TEO

2 Technical Data Table

Technical Data	
Stepper motor	Two-phase stepper motors with 4-, 6- or 8-lead wiring scheme with up to 9 A_{PEAK} phase current Winding resistance < 10 Ohm Winding inductance: 0.5 to 10 mH per phase
Step resolution	The step resolution is programmable: 1/1, 1/2, 1/4, 1/5, 1/8, 1/10, 1/20, 1/32, 1/64, 1/128, 1/256 of a full step. Factory setting: 1/256 step
Phase currents	Run current, stop current and boost current can be independently programmed. Programmable from: 0 to 6.3 $A_{r.m.s.}$ Peak current 9 A_{PEAK} Select phase currents fitting to the motor! Factory settings: run current 0.4 A stop current 0.2 A boost current 0.6 A
Lead cross section of the motor cable	Minimum 1.0 mm² is recommended.
Supply voltage	24 to 70 V_{DC} Nominal voltage: 70 V_{DC} Reinforced or double insulation between mains and secondary circuit is required.
Error message low voltage	Supply voltage DC < 20 V
Short circuit proof	The PAB is short circuit-proofed (phase/phase, phase/ground). The power stage powers off or gives an error message in case of short circuit.
Mounting	2 fastening screws for mounting in the standard rack 19"/3 U
Permissible ambient temperatures	Operation: 4 to +50 °C Storage: –25 to +55 °C Transport: –25 to +70 °C *Remark: If the heat sink temperature (cage) is more than 85 °C, the power stage is switched off and the red LED shines.*
Ventilation	Depending on load, fans must be installed in the rack to ensure a good air circulation.
Weight	0.5 kg

<table>
<tr><th colspan="3">Technical Data</th></tr>
<tr><td>Connectors</td><td colspan="2">48-pole connector according to DIN 41612, type E
9-pole D-SUB connector according to DIN 41612</td></tr>
<tr><td rowspan="6">Inputs</td><td colspan="2">The signal inputs are optocoupler-isolated and can be controlled via push-pull driver or Open-Collector.
Input level 5 V</td></tr>
<tr><td>Signal level</td><td>5 V</td></tr>
<tr><td>High</td><td>3 – 5.5 V</td></tr>
<tr><td>Low</td><td>< 0.4 V</td></tr>
<tr><td rowspan="2">Necessary Driver current</td><td>max. 10 mA (at 3 V)</td></tr>
<tr><td>max. 30 mA (at 5.5 V)</td></tr>
<tr><td>Control pulse</td><td colspan="2">Maximum step frequency: 500 kHz
Minimum pulse width: 1 µs
The step is executed with the falling flank of the control pulse.</td></tr>
<tr><td>Motor direction</td><td colspan="2">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 after the falling flank of the control pulse!</td></tr>
<tr><td>Boost/Activation</td><td colspan="2">The input function is programmable by software:
See chap. 8.2
<u>Boost:</u> When the optocoupler is energized, the PAB changes the current to the preset Boost current (default).
<u>Activation:</u> When the optocoupler is energized, the motor current is activated.</td></tr>
<tr><td>ServiceBus inputs</td><td colspan="2">RS485 4-wire standard, optocoupler-isolated</td></tr>
</table>

Technical Data		
Output	Optically insulated from the motor voltage, Type Open-Collector I_{max} = 20 mA, U_{max} = 30 V, U_{CEsat} at 20 mA < 1 V The output function is programmable by software. See chap. 8.2 Error: The output opens in case of an error signal: overcurrent, undervoltage, overvoltage, overtemperature, Deadman monitoring, Error TEO, Temperature TEO The power stage is deactivated at the same time to avoid damages. Basic position The output opens, when the motor is in basic position. Ready: The output opens, when there is no error (default).	
LEDs	Ready green	The LED function can be programmed.
	Fault red	Error signal from the monitoring circuit

3 To Consider Before Installation

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

3.1 Qualified Personnel

Design, installation and operation of systems using the PAB 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. Power supply, construction and cabling, as well as the choice of the connected motor must be designed according to the corresponding safety standards.

2. If you need to remove the front panel or open the device:
   Up to 1 minute after turning off the supply voltage, dangerous voltages may still exist within the device.
3. **Be careful handling the connectors and any motor cable coupling.**
   As long as the PAB is connected to supply voltage, a hazardous voltage level is present at motor connector and motor cable, even if the motor is not wired.

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 error. The secondary winding of the transformer shouldn't be grounded (SELV supply) (acc. to DIN VDE 0550 or DIN EN 60742).
5. **Up to 1 minute after turning off the supply voltage, dangerous voltages may still exist within the device.**
6. Always switch off the supply voltage if you connect or disconnect any wires or connectors at the PAB.
   Most important:
   Do not unplug the motor connector while powered.
   Danger of electric arcing.
7. Voltages connected to the signal inputs and outputs should be safely separated from mains (SELV power supply). The maximum voltage against protective earth must not exceed 60 V_{DC}.

8. The surface of the PAB may reach temperatures up to 85 °C.
   Danger of injury if touching the surface!

4 Power Supply

The PAB power stage is powered by DC voltage. We recommend to operate the PAB with the G-PAB adapter board with connectors for power stage, power supply, input/output and motor connection.

Permissible voltage range: 24 to 70 V_{DC}

The supply voltage must not drop under 20 V, not even for a very short period. The PAB would recognize this after 1 ms as a low voltage error condition and switch off.

⚠ The supply transformer **must** be constructed with reinforced or double insulation.

The secondary winding of the transformer shouldn't be grounded (SELV supply).

5 Motor Connection

The following chapter gives a description of how to wire different types of two-phase stepper motors. PAB stepper motor power stages may be connected to stepper motors with up to 9.3 A_{PEAK} phase current.

The stepper motor winding resistance should be less than 10 Ohms 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).

Warning:

5-lead stepper motors must **not** be connected to the PAB.

5.1 Wiring Scheme

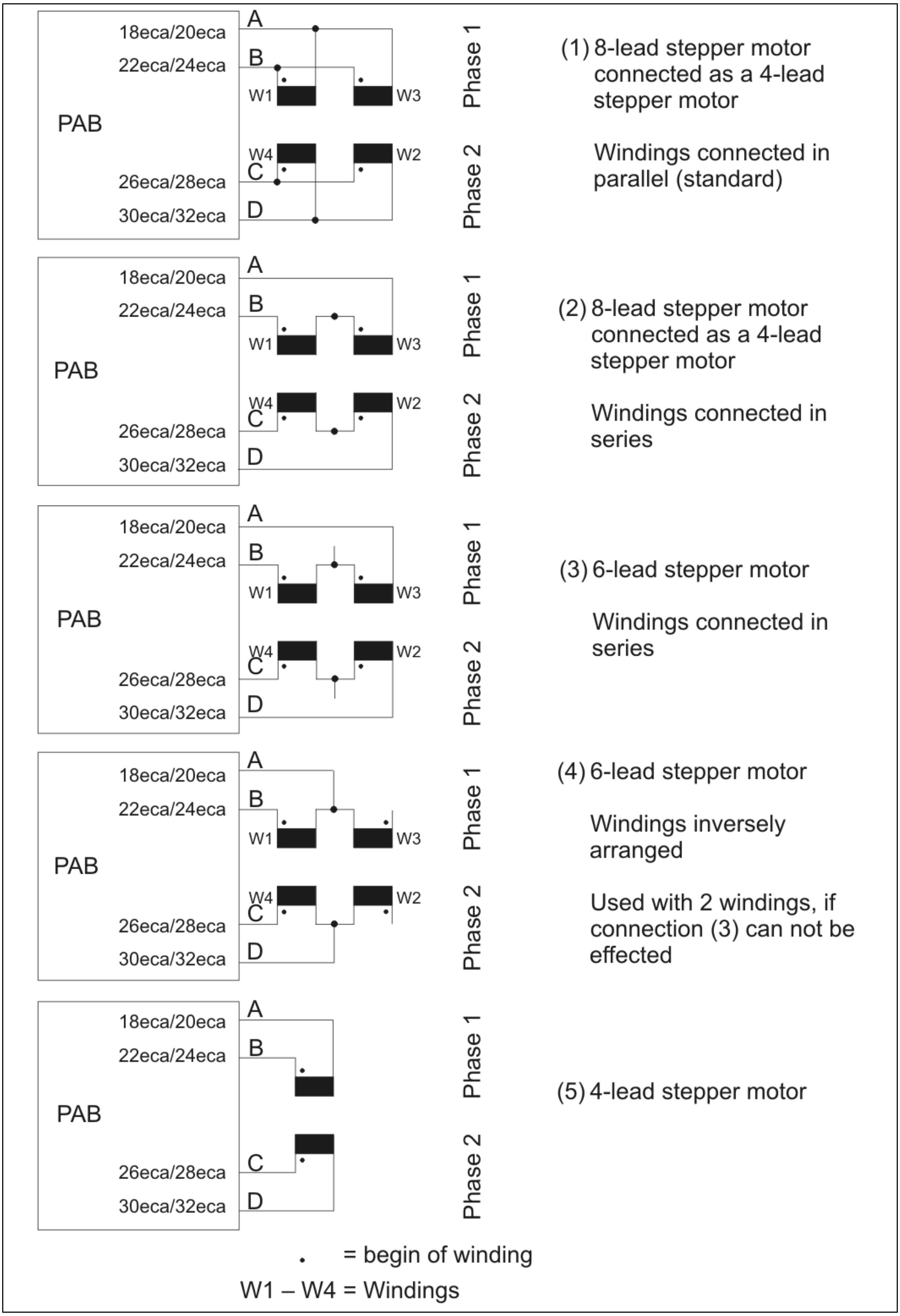


Fig. 5: Connection diagram for 4-, 6- and 8-lead stepper motors

5.2 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 minimum cable cross section: 1 mm^2
(0.1 mm^2 per 1 Ampere motor current)

⚠ For best electromagnetic compatibility (EMC), you should connect the shielding mesh to the PAB housing. Use the cable clamps on the rear side of the PAB power supply unit. The free cable ends must be as short as possible.

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 to use 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 or 4)!

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

6 Inputs

The control inputs Control pulse, Motor direction and Boost / Activation are electrically insulated by optocoupler from the PAB supply voltage. This assures best noise suppression between control and power circuit.

The signals are active, when current flows through the optocoupler.

Controlling via push-pull driver confers optimum suppression of disturbances, because always the current flows. Specially in case of long leads this kind of controlling should be preferred. The input level is 5 V.

The input function Boost / Activation is programmable per software.

Warning:
Please check if the input level of the PAB corresponds to the controller!

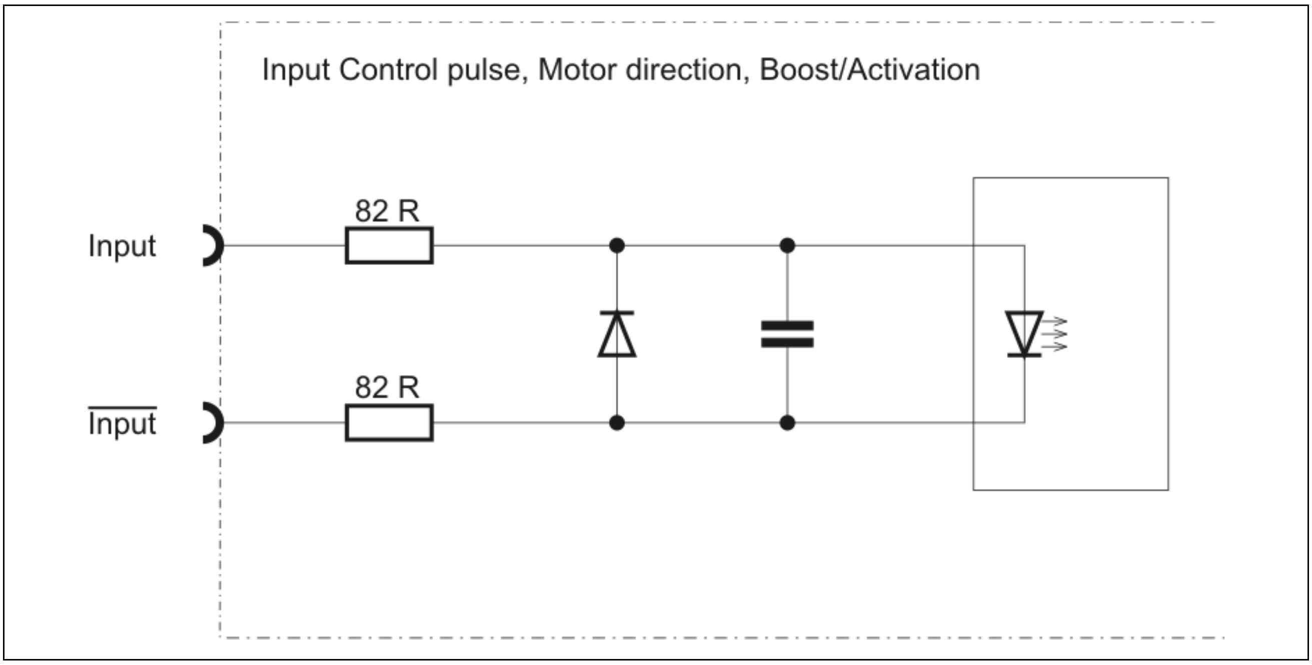


Fig. 6: Input wiring diagram

The ServiceBus inputs correspond to the RS485 standards and are electrically insulated.

6.1 Push-Pull- or OC-Controlling

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

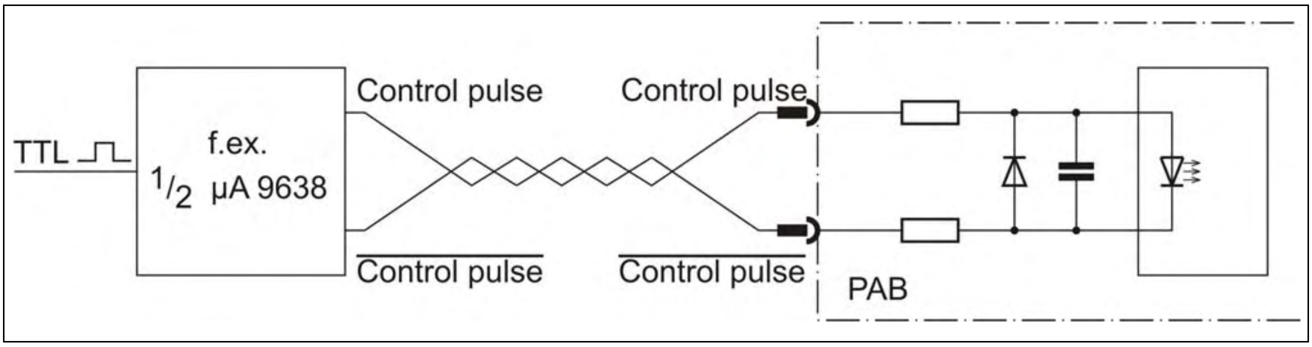


Fig. 7: Push-pull controlling

Alternatively a controlling via Open-Collector is possible:

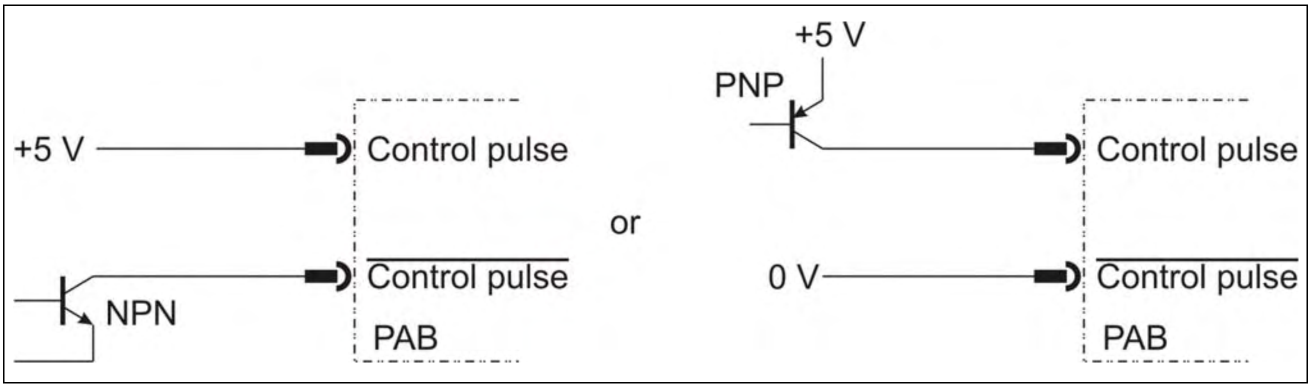


Fig. 8: Open-Collector Controlling

6.2 Logic Level

PAB power stages are available with 5 V input level.

Signal level	**5 V**
High	3 – 5.5 V
Low	< 0.4 V
Necessary driver current	max. 10 mA (at 3 V)
	max. 30 mA (at 5.5 V)

6.3 Control Pulse Input

Maximum step frequency: 500 kHz

Minimum pulse width: 1 µs

The step is done with the falling 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.

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 delay time. The delay time can be set by the interface, the default value is 20 ms.

⚡	**Warning:** As long as the Boost input is energized, **always** the motor current will be the Boost current. Although no control pulses arrive, **no** change to the stop current!

6.4 Motor Direction Input

If the input optocoupler is powered, the selected motor direction of rotation is reversed. Don’t change the signal 1 µs before the rising flank and after the falling flank of the control pulse!

6.5 Boost / Activation Input

The input function is programmable by software (instruction code ‚H‘, see chap.8.2).

Parameter: 0: Boost (default),
1: Activation

6.5.1 Boost

If the input optocoupler is energized the PAB sets the current to the selected value for the Boost current. Therefore it is possible, to set a Boost current, which is higher than the run current.

Thus, a higher torque can be reached during the acceleration and deceleration time of the motor.

Warning:
As long as the Boost input is energized, **always** the motor current will be the Boost current. **No change to the stop current!**

6.5.2 Activation

If the input optocoupler is energized, the motor current is energized.

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 rotate the motor by hand slowly.

WARNING!

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

The Activation input 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 Output

Open-Collector Darlington output insulated by means of optocoupler

I_{max} = 20 mA, U_{max} = 30 V, $U_{CE\ sat}$ at 20 mA < 1 V

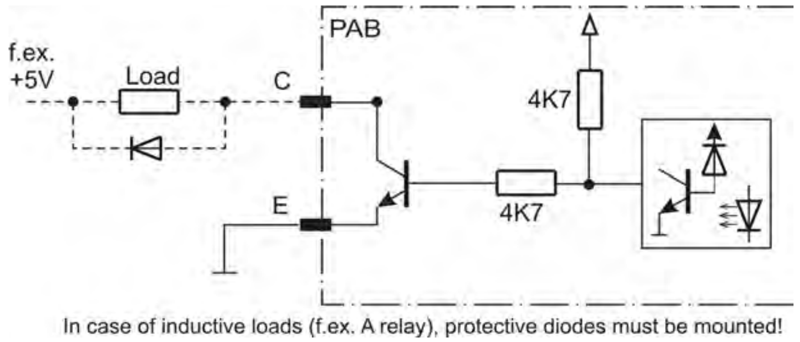


Fig. 9: Output wiring diagram

The output function can be set by software (instruction code ‘O’, see chap. 8.2) :

Parameter	Function	Output is active when
0	Error	error message
1	Basic position	the motor is in basic position
2	Ready	there is no error (default)

7.1 Error

This output is active in case of an error message:

Overvoltage,
Short circuit > 20 A (>1 µsec),
Undervoltage < 20 V,
Overtemperature > 85 °C at heat sink (housing),
error at deadman monitoring,
error in TEO,
error temperature in TEO.

At the same time the driver is deactivated to avoid damages.

An error message can be reset after error elimination or cooling. Hereto the **RESET instruction** should be transmitted to the controller via interface.

7.2 Basic Position

The output is active when the motor is in basic position. Both motor phases are energized by the same current value in basic position (70 % maximum and positive) independent of the selected step resolution.

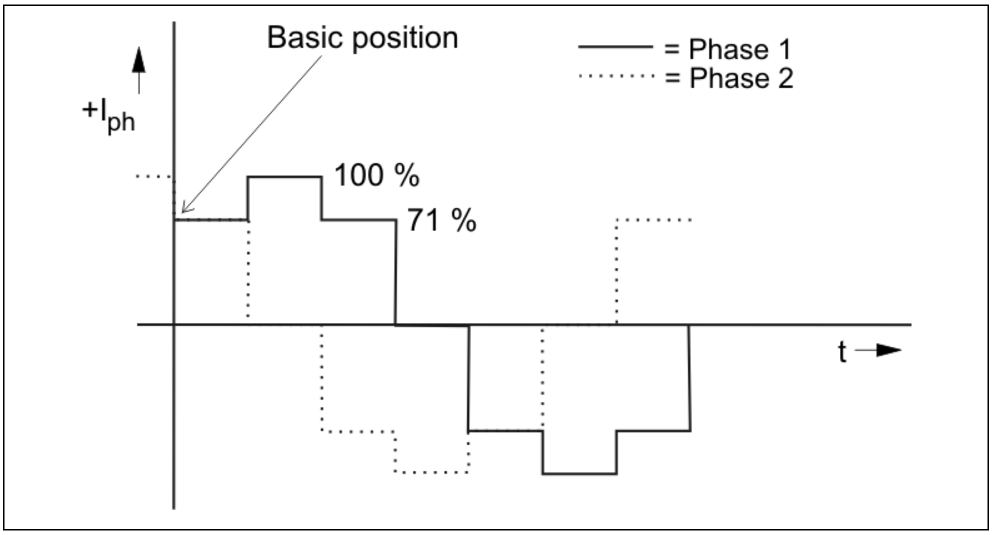


Fig. 10: Motor phases in basic position (half step)

7.2.1 Ready

The output is active, when there is no error (default).

The Ready output is switched through, when the PAB is ready. The power stage must be activated, that is the Activation input must be energized.

Remark:

After a reset signal, the power stage will enable the ready signal after approximately 500 ms.
Don’t activate before. As soon as the Ready output is switched through, drive instructions can be done.

8 Bus Connection Configuration

If operating more than one PAB device (max. 16) at one serial interface, the RS485 field bus is the best choice.
Each parameter in the PAB can be set by the serial bus connection. Thus, a safe stepper motor operation with correct preset parameters is assured.

8.1 Bus Connection

The bus connection is defined as follows:

- RS485: 4 wire connection, also point to point connection possible
- Signal input: Rx+ Rx-
- Signal output: Tx+ Tx-
- insulated from the motor voltage by means of optocoupler acc. to EN 50178

To assure a safe data exchange, a well-defined protocol should be maintained:

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

Transmission rate: 9600 Baud

Permanent telegram format:
<STX> <address> <instruction> <value> : <csh> <csl> < ETX>

<STX>	Start-of-text character, 02_H
<address>	Device address: 0...9 or A...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
<csl>	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 (⊕):

```
CS = address ⊕ data byte 1 ⊕ data byte 2 . . . ⊕ data byte n ⊕
     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 in the telegram.

The PAB also calculates (Exclusive OR) the checksum of the received data. The telegram will be rejected if a difference to the received checksum is detected and an error bit is set in the status byte.

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 PAB. 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>

8.2 Operating Parameters

The operating parameters are stored in a permanent memory of the PAB.
In the following table the operating parameters are defined with
W for **w**rite,
R for **r**ead and
X for e**x**ecute.

For current, voltage and temperature values reading or writing is applied:
Integer value x 1/10 = valid current, voltage or temperature value
Example: 55 x 1/10 = 5.5 ($A_{r.m.s}$)

The PAB instruction set consists of one-byte-instructions, this means, that on the second byte the data for the instruction will follow.
Exception: The instructions for additional parameters with instruction code **P** and the instructions for controlling of the optional temperature module TEO with instruction code **X**.
The data will begin on the 3rd byte in this two 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.

The following table gives an overview:

Additional input to the instruction code	**Function**	**Example**	**Description**	**Answer**
I	**I**nformation about the instruction	FI	Information about the instruction F	f,R/– PAB Status'
U	**U**pper limit of the number range	SU	Stop current: highest value	s63
L	**L**ower limit of the number range	RL	Run current: lowest value	r1
?	Read the preset value	R?	Display run current: 2.5 A	r25
<value>	Set the value	S5	Stop current 0.5 A	s5

Remark:

- If the instruction input values are faulty, the actual preset value will be the answer.

Instruction code	**Parameter name**	**Type**	**Value**	**Description**	**De-fault values**
A	Boost	R/W	0 to 63	Boost current from 0 to 6.3 $A_{r.m.s}$	6
B	Software version	R	<String>	Power stage software version	–
C	Reset	X	–	Reset of the power stage	–
D	Power stage temperature	R	0 to 999	Temperature of the power stage by 1/10 °C	–
E	Delete EPROM	X	–	Delete the EPROM	–

<table>
<tr><th>Instruction code</th><th>Parameter name</th><th>Type</th><th>Value</th><th>Description</th><th>Default values</th></tr>
<tr><td>F</td><td>PAB Status</td><td>R</td><td colspan="2">Read the power stage and TEO status (0001 to FFFF)
<table>
<tr><th>Hex.[1]</th><th>Dec.[1]</th><th>Valency</th><th>Description</th></tr>
<tr><td>01</td><td>1</td><td>0[2]</td><td>Error undervoltage</td></tr>
<tr><td>02</td><td>2</td><td>1[2]</td><td>Error overtemperature</td></tr>
<tr><td>04</td><td>4</td><td>2</td><td>TEO could not be acted</td></tr>
<tr><td>08</td><td>8</td><td>3</td><td>Temperature error in TEO</td></tr>
<tr><td>10</td><td>16</td><td>4</td><td>TEO is in use</td></tr>
<tr><td>20</td><td>32</td><td>5</td><td>Power stage is in basic position</td></tr>
<tr><td>40</td><td>64</td><td>6</td><td>Error checksum</td></tr>
<tr><td>80</td><td>128</td><td>7</td><td>Reset in PAB</td></tr>
<tr><td>100</td><td>256</td><td>8</td><td>Temperature limit 1 exceeded</td></tr>
<tr><td>200</td><td>512</td><td>9</td><td>Temperature limit 2 exceeded</td></tr>
<tr><td>400</td><td>1024</td><td>10</td><td>Temperature limit 3 exceeded</td></tr>
<tr><td>800</td><td>2048</td><td>11</td><td>Deadman monitoring active</td></tr>
<tr><td>1000</td><td>4096</td><td>12</td><td>Error deadman monitoring</td></tr>
<tr><td>2000</td><td>8192</td><td>13</td><td>1= Boost current active</td></tr>
<tr><td>4000</td><td>16384</td><td>14</td><td>0=Boost/stop current active
1=Boost/run current active</td></tr>
<tr><td>8000</td><td>32768</td><td>15</td><td>Reset in TEO</td></tr>
</table></td><td>–</td></tr>
</table>

1) The status can be read by an adequate instruction in a dec. or hex. mode. See chap.8.2.3
2) If both error bits are set, the status means “short circuit in PAB”.

Instruction code	Parameter name	Type	Value	Description		Default values
G	Pref. direction	R/W	0 or 1	1=pref. direction 0=contrary to pref. direction		0
H	Input function	R/W	0 or 1	Allocate to the input the function boost or activation 0 = Boost 1 = Activation		0
I	Actual current	R	0 to 63	Rms-value (measured): 0 to 6.3 $A_{r.m.s}$ in 1/10 A		4
J	Zero position	X		Enforce the basic position see chap. 7		–
K	Green LED	R/W	0 to 2	0 = LED shines at basic position 1 = shines always (exception: in case of error) If the PAB is de-activated, the LED blinks with the frequency, which is set by the instruction Y. 2 = shines always (exception: in case of error or deactivation)		1
L	Inputs logic level	R/W	0 or 1	Define the logic level of the inputs 0 = HIGH 1 = LOW		0
M	Step width (see appendix A1)	R/W	0 to 10	0=1/1 1=1/2 2=1/4 3=1/5 4=1/8	5=1/10 6=1/20 7=1/32 8=1/64 9=1/128 10=1/256 step	10
N	Serial number	R	<String>	Device serial number		–

Instruction code	Parameter name	Type	Value	Description	De-fault values
O	Output function	R/W	0 to 2	0=Error sum 1=Basic position 2=Ready	2
P	Extra parameters	R/W/X		1st byte of the instructions ‚Extra parameters', to define security functions See chap. 8.2.1	–
Q	Error inquiry	R	0 to 3	0=no error 1=undervoltage 2=overtemperature 3=short circuit	–
R	Run current	R/W	1 to 63	Run current values from 0.1 to 6.3 $A_{r.m.s}$	4
S	Stop current	R/W	0 to 63	Stop current values from 0 to 6.3 $A_{r.m.s}$	2
T	Delay time	R/W	1 to 200	1 to 200 ms (see appendix A3)	20
U	Power stage deactivation	R/W	0 or 1	0 = activated 1 = deactivated	1
V	Actual voltage	R	variable	Voltage in intermediate circuit in 1/10 V	–
W	Write EPROM	X	–	Write parameter into EPROM	–
X	TEO instructions	R/W/X		1st byte of the instructions for TEO module control See chap.8.2.2	–

Instruction code	Parameter name	Type	Value	Description	De-fault values
Y	Blinking time	R/W	0 to 2000	Defines the time in ms for the blinking frequency of the green LED in K1 mode. Y = LED is blinking high value slow Low value fast 0 does not (as in K2 mode)	0
Z	Motor test	X	–	Self test: one motor rotation	–

8.2.1 Extra Parameters

Instruction code	Parameter name	Type	Value	Description	De-fault values
PA	Action Deadman time (see appendix A4)	R/W	0 or 1	Set action for deadman time 0 = Deactivation 1 = Stop current	0
PB	Operation mode	R/W	0 or 1	Set operation mode 0 = bus 1 = stand alone	1
PD	Deadman monitoring	R/W	0 or 1	0 = on 1 = off	0
PI	Information	R/–		Information about P instructions	‚R/W Para-meters’
PN	Axis name	R/W	<String>	Assign or read an axis name (max. 40 characters)	0

Instruction code	Parameter name	Type	Value	Description	Default values
PT	Deadman time	R/W	500 to 10000	Set deadman time (for bus operation) in ms	1000

8.2.2 Instructions for TEO Module

Instruction code	Parameter name	Type	Value	Description	Default values
XB	TEO version	R	<String>	Read version of TEO module	V1.0
XC	Reset	X	–	Reset of TEO module	–
XF	TEO LED output	R/W	1 to 3	Allocate the temperature limit to the red LED	3
XH	Degassing function	X	–	Start the degassing function	–
XI	X instructions	R/–	–	Information about X instructions	–
XM	TEO temperature	R/–	–	Read TEO temperature (in 1/10 °C)	–
XN	TEO serial number	R/–	–	Read TEO serial number (in 1/10 °C)	–
XP	TEO connection	R/W	0 to 1	Signal PAB that TEO is connected and should be used: 0 = not connected 1 = connected	0
XR	Reference temperature	R/–	–	Read reference temperature at connector K (in 1/10 °C)	–
XS	Status TEO	R/–	–	Read TEO module status 0 = Temperature limit 1 2 = Temperature limit 2 4 = Temperature limit 3 128 = Cool boot (Reset)	–

Instruction code	Parameter name	Type	Value	Description	De-fault values
XT	Heat time	R/W	1 to 30000	Set heat time in min	10
XW	Sensor type thermocouple	R/W		Select thermocouple 0 = PT100 1 = K	PT100
XX	Temperature limit 1	R/W	-200 to 300	Read or write temperature limit 1 (in °C)	100
XY	Temperature limit 2	R/W	-200 to 300	Read or write temperature limit 2 (in °C)	150
XZ	Temperature limit 3	R/W	-200 to 300	Read or write temperature limit 3 (in °C)	200

8.2.3 Examples

Instruction code	Action	Answer
A? A60	Read Boost current Set Boost current to 6 $A_{r.m.s}$	e. g. a55 (= 5.5 $A_{r.m.s}$) a60
B?	Read PAB Software version	b<String> (e.g. bV1.0)
C	Reset PAB	c1
D?	Read PAB temperature	e. g. d570 (= 57 °C)
E	Delete EPROM	e1
F? FH?	Read PAB status in decimal mode Read PAB status in hexadecimal mode	e. g. f1 e. g. f01 (= Error undervoltage)
G? G1 or G0	Read pref. direction Set pref. direction	g0 or g1 g1 or g0
H? H1 or H0	Read the input function Allocate the input function	h0 or h1 h0 or h1

Instruction code	Action	Answer
I?	Read actual rms-current	e. g. i59 (= 5.9 $A_{r.m.s}$)
J	Enforce the basic position	j1
K? K0, K1 or K2	Read the green LED status Set the green LED status	k0, k1 or k2 k0, k1 or k2
L? L0 or L1	Define input logic level	l0 or l1 l0 or l1
M0....M10 M?	Set step width Read step width	m0...m10 m0...m10
N?	Read device serial number	n<String> (e. g. 00077231)
O? O0...O2	Read the output function Allocate the output function	O0...O2 O0...O2
PA? PA0 or PA1	Read the deadman time action Set the deadman time action	pa0 or pa1 pa0 or pa1
PB? PB0 or PB1	Read the operation mode Set the operation mode	pb0 or pb1 pb0 or pb1
PD? PD0 or PD1	Read the deadman monitoring Set the deadman monitoring	pd0 or pd1 pd0 or pd1
PI	Information	pi<String>
PN? PN<String>[3]	Read the axis name Allocate the axis name	pn<String> pn<String>
PT? PT500...PT10000	Read the deadman time Set the deadman time in ms	e. g. pt1000 (=1 s) pt500...pt10000
Q?	Error inquiry	q0...q3
R? R45	Read run current Set run current to 4.5 $A_{r.m.s}$	e. g. r54 (=5.4 $A_{r.m.s}$) r45
S? S27	Read stop current Set stop current to 2.7 $A_{r.m.s}$	e. g. s18 (=1.8 $A_{r.m.s}$) s27

Instruction code	Action	Answer
T? T120	Read current delay time Set current delay time to 120 ms	e. g. t180 (=180 ms) t120
U? U0 or U1	Read deactivation of the PAB Set deactivation of the PAB	e. g. u0 or u1 u0 or u1
V?	Read voltage in intermediate circuit	e. g. v490 (=49 V)
W	Write EPROM	w1
XB?	Read TEO module version	xb<String> (e. g.V1.0)
XC	Reset TEO module	xc1
XF? XF1...XF3	Allocate temperature limit to the red LED	xf1...xf3 xf1...xf3
XH	Start degassing function	xh1
XI	Information about X instructions	xi<String>
XM?	Read TEO temperature	e. g. xm600 (=60 °C)
XN?	Read TEO serial number	xn<String>
XP? XP0 or XP1	File TEO in the parameter memory	xp0 or xp1 xp0 or xp1
XR?	Read reference temperature at connector K	e. g. xr270 (=27 °C)
XS?	Read TEO module status	xs0, xs2, xs4, xs128
XT? XT1...XT30000	Set heat time in min	xt1...xt30000 xt1...xt30000
XW? XW0 or XW1	Read thermocouple Select thermocouple	xw0 or xw1 xw0 or xw1
XX? XX-200...XX300	Read temperature limit 1 Write temperature limit 1	xx-200...xx300 xx-200...xx300
XY? XY-200...XY300	Read temperature limit 2 Write temperature limit 2	xx-200...xx300 xx-200...xx300
XZ? XZ-200...XZ300	Read temperature limit 3 Write temperature limit 3	xx-200...xx300 xx-200...xx300

Instruction code	Action	Answer
Y? Y500	Blinking frequency	e. g. y0 y500
Z+, Z-	Do the Motor self test	z1

3) The axis name can only be written one time. Before using another name, the old name must be deleted by **PN0**.

Appendix A: Technical Information

A stepper motor can be used with different step resolutions, which are described in the first part of this chapter. The function BOOST you'll find in the second part.

A1 Full Step / Half Step / Micro Step

Full step

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.

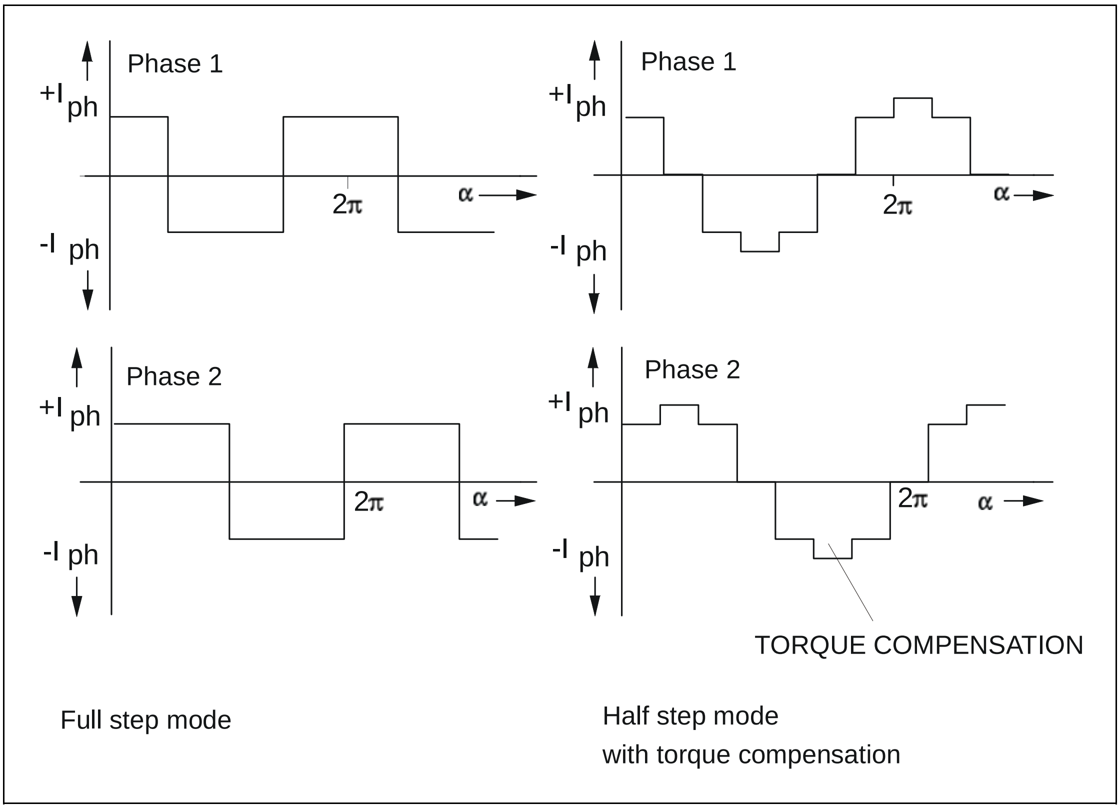


Fig. 11: Phase current curves

Half step

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.

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.

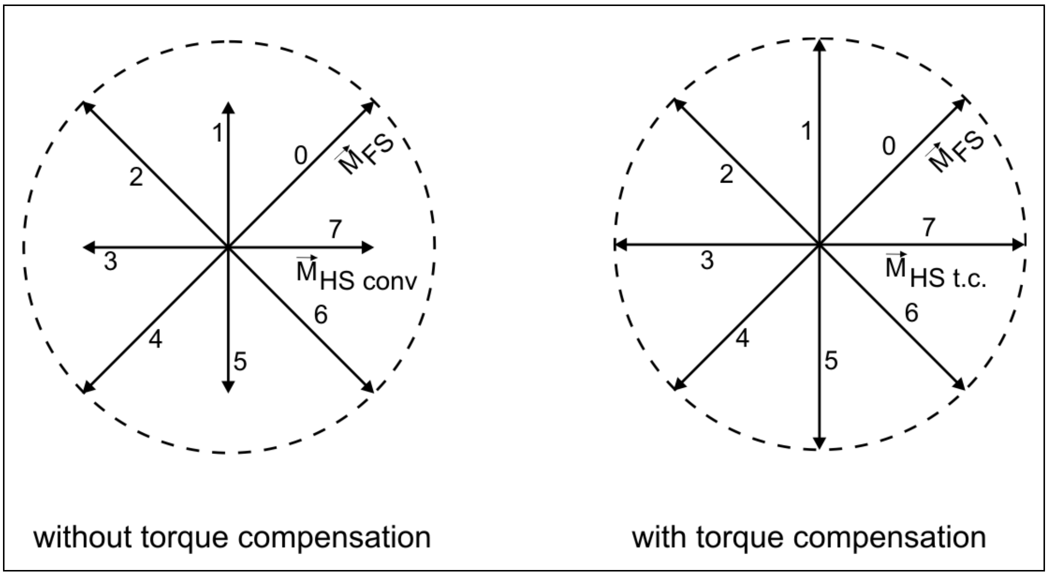


Fig. 12: Holding torques without/with torque compensation

Microstep Mode

When used in the „microstep mode“, the power stage PAB increases the step resolution by a factor 2, 4, 5, 8, 10, 20, 32, 64, 128 or 256.

Various advantages are obtained by the micro-step mode:

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

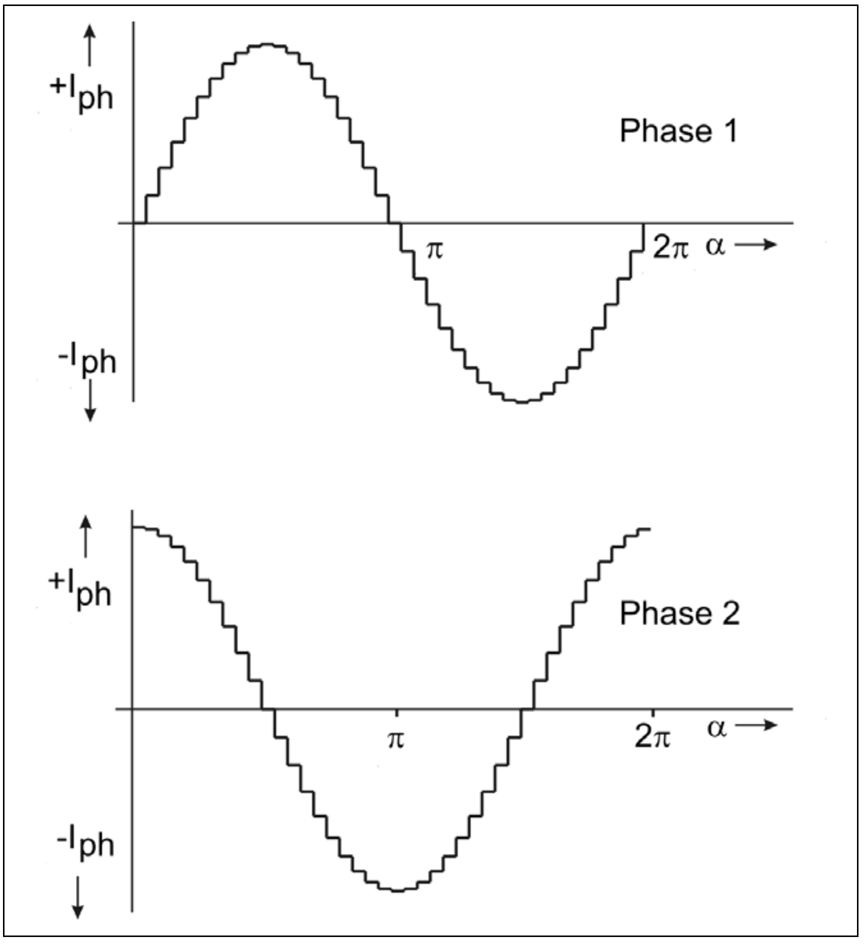


Fig. 13: 1/10 step mode

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, the PAB selects the phase current set by the program.

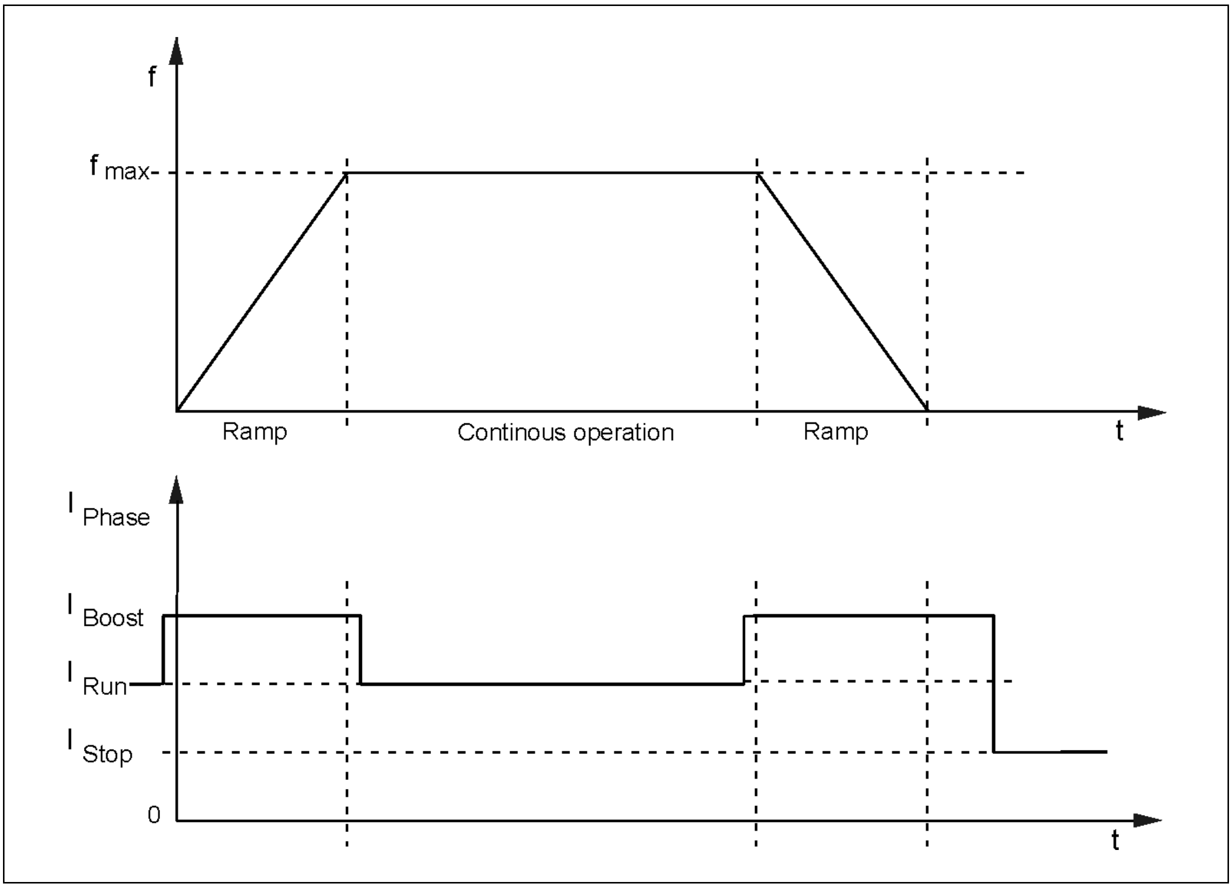


Fig. 14: Boost

A3 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 change to 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.

The current delay time can be set from 1 to 200 ms.
The default value is 40 ms.

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 for both motor phases.
In the following figure the next motor step follows after every **falling** control pulse edge:

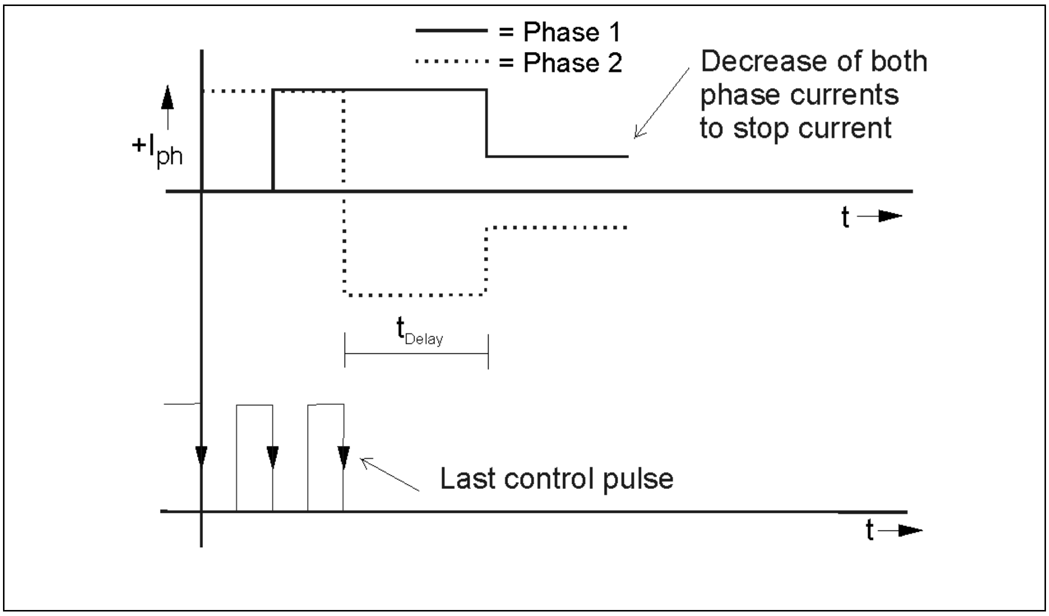


Fig. 1: Decrease to stop current after the last control pulse (full step)

Decreasing to stop current takes the following advantages:

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

A4 Deadman Monitoring

The deadman installation in PAB verifies the communication to the superordinate control unit.

The µController in the PAB can be programmed to use a telegram failure monitoring (instruction code ‚PD‘).
When the superordinate control unit doesn’t receive any telegram within a defined time (instruction code ‚PT‘), PAB assumes a communication failure (e. g. cable break). Then PAB runs the parameterized action (PAB deactivation or turn to stop current) by instruction code ‚PA‘.

Appendix B: Accessories

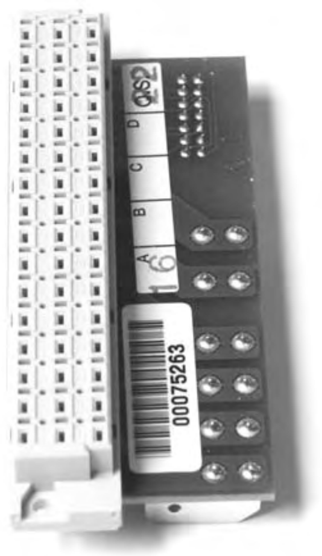
B1 Temperature Monitoring Module TEO

The PAB power stage can be optionally joined with the temperature monitoring module TEO. The PAB is connected to the module TEO by the 9pole connector at the front panel.

More detailed information you'll find in the manual „TEO Temperature monitoring module".

B2 G-PAB Adaptor Board

The PAB power stage can be directly plugged on the G-PAB adaptor board.
The G-PAB can be used to simplify mounting into a 19" rack or to minimize the amount of cabling.



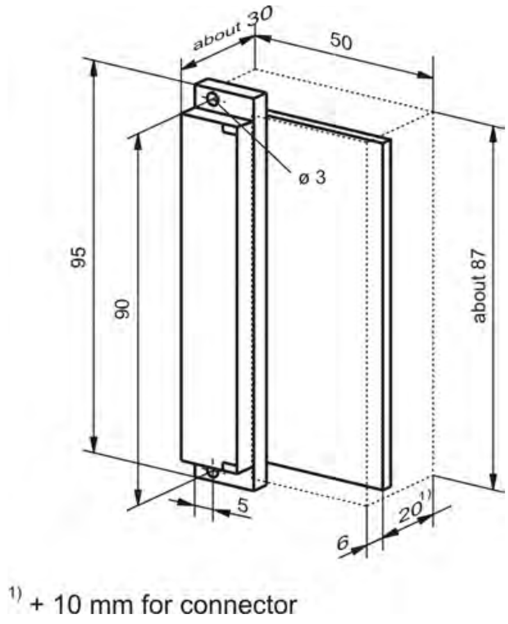


Fig. 1: Adaptor board G-PAB with dimensions (in mm)

Appendix C

In this chapter: warranty, trade marks and ESD protective measures

C1 Warranty

The PAB devices 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.

C2 Trade Marks

In this manual several trade marks are used which are no longer explicitly marked as trade marks 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-Elektronik GmbH.
- Microsoft is a registered trade mark and WINDOWS is a trade mark of the Microsoft Corporation in the USA and other countries.

C3 ESD Protective 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). 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 D: Declarations of Conformity

Phytron-Elektronik GmbH

EG-Konformitätserklärung

Declaration of Conformity

Hiermit erklären wir, dass die Bauart der nachfolgend bezeichneten Produkte in der von uns in Verkehr gebrachten Ausführung den unten genannten einschlägigen EG-Richtlinien entspricht.

We, the manufacturer, declare hereby on our own responsibility, that the following products meet all the provisions of the EU directive cited below:

Produktbezeichnung *Part name*	**Identnummer** *ID-No.*	**Ab Seriennr.** From *Serial No*
PAB+ MICRO, PAB 93-70 MICRO	10003560, 10003627	Alle/*all*

Angewendete EG-Richtlinie / *EU Directive Applied*:
89/336/EWG vom 3. Mai 1989 (EMV-Richtlinie) *89/336/EEC of May 3rd, 1989 (EMC Directive)*

Angewendete harmonisierte Normen / *Harmonized Standards Applied*:	
EN 50178	Ausrüstung von Starkstromanlagen mit elektronischen Betriebsmitteln / *Electronic equipment for use in power installations*
EN 61000-6-3	Elektromagnetische Verträglichkeit (EMV) Fachgrundnorm Störaussendung - Wohnbereich, Geschäfts- und Gewerbebereiche sowie Kleinbetriebe *Electromagnetic compatibility (EMC) - Emission standard for residential, commercial and light-industrial environments*
EN 61000-6-4	Elektromagnetische Verträglichkeit (EMV) - Fachgrundnorm Störaussendung für Industriebereich *Electromagnetic compatibility (EMC) - Emission standard for industrial environments*
EN 61000-6-1	Elektromagnetische Verträglichkeit (EMV) - Störfestigkeit für Wohnbereich, Geschäfts- und Gewerbebereiche sowie Kleinbetriebe *Electromagnetic Compatibility (EMC) - Immunity for residential, commercial and light-industrial environmental*
EN 61000-6-2	Elektromagnetische Verträglichkeit (EMV) - Störfestigkeit für Industriebereiche *Electromagnetic compatibility (EMC) - Immunity for industrial environments*

Anmerkung/*Comment:*

Gröbenzell, den 30. Oktober 2007 / Gröbenzell, October 30th, 2007

Heribert Schmid
Technischer Geschäftsführer/ Managing Director

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customized solutions in motion

Phytron-Elektronik GmbH

EG-Herstellererklärung

gemäß EG-Richtlinie Maschinen 98/37/EG, Anhang II B

Declaration of Conformity

According to EC Directive on Machinery 98/37/EC, Annex II B

Hiermit erklären wir, dass es sich bei dieser Lieferung um die nachfolgend bezeichnete unvollständige Maschine handelt. Die Inbetriebnahme dieser Maschine/des Maschinenteils ist so lange untersagt, bis festgestellt wurde, dass die Maschine, in die sie eingebaut werden soll, den Bestimmungen der EG-Richtlinien Maschinen 98/37/EG entspricht.

We, the manufacturer, declare that this delivery is for an incomplete machinery as defined below. The start-up of this machine/machine part is prohibited until it has been determined that the machine in which it is to be incorporated complies with the requirements of EC machine guidelines 98/37/EC.

Produktbezeichnung ***Part name***	**Identnummer** ***ID-No.***	**Ab Seriennr.** **From *Serial No***
PAB+ MICRO, PAB 93-70 MICRO	10003560, 10003627	Alle/*all*

Angewendete harmonisierte Normen / *Harmonized Standards Applied*:	
EN 12100-1: 2004-04	Sicherheit von Maschinen - Grundbegriffe, allgemeine Gestaltungsleitsätze - Teil 1: Grundsätzliche Terminologie, Methodologie
EN 12100-2: 2004-04	Sicherheit von Maschinen - Grundbegriffe, allgemeine Gestaltungsleitsätze - Teil 2: Technische Leitsätze
EN 60204-1: 1998-11	Sicherheit von Maschinen - Elektrische Ausrüstung von Maschinen - Teil 1: Allgemeine Anforderungen

Anmerkung/*Comment:*

Diese Erklärung verliert ihre Gültigkeit bei baulicher Veränderung und bei nicht bestimmungsgemäßer Verwendung, sofern nicht ausdrücklich die schriftliche Zustimmung des Herstellers vorliegt.

This declaration loses its validity in case of structural alterations and/or use other than defined, unless the express written approval of the manufacturer is available.

Gröbenzell, den 30. Oktober 2007 / Gröbenzell, October 30th, 2007

Heribert Schmid
Technischer Geschäftsführer/ Managing Director

AP QS-0427-4

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customized solutions in motion

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