MOTOR CONTROLLER SERIES 9000

INSTRUCTION MANUAL

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1 Introduction

The HUBER Motor Control Series 9000 is an improved version of the former successful Series 9000. The new design has been changed drastically to increase flexibility and comfort. The manual interaction between operator and controller is dialog-based. Position and status information is visualized by a 40-character LC-display.

The basic unit is a single-axis model with a 16-bit NEC micro-controller and on-board memory. Configuration data are permanently stored on E^2PROMs. It may be extended to up to a maximum of eight individually and independently controllable axes. Special extensions for the use in X-Ray-Diffractometry are available as well: Impulse counter 9000.07 and control units for filter device 9000.08 and half-screen device 9000.09 can be ordered optionally.

Two standard interfaces for remote control are included: A serial (RS232 C) interface and a parallel GPIB (IEEE 488) interface. Additionally, an optocoupled 16 bit I/O-port is available to control- or react on external events.

All functions of the MC are either accessible manually by key panel or under remote control from any suitable computer. The unit is capable of performing even complicated positioning and data collection tasks by means of an extensive command set.
For data collection, it may act as a stand-alone unit without computer control. Sampled measurement data are kept in memory until a transfer is requested.

Various types of driver boards are available to control any type of stepping motor. Mixed configurations (power, resolution etc.) are no problem at all. The overall size of control units for more than two axes depends on size and power requirement of the driver boards.

2 Installation

2.1 Before you Start

This chapter contains some important details you should read and check before switch on the MC for the first time.

i) Mains Power Voltage

Check the correct AC mains power voltage setting: 240 VAC at 50/60 Hz is the default value.

In order to change the mains power voltage, remove the voltage selector of the mains plug socket on the rear panel of the controller and re-insert it with the corresponding setting. If you have a controller with more than two axes, do not forget to change the voltage settings of the additional power supply boxes correspondingly.

The fuse cap is integrated in the mains plug socket. Always replace fuses corresponding to the individual Configuration List, which is delivered with your controller.

For better air circulation, it is recommended to remove the top and bottom cover plates when the unit will be mounted into a 19"-rack.
It is very important that the types of step motors are identical with the specifications shown on the Configuration List mentioned above. There are various types of motor driver boards available for 2-, 3- or 5-phase operation modes in full- or half step mode.

ii) Motor Connection

On the rear panel, there are separate sockets for motor power output and signal input of limit switches and reference position indicators (see Fig. later in this section).

> **ATTENTION:** In order to avoid damaging your controller, **always disconnect mains power** before connecting or disconnecting your positioning hardware.

The individual configuration list provided with each MC contains the information about the assignment of the power and signal connectors to the corresponding motor axes.

> **ATTENTION:** Make sure you are connecting your positioning hardware according to the configuration list. Especially in 'mixed' configurations, i.e. in case your controller is equipped with different types of power boards, it is extremely important that you do not mix up connections.
> **This may cause serious damage to your controller!**

Controller units with more than 2 axes consist of more than two cases: The controller itself and, depending on number and type of the individual axes, of one or two additional power supply cases for the motor driver boards.

iii) Limit Switches

For test reasons, the controller may be operated without step motors: Short circuit plugs are provided with the controller to simulate the presence of limit switches. If you want (or have to) run your positioning devices without limit switches, just insert the plugs into the corresponding signal connectors on the rear panel of the controller.

> **ATTENTION**: Driving positioning devices without properly installed and adjusted limit switches may cause serious damage to the positioning hardware in case of collisions.

iv) Power ON

After switching on the MC, the controller performs a self-test subroutine and checks for the amount of available axes and the current status of the limit switches. Under normal circumstances the following message should appear on the display:

```
1: +0.000 DEG
READY FOR YOUR COMMANDS            <LOCAL>
```

The following message indicates that both limit switches of the displayed axis were found active during POST (power-on self test).

```
AXIS1: LIMIT SWITCH ERROR!!!
CHECK CABLES AND SWITCHES!
```

Possible reasons are:

a) The signal connector of the corresponding axis is disconnected. If the corresponding axis is not equipped with limit switches, insert the short circuit plugs instead.

b) Damaged cable connection and/or micro-switch defect.

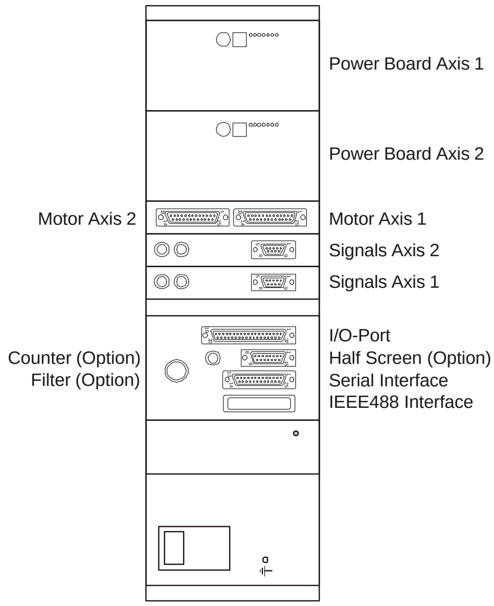
A similar message will appear, if the positioning device is at a limit switch position:

```
AXIS1: <+> LIMIT SWITCH ERROR!!!
PRESS <-> TO RUN FREE
```

In order to return to normal operation, you have to move the positioning unit manually out of this position by typing the indicated direction key. If the limit switch is still active after performing this action, the controller assumes a connection problem and reports the same message as already mentioned above.

Motor Power and Signal Connections Rear Panel 9011-9018

9011, 9012



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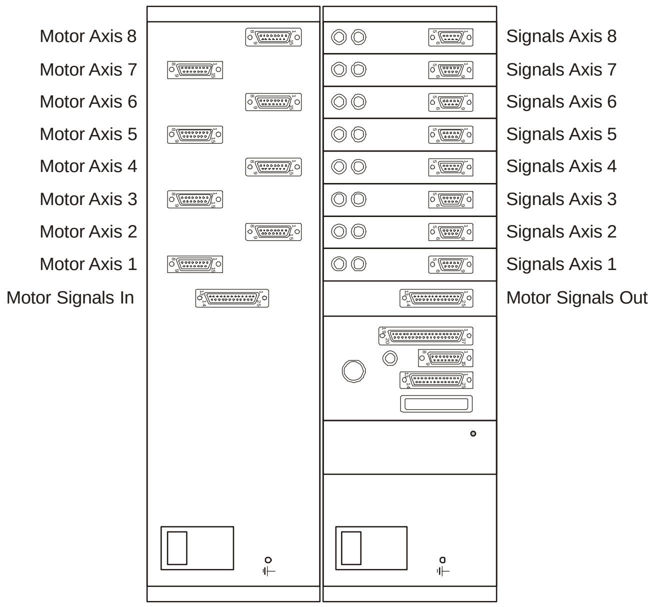

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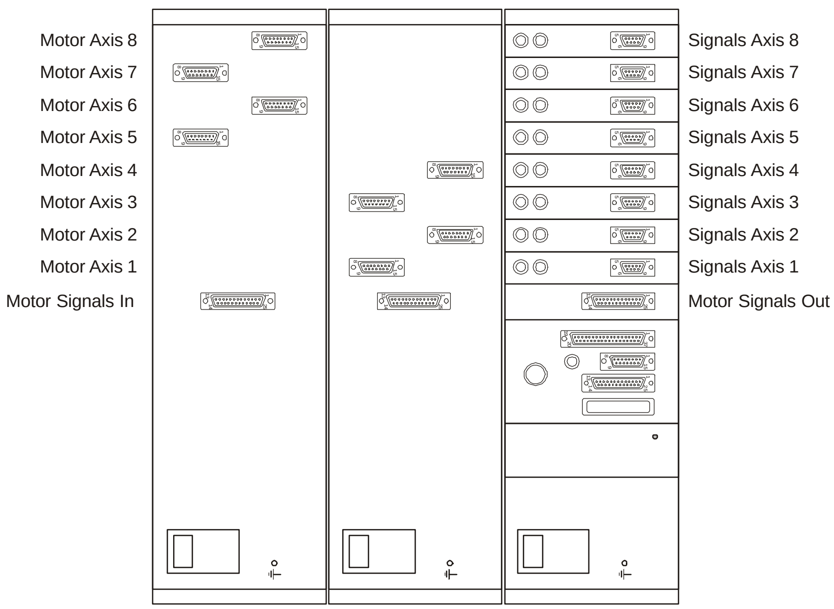


2.2 Configuration

Configuration means, to inform the controller about the properties of the connected positioning hardware. If the controller has been ordered together with a certain positioning hardware, configuration is not necessary. The controller has been pre-configured before shipment. An individual configuration data sheet is provided with each controller.

You may change the configuration either manually or, more comfortable, under computer control by means of a set of configuration commands. The latter requires the proper configuration of the desired communication interface.

The following paragraphs describe the manual configuration procedure step-by-step, starting from the initial display after power on. Press function key <F1> to enter the configuration menu:

```
     ---> CONFIGURATION MENU <---
CONFIGURE <F1>:AXIS <F2>:INTERFACE
```

Press <F1> a second time to start editing the properties of the present axes:

```
AIXS 1 = GONIOMETER
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

Each axis may be configured as GONIOMETER, LINEAR TABLE or SLIT SCREEN, which results in a unit display in [deg] or [mm]. If you decide to change the actual setting, press <F1>. To skip this setting and continue with the next one, press <F2>. To quit the configuration procedure, press <F3>.

Selection of <F1> results in the following message:

```
<F1>:GONIOMETER
<F2>:LINEAR TABLE <F3>:SLIT SCREEN
```

Position values of Goniometers are always displayed MODULO 360. Internally, however, the controller remembers the accumulated position. E.g. if the controller has recently executed a positioning command to 370 deg, the display will show 10 deg. A subsequent command to 0 deg will cause a motion over the full distance of 370 deg in reverse direction.

PLEASE NOTE: The internal counter registers of the controller allow a maximum number of motor steps of $\pm 2^{23}$-1, i.e. 8.388.607 steps. You have to consider this fact during the following selection of the gear ratio settings.

```
AXIS 1 GEAR RATIO NUMERATOR = 1000
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

```
AXIS 1 GEAR RATIO DENOMINATOR = 1
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

This example configures a gear ratio of 1000/1. If we assume this axis is defined to be a Goniometer, 1000 motor steps correspond to a distance of 1 deg. Due to the fact, that the smallest positioning interval is one motor step, this setting results in a maximum position resolution of 0.001 deg.

```
AXIS 1 REFERENCE OFFSET = +0.000
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

At this point, you may configure the position value that will be displayed after the controller has been powered on, RESETted or a search-reference-position procedure has been executed.

After this, you will be prompted for some positioning speed settings. You have to enter the values for the speed settings in [Hz] units, i.e. steps per second. These settings depend on motor type, driver board and positioning mode of the corresponding axis, i.e. it is a matter of trial-and-error to find out suitable settings.

```
AXIS 1 REF SWITCH SCAN FRQ = 1500
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

This setting affects the positioning speed which is used by the controller for searching the reference position. You may change the speed settings for the manual positioning modes <RUN> and <FAST> correspondingly:

```
AXIS 1 MANUAL RUN FREQUENCY = 250
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

```
AXIS 1 MANUAL FAST FREQUENCY = 2500
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

The value of the RUN speed must be set below the so-called START-STOP frequency of the motor. The START-STOP frequency is the maximum step frequency a motor can execute without acceleration/deceleration ramp.
The value of the RUN speed also serves as the start speed for manual FAST mode positioning. In FAST mode, the motor accelerates/decelerates with a certain ramp between RUN speed and FAST speed.

The default rotation sense of the motor can be selected now:

```
AXIS 1 LEVEL FOR POS. DIRECTION = 0
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

0 corresponds to positive, 1 to negative rotation sense. The direction output signal at the BNC-connector on the rear panel will be inverted as well.

PLEASE NOTE: Motor rotation sense and the limit switch assignment are related to each other. If you change the rotation sense of a motor, you have to check the correct assignment of the corresponding limit switches as well. Otherwise the direction of movement which is used to run off the limit switch position may be wrong. To adapt the limit switch sense, change the following setting to either 0 or 1:

```
AXIS 1 LIMIT SWITCH ASSIGNMENT = 0
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

If you have multiple axes, the procedure starts from a new with the first configuration parameter of the next axis.

After changing the last axis specific parameter, you will be prompted as follows:

```
IO-CONTROL = 0
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

Setting the IO-Control parameter value to 1 enables the observation mode for the input port. If this mode is enabled, the controller will permanently watch the status of the input port lines. If the signal level of one of the lines changes from 0 to 1, the controller performs an emergency stop (comparable with the occurrence of a limit switch event), i.e. immediately aborts any movement.

After changing the last setting or if you quit the configuration procedure with <F3>, you will be prompted as follows:

```
UPDATE CURRENT CONFIGURATION ?
<F1>:YES <F2>:NO
```

Select <F1> to save the complete parameter set permanently. If you select <F2>: NO, all changes will be active *temporarily*, i.e. until the MC is switched off or you press the <RESET> button.

The configuration of the interfaces works correspondingly. After switching on the controller, press<F1> and from there select <F2>: INTERFACE. The following display will appear:

```
ACTIVE INTERFACE: IEEE 488
<F1>:CHANGE <F2>:GO ON <F3>:QUIT
```

After selection of the desired interface, you may change the corresponding interface settings. In case of the IEEE 488 interface, the only parameter you may change is the unit's device address. For the serial (RS 232 C) interface, the following parameters are selectable:

- Baud rate:	2400, 4800, 9600, 19200
- Number of data bits:	7 or 8
- Number of stop bits:	1 or 2
- Parity:	NONE, EVEN, ODD, NULL

- Data terminator character(s): <LF> (LINE FEED)
<CR> (CARRIAGE RETURN)
<CR+LF>

PLEASE NOTE: Only data transmitted *from* the MC to a host computer will be terminated by this configurable sequence. Independent from this, commands transferred *from* a computer *to* the MC must always be terminated by <CR+LF>.

3 Front View and Key Panel Functions

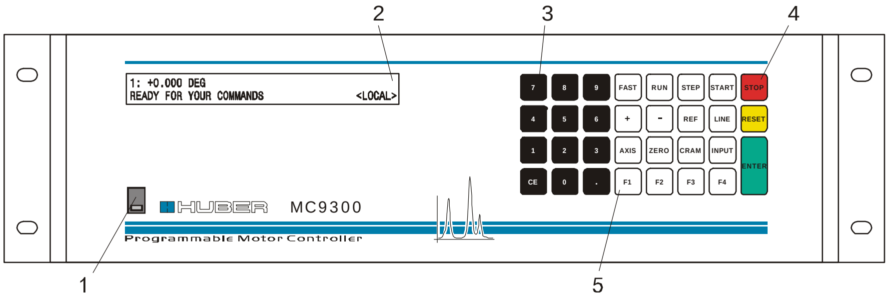
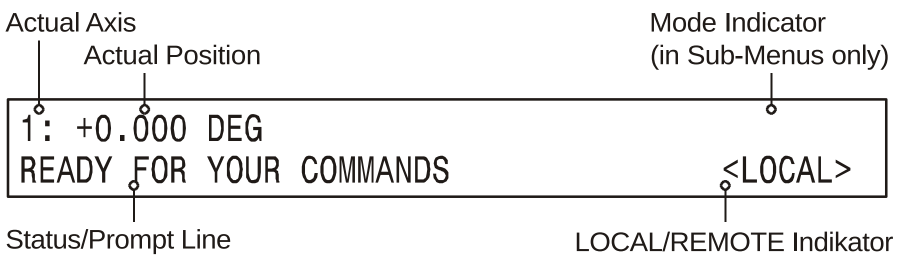


Fig. 3-1 Front View of MC

1 Mains Power Switch	4 Operating Key Panel
2 LC-Display	5 Function Keys
3 Numerical Key Panel	

The Figure below shows the display content after power on and successful initialization.



Depending on what the controller is actually doing, the display content may vary. Changing between <LOCAL> and <REMOTE> status is only possible under computer control. The following paragraphs describes all functions which are executable via key panel input. The term '<KEY>' is used as an abbreviation for 'Pressing the key <KEY>...' The controller confirms any recognized keystroke with a short acoustic signal.

3.1 RESET

<RESET> triggers a 'warm start' and resets the MC to default conditions. The position information is set to zero and the program memory will be cleared, i.e. all program information is lost. After <RESET>, you have to execute a reference position search procedure in order to get valid position information.

3.2 STOP

<STOP> immediately aborts any motor movement. This is comparable to an 'Emergency Stop' which may result in a loss of motor steps, i.e. the real position(s) may be different from the displayed positions. It is recommended to execute a reference position search procedure in order to get valid position information.

Besides this, a <STOP> during any key panel input will usually return the controller to the default 'READY FOR YOUR COMMANDS' mode.

3.3 REF - Searching the Reference Position

If you switch off or <RESET> the MC, it will loose the actual position information. In order to return the positioning system into a valid state, it is necessary for each positioning axis to have a certain reproducible reference position which can be found by the controller.
Most of the Huber positioning devices can be equipped with reference position indicators. Such an indicator usually consists of a set of two independent optoelectronic light barriers, which allow the precise and reproducible search of a reference position. The illustrated function principle and a flow diagram of the process can be found in the Appendix.

```
1: +0.000 DEG                              REF
INPUT AXIS (1-2); <ENTER>=ALL:
```

After <REF>, you will be asked for the axis for which you want to perform the reference search procedure. <ENTER> without any input starts the procedure for all axes at the same time.
ATTENTION: Be careful with selecting 'ALL': The more involved axes you have, the higher is the possibility of a mechanical crash when you start all movements at the same time. For a detailed description of the homing mode and the way it is executed, refer to the corresponding chapter.

3.4 AXIS - Selecting the Active Axis

The MC's display is able to show the actual position of only one axis. If your MC is equipped with more than one axis, and you want to view or manually move a different one, you have to select this axis first by <AXIS>. After selection of the axis, its actual position is shown on the display.

```
1: +0.000 DEG                             AXIS
INPUT AXIS (1-2); <ENTER>=ALL:
```

3.5 FAST/RUN/STEP - Manual Positioning

There are three types of manual modes available. <STOP> will return you to the initial display.

1) <FAST>:

```
1: +0.000 DEG                             FAST
PRESS <+> OR <->; <STOP> TO QUIT
```

As long as you press one of the direction keys <+> or <->, the motor will move in the corresponding direction with the configured speed profile: It starts with the RUN frequency and accelerates to FAST speed. When you release the key, the motor decelerates to RUN speed and stops.

2) <RUN>:

```
1: +0.000 DEG                              RUN
PRESS <+> OR <->; <STOP> TO QUIT
```

<+> or <-> moves the motor continuously in the corresponding direction at RUN speed. <STOP> interrupts the movement.

3) <STEP>:

```
1: +0.000 DEG                              STEP
PRESS <+> OR <->; <STOP> TO QUIT
```

Pressing <+> or <-> briefly performs a single motor step in the corresponding direction. Keep the button pressed for continuous stepping.

3.6 Manual Setting of the Reference Position

As already mentioned, <REF> automatically adjusts the reference position if the positioning hardware is equipped correspondingly. I some cases, it may be necessary to set a certain position value manually.

<ZERO> allows presetting the display with any desired position value:

```
1: +0.000 DEG                              ZERO
<F1>:ZERO <F2>:SET POSITION <F3>:QUIT
```

With <F1>, you will be prompted as follows:

```
1: +0.000 DEG                              ZERO
INPUT AXIS (1-2); <ENTER>=ALL
```

<ENTER> without input sets the position display of all axes to the configured reference offset value.

> **Please Note:** This value depends on the configuration and is not necessarily '0.000'.

<F2> allows for free input of the reference position value.

```
1: +0.000 DEG                              ZERO
PRESET VALUE: 0
```

Please note: If the axis was configured to drive a Goniometer, any number is accepted but the actual position display is always calculated MODULO 360.

3.7 CRAM - Clearing the Program Memory

Prior to entering a new program, we recommend to <CRAM>. This function initializes the program memory of the controller after confirmation with <F1>.

```
ARE YOU SURE ?                             CRAM
<F1>:YES  OTHER KEY:NO
```

If a program was 'saved' before, it can be re-loaded at the beginning of the manual program input mode. This 'Load Program' feature will be explained in chapter 6.

4 Rear Panel

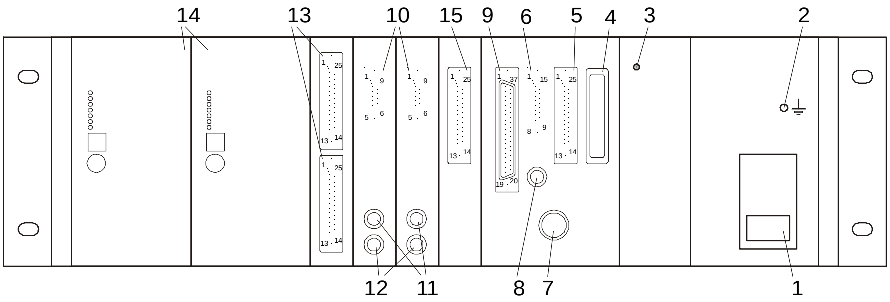


Fig. 4-1 MC Rear View

1 Mains Power Connector with Fuse
2 Ground
3 Power Supply Active LED
4 GPIB (IEEE 488) Interface
5 Serial (RS232 C) Interface
6 Half Screen Device (opt.)
7 Absorption Filter Device (opt.)
8 Counter Input (opt.)
9 16-Bit I/O-Port
10 Limit/Reference Signal Input
11 Motor Frequency OUT
12 Motor Direction OUT
13 Motor Power OUT
14 Power Boards
15 Motor Signals Out (> 2 axes)

Fig. 4-1 shows the rear view of a MC with 2 axes. This view may vary depending on the type of power board that is used. Controllers with more than two axes consist of 2 or 3 cases with independent power supply, depending on the number and the type of power boards. In order to configure motor current and step mode, you have to take down the font panel of the power board cases.

4.1 Signal Input for Limit Switches and Reference Indicator

The signal input of limit switches and reference position indicator is optocoupled. HUBER positioning devices are usually equipped with mechanical limit switches and optoelectronic indicators for the reference position, but other switches or signal-generators may be used as well.

4.1.1 Limit Switches

Limit switches are usually responsible for the protection of the positioning hardware against mechanical collisions. Depending on the type of positioning device, they are either located at fixed positions or adjustable within a certain range. Upon the occurrence of a limit switch event, the controller will perform an emergency stop, i.e. immediately abort any movement. A corresponding message will appear on the display. Under computer control, you may query the status information, which will also report this event.

Limit switch contacts have to be wired 'normally-closed', i.e. an open switching contact, as well as a missing or damaged cable connection, will generate a limit switch event.

As already mentioned, the controller checks the status of the limit switch input signals during power on self test. In case of an active signal input, the following message will be generated:

```
AXIS1: <+> LIMIT SWITCH ERROR!!!
PRESS <-> TO RUN FREE
```

After <->, the MC tries to move the motor for a short interval in the given direction. If the event is still active, the controller assumes a cable- or switch problem and informs you with the following message:

```
AXIS1: LIMIT SWITCH ERROR!!!
CHECK CABLES AND SWITCHES!
```

During normal operation, the limit switch status is being checked just before starting a movement and later on permanently during a movement. The occurrence of a limit switch event will trigger the same actions as already mentioned at the beginning of this chapter.

> **PLEASE NOTE**: Upon the occurrence of a limit switch event, the controller performs an emergency stop, i. e. it immediately interrupts any movement. Due to inertia effects, it may happen that moving motors loose steps and consequently the position display differs from the real hardware position. Triggering a reference position search procedure is strongly recommended in this case.

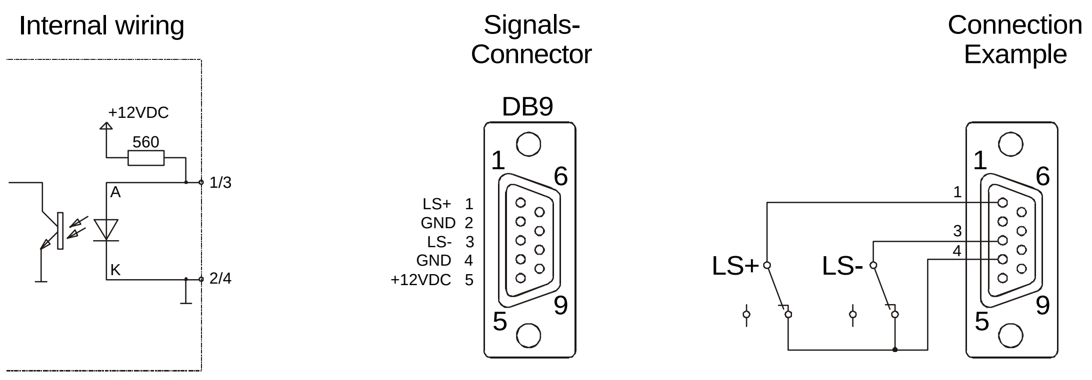


Fig. 4-2 Signal INPUT: Internal connections of the limit switches

Closed (inactive) limit switches between pin 1/3 and 2/4 pull down the voltage source of the diodes of two optocouplers to ground level.

4.1.2 Reference Indicators

The reference position of Huber positioning devices is usually defined by a set of two optoelectronic indicators which generate a signal drop from 12VDC to 0V at the corresponding input when activated. A detailed description of the function principle is available in the Appendix.

Depending on the configured type of positioning hardware (Goniometer, linear table or slit screen) a predefined procedure will be executed upon receiving the REF command, in order to search for the position of the reference indicators. Detailed flow diagrams of the search sequences are listed in the Appendix.

Usually, the controller starts the corresponding axis with negative direction of movement and monitors the status of the reference input signals. Upon the occurrence of a signal change at the first input, the controller decelerates the motor speed. It continues moving at slow speed and stops immediately when it detects the occurrence of a signal change at the second input.
The appearance of limit switch events during this search procedure will cause corresponding variations in the sequence. See the Appendix for details.

After successful execution of the procedure, the status byte of the axis will be updated correspondingly to report this fact and the position display of the controller is set to the configured reference offset value (usually 0.00).

If there is no reference position indicator connected to the controller, the MC assumes the actual position to be the reference position and performs the actions mentioned above except moving the motor.

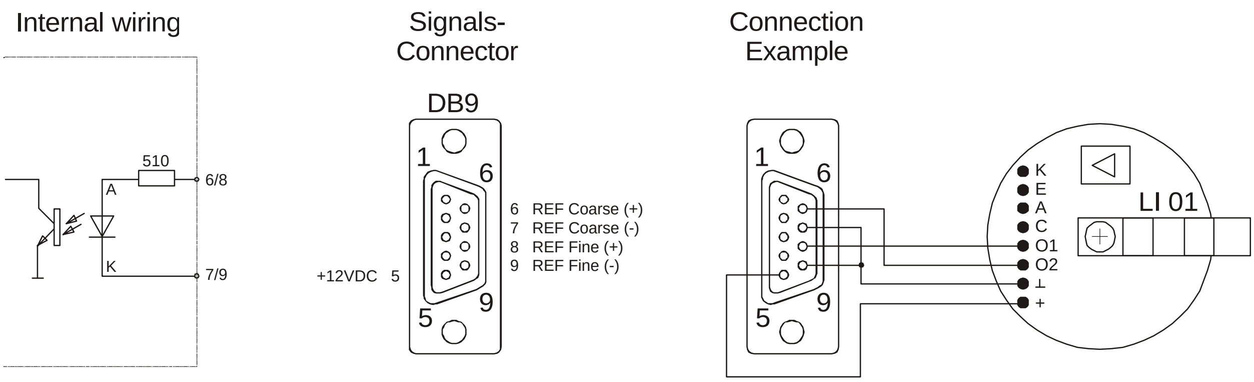


Fig. 4-3 Pin assignment of the 'Signals' connector for the connection of reference indicators.

In principle, you may use any suitable type of indicator that is capable of producing a precise and reproducible switching event.

4.2 Impulse Counter 9000.07 (Option)

An impulse counter option is available for the MC. This accessory board is capable of counting digital input signals at TTL level (5VDC) for programmable time intervals. With this counter option, the MC is able to execute data collection independently, i.e. without being connected to a controlling computer during the measurement. Collected data will be kept in memory until a transfer across one of the interfaces is requested.

PLEASE NOTE: The content of the counter memory is lost when the controller is switched off or the <RESET> button is pressed.

Specifications:

Max. count rate:	Earlier firmware versions: Unsigned Integer (0...65535) since version 2.45: Unsigned Long (0...4.294.967.295)
Max. number of values:	65535

Programmable counter gate intervals:

0.1	1	10	100
0.2	2	20	200
0.5	5	50	500

The signal source, a Scintillation Detector System for example, must be connected to the

'Cnt In' BNC connector (8) on the rear panel of the controller.

4.3 Filter Device Control 9000.08 (Option)

This option enables the MC to control a special hardware designed for the use on 2- or 4-Circle Single-Crystal Diffractometers. The Filter Device consists of a wheel equipped with a set of six absorption filters which have to be selected corresponding to the used X-Ray radiation used. A small DC motor turns the wheel to the desired position, i.e. moves the filter into the beam path.
The filter positions are labeled from 1 to 6 and may be selected either manually using soft key <F3> on the front panel or under program control with the FI command.

The filter device must be connected to plug socket (7) located on the rear panel of the controller.

4.4 Half Screen Device Control 9000.09 (Option)

Similar to the Filter Device 9000.08, the Half Screen device has been especially designed for Single-Crystal Diffractometry. It is used to find out the exact centering of a single crystal Bragg-reflection. When activated, it shadows exactly one half of the circular cross-section of a collimated X-Ray beam.
Five modes are available: Mode 0: Beam open; Mode 1: Left half shadowed, Mode 2: Right half shadowed; Mode 3: Top half shadowed; Mode 4: Bottom half shadowed.

The device has to be connected to plug (6) located on the rear panel of the controller.

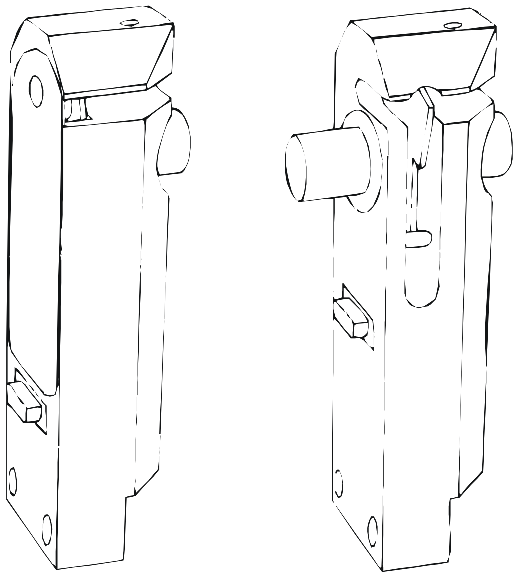


Fig. 4-3 Filter Device 9000.07 and Half Screen Device 9000.09

5 INTERFACES

The MC Controller Series is equipped with two interfaces for the communication with host computers: A parallel GPIB interface (IEEE 488) and a serial RS232 C interface. See Selection Section 2.1 for details concerning selection and configuration.

For standard applications, the serial interface should be sufficient for communication purposes. The maximum transfer rate is 19200 bits per second. A simple three-wire connection is necessary for connecting the controller to any standard PC. Handshaking is not supported.
For increased performance, especially concerning data transmission speed, communication across the GPIB interface is certainly the better choice.

5.1 IEEE 488

The following IEEE standard functions are implemented:

SH1	Source Handshake
AH1	Acceptor Handshake
T6	Talker (Basic Talker, Serial Poll, disabled by MLA)
TE0	**No** Talker Extended Function
L4	Listener (Basic Listener, disabled by MTA)
LE0	**No** Listener Extended Function
SR1	Service Request Function
RL1	Remote/Local Function
PP0	**No** Parallel Poll Function
DC1	Device Clear Function
DT0	**No** Device Trigger Function
C0	**No** Controller Function

Multi-wire messages: DCL, LLO, SDC, GTL, UNT, UNL, SPE, SPD.
One-wire messages: IFC, REN, EOI, SRQ, ATN.

Note: Upon receiving a DEVICE CLEAR message, the controller will perform a 'warm start', i.e. it runs the same initialization routine as after power-on or <RESET>.
See chapter 3.1 for details.

5.2 Serial Interface (RS232 C)

As already mentioned, establishing a three-wire connection between host computer and MC is sufficient for communication. See the following pin assignment for connecting the controller with a standard PC’s COM interface (9-pin connector):

MC				**PC (COMx)**
Pin 2	TxD	->	->	Pin 2 RxD
Pin 3	RxD	<-	<-	Pin 3 TxD
Pin 7	GND	--	--	Pin 5 GND

5.3 I/O-Port

The MC is equipped with an optocoupled universal 16-Bit I/O-Port, i.e. 8 input- and 8 output signal lines are available to react on- or control external events. Corresponding external hardware can be connected to the 37-Pin Sub-D Connector (9) on the rear panel of the controller.

5.3.1 Signal Output

The maximum switching current must not exceed 500 mA. Supply voltages of 5 VDC and 12 VDC are available at pins 35/34. External supply voltages must not exceed 50 VDC. The signal outputs can be controlled by corresponding commands during remote operation. See sections 6.2.1.3 and 6.2.1.4 for details.

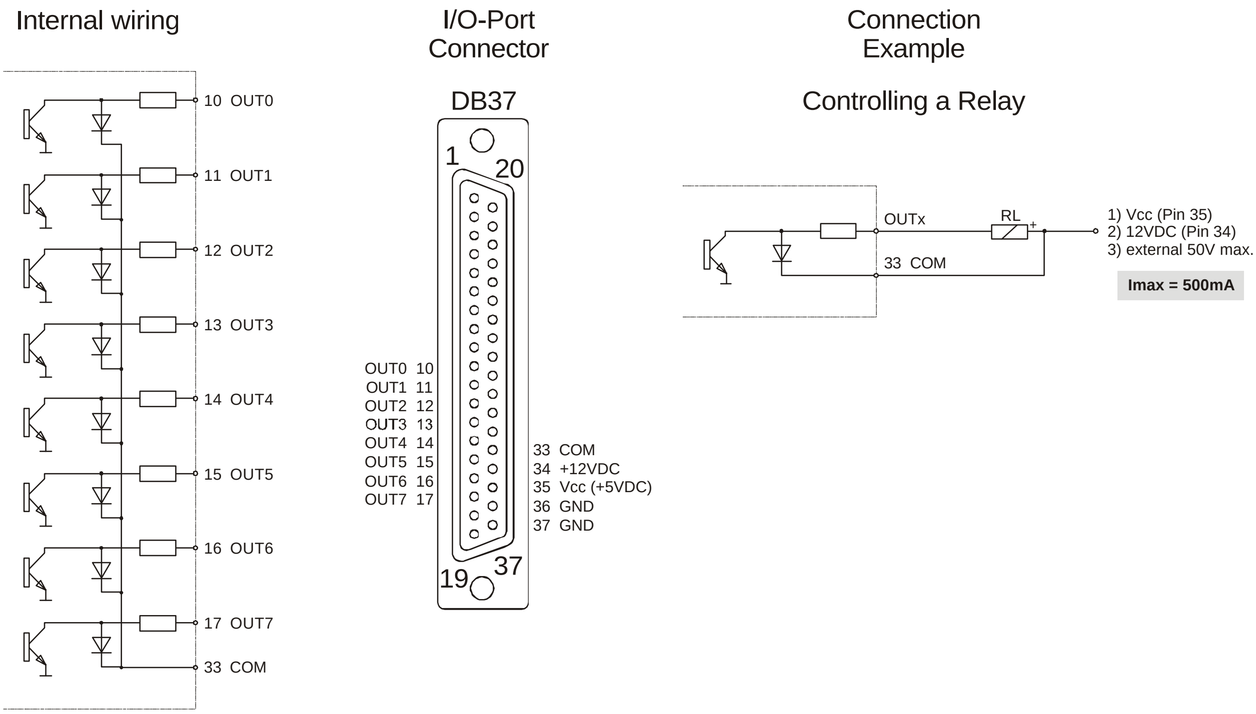


Fig. 5-1 Output Port

5.3.2 Signal Input

The signal inputs are designed for the application of supply voltages between 5 VDC and 12VDC (which corresponds to a max. optocoupler diode current of 20 mA). Input signals above this level have to be connected using a suitable additional resistor. The value has to be calculated according to the formula below.
The status of the input signals can be observed by corresponding commands during remote operation. See sections 6.2.3.3 and 6.2.3.4 for details.

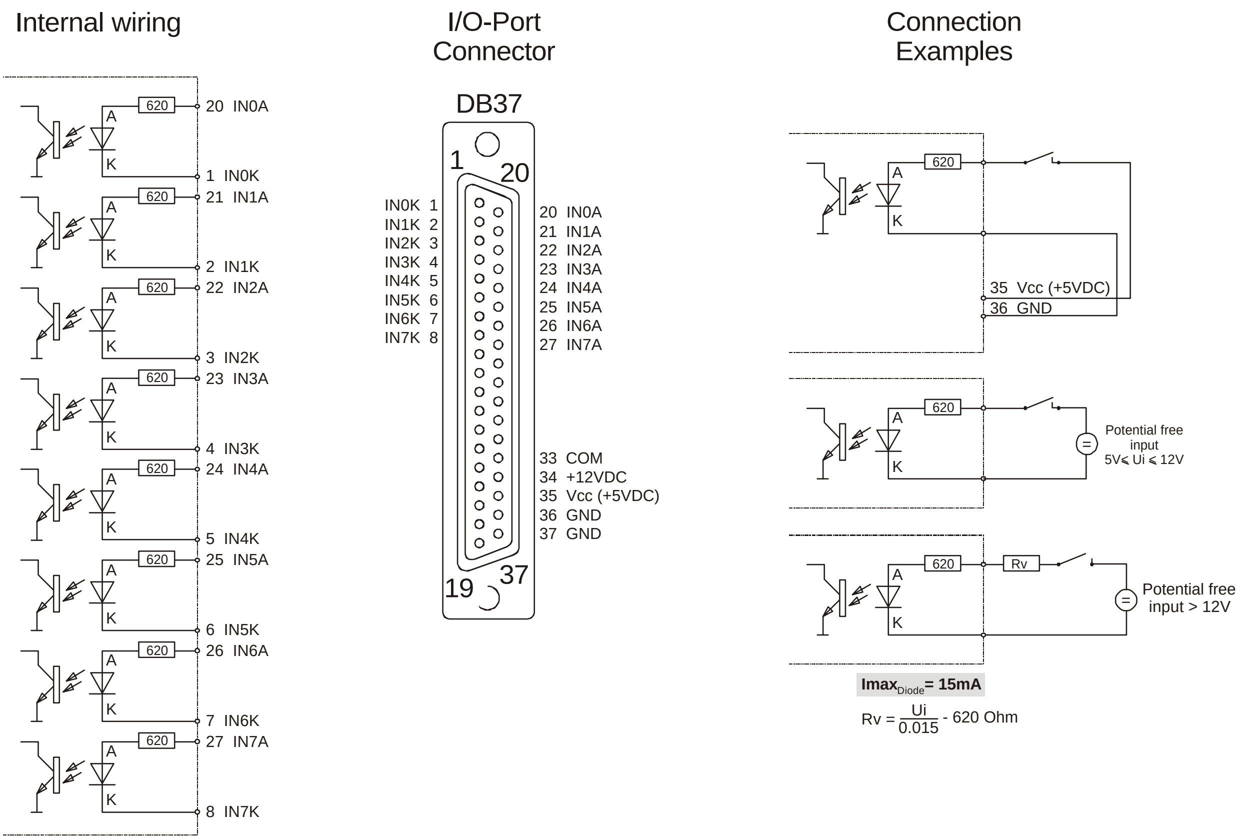


Fig. 5-3 Input Port

6 PROGRAMMING

The MC capable of executing various types of programmed tasks, from simple single axis positioning up to simultaneous control of eight axes including data collection. Programming can be done either manually from the front panel keyboard or by means of an extensive command set across the serial interface.

In the sense of a MC, the term 'Program Line' has a different meaning compared to a normal computer program (text-) line. A program line for a MC may consist of up to five parts or commands respectively.

If desired, the following actions will be executed in the order listed below:

1: I/O-port control (Input or Output)
2: Filter or Half-Screen selection (if applicable)
3: Execution of a positioning command
4: Activation of the Impulse Counter (if applicable)
5: Program execution delay

Exceptions: The return-from-subroutine (RET) command or the command for an unconditional jump (JMP) are single program lines that do not include the actions listed above.

6.1 Programming via Key Panel

As you may see when you try to perform the procedure described in the following paragraphs, it is pretty time consuming to enter a program manually by means of the front panel keyboard. But in some cases, it may be quite helpful to have this possibility.

Anyway, before you start entering a new program, we recommend clearing the controller's program memory by <CRAM>. Overwriting of previously entered program lines may result in unexpected behavior during program execution.

Start the manual programming mode by <INPUT>. The following message will appear on the display:

```
                                          INPUT
<F1>:INPUT COMMANDS <F2>:LOAD COMMANDS
```

<F1> starts the input mode for new program lines.
<F2> would re-load the previously saved content of the program memory. The meaning of 'saving' the program memory will be explained at the end of this Chapter.

At the beginning of a new program line, you have four choices: <F1>: Input of a new program line with movement instructions for all axes. <F2>: Subroutine call. <F3>: Return from a subroutine. <F4> Unconditional jump. In order to exit the program input mode, press <STOP>.

```
LINE#1  CHOOSE COMMAND: <F1>:MOVE
<F2>:GOSUB   <F3>:RET   <F4>:JUMP
```

We assume you want to enter a positioning command. After <F1>, you may select the line number of the next program line that will be entered. You may change the number by either <+> or <-> or by <LINE> with finally entering a number between 1 and 50 from the key panel.

In principle, it is possible to enter several independent positioning tasks at the same time. To select a certain program, just give the START command together with the corresponding start line.
Now you will be prompted step-by-step to enter the required information which is necessary to perform a motor movement. The actual parameter settings will displayed. Press <ENTER> to accept the default setting or enter a new value by means of the keypad and confirm the changes with <ENTER>.

```
LINE#1  AXIS: 1
INPUT DISTANCE:
```

First, you have to enter the desired positioning distance:

Then you have to decide for the positioning mode:

```
LINE#1  AXIS: 1
<F1>:RELATIVE <F2>:ABSOLUTE
```

<F1> defines the given distance to be relative to the actual position, <F2> defines the distance value to be an absolute position with respect to the reference position.

The next three inputs serve to define the speed profile for the positioning step: Start frequency [Hz], run frequency [Hz]and acceleration ramp [Hz/ms] have to be entered:

```
LINE#1  AXIS: 1
INPUT START FREQUENCY: 0
```

```
LINE#1  AXIS: 1
INPUT RUN FREQUENCY: 0
```

```
LINE#1  AXIS: 1
INPUT RAMP: 0
```

The corresponding positioning step will start with f_{START}, accelerates to f_{RUN} using the entered ramp until f_{RUN} is reached. At the end of the distance, it decelerates to f_{START} and finally stops at the target position.

Please consider the following limitations when you select the speed profile parameters:

a) 1 Hz < f_{START} < 64000 Hz
otherwise 10 Hz or the last valid input will be set.

b) 200 Hz < f_{RUN} < 64000 Hz
otherwise 200 Hz will be set.

c) f_{START} < f_{RUN}
otherwise f_{START} is set to 100 Hz.

d) The acceleration ramp must be set to a value selected from the following fixed set of numbers [Hz/ms]:

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	17	18	20	22	25	29	33
40	50	68	100	200						

PLEASE NOTE: During the acceleration/deceleration phase, the controller does not update the position display. A position query during that time does not reflect the real position: It will return the position value at the point in time when the acceleration/deceleration started.

This procedure has to be repeated for all present axes. If you do not enter a distance value, subsequent parameter input prompts for the corresponding axis will be skipped, and it will not perform any movement. The input continues with the next available axis.

If your controller is equipped with the Impulse Counter Option 9000.07, the program input continues with entering a counter gate interval. If you do not enter a value, no counting will be performed. You may select one of the counter gate intervals listed below:

```
LINE#1  COUNTER PROGRAMMING
INPUT GATE IN S:
```

0.1	1	10	100
0.2	2	20	200
0.5	5	50	500

The next step will be the programming of the I/O-port. <ENTER> without input leads further on ignoring it.

```
LINE#1  I/O-PORT PROGRAMMING
<F1>:IN/WAIT <F2>:OUT/SET/RESET
```

As already mentioned, the MC is capable of controlling and reacting on external events connected through the I/O-port plug socket (7) located on the rear panel of the controller case.

<F1> leads to the following menu:

```
LINE#1  INPUT FROM PORT
<F1>:READ BYTE <F2>:READ BIT <F3>:WAIT
```

Another <F1> reads the state of all input signals (8 bit) at once, <F2> would read the state of a particular bit (bits are numbered 0-based, i.e. from 0 to 7).
With selection of <F3> you can define a program break until the state of a particular input bit shows a certain signal level (low or high).

Please Note: I/O events are usually not reported on the display during program execution. Only if the MC is waiting for a certain bit to change its status, you will be informed. If a bit/byte status information is available, a SRQ message will indicate this event.

The final step in defining a program line is the optional input of a delay time (in seconds). The controller will interrupt the program execution for this time interval before it continues with the next program line.

```
LINE#1
INPUT DELAY TIME:
```

<ENTER> without input to skip the execution of a program delay.

```
LINE#1  AXIS: 1
<ENTER> FOR NEXT LINE, <STOP> TO QUIT
```

After this, <ENTER> to start over and continue with the next program line. If your program is finished, press <STOP> and you will be prompted as follows:

```
SAVE COMMANDS ?
<F1>:YES <F2>:NO
```

Selection of <F1> transfers the actual content of the program memory to a protected part of the MC's memory, which will not be affected, i.e. cleared, when you press <RESET> or perform a GPIB 'DEVICE CLEAR'.

> **PLEASE NOTE:** The memory content of the controller is always lost when the mains power supply of the controller is switched OFF. The 'SAVE'-option only protects program data from being erased by pressing the <RESET> button on the front panel keyboard.

Finally, the controller returns to the initial display mode and shows 'READY FOR YOUR COMMANDS'.

6.1.1 Example

We will program the MC manually that it will perform the following positioning task:
A detector on a Goniometer has to scan between the absolute positions 10° and 30° in steps of 0.01° at each position, it shall count the detector signal with a gate interval of one second. After that, the controller shall suspend program execution for 30 seconds and finally return to the start position of 10°.
We assume, that we have a single axis MC equipped with Impulse Counter Option 9000.07 which is properly configured to operate a step motor with 1000 Steps/Rev. The reference position at 0° has been searched prior to starting the program.

**** The Main Program ****

KEY	INPUT	ACTION/REMARKS
<CRAM>		
<F1>		
<F1>		Program RAM cleared
<INPUT>		
<F1>		Input program lines
<F1>		Move command
	10	
<ENTER>		Distance 10°
<F2>		Distance value is 'absolute'
	500	
<ENTER>		Start frq. 500 Hz
	8000	
<ENTER>		Run frq. 8000 Hz
	5	
<ENTER>		Ramp 5 Hz/ms

If your controller is equipped with more than one axis, you will be prompted here for the corresponding settings of the next axis. If do not enter a distance value, all subsequent input prompts for that axis are omitted.

KEY	INPUT	ACTION/REMARKS
	1	
<ENTER>		Count time 1 sec
<ENTER>		No I/O-Port program
<ENTER>		No wait loop
<ENTER>		New line
<F2>		GOSUB
	10	
<ENTER>		SUB starts at line 10
	3000	
<ENTER>		Repeat it 3000 times
<ENTER>		New line
<F1>		Move command
<ENTER>		No movement at this point
<ENTER>		No counting at this point
<ENTER>		No I/O-Port action at this point
	30	
<ENTER>		Delay program execution for 30 seconds
<ENTER>		New line
<F1>		Move command
	10	
<ENTER>		Distance 10°
<F2>		Distance value is 'absolute'
<ENTER>		Use recently entered speed setting (500)
<ENTER>		Use recently entered speed setting (8000)
<ENTER>		Use recently entered speed setting (5)

If your controller is equipped with more than one axis, you will be prompted here for the corresponding settings of the next axis. If do not enter a distance value, all subsequent input prompts for that axis are omitted.

<ENTER>		No counting
<ENTER>		No I/O-Port action
<ENTER>		No delay
<ENTER>		New line

**** Programming the Subroutine at line 10 ****

<LINE>		
	10	
<ENTER>		Line number 10
<F1>		Move command
	.01	
<ENTER>		Increment 0.01 deg
<F1>		Distance relative
	1000	
<ENTER>		Start frq. 1000 Hz

KEY	INPUT	ACTION/REMARKS
	0	
<ENTER>		No run freq., i.e. motor runs in start-stop-mode

If your controller is equipped with more than one axis, you will be prompted here for the corresponding settings of the next axis. If do not enter a distance value, all subsequent input prompts for that axis are omitted.

	1	
<ENTER>		Count gate 1 second
<ENTER>		No I/O-Port action
<ENTER>		No delay
<ENTER>		New line
<F3>		RET = End of subroutine
<STOP>		Quit INPUT mode
<F1>		SAVE program and leave manual input mode.

You may start the program now, either manually by <START> or from an external host computer via interface. After successful execution of the program, a set of 3001 count rate values is available at the MC for the subsequent transfer across the interface.

6.2 Remote control of the MC

The following chapter treats the remote control of the MC across the communication interfaces. The controller is capable of processing an extensive command set in order to execute even complicated positioning- and data collection tasks.

After being switched on, the controller displays the known message 'READY FOR YOUR COMMANDS'. In this mode, i.e. when the display shows this message, the MC permanently checks the input buffer of the selected interface for incoming command data. Unknown or invalid command lines will usually be ignored.

The term 'Command Line' denotes a single character string that is terminated by a semicolon (;), a carriage return <CR> ***AND*** a line feed <LF> character.

> ***PLEASE NOTE****: All characters within a command line must be uppercase letters. Space characters are not allowed. Each command lines must be terminated by a semicolon (;) and a carriage return <CR> and a line feed <LF> character.*

Samples:

VALID:	**INVALID:**
CLR;	Clr;
1:A45S1000L12000B50;	1:a45 s1000 l12000 b50;
NL;	NL

The MC distinguishes four different categories of commands:

a) *Configuration commands*, which serve to define the attached positioning hardware.
b) *Query commands*, which will return information about the actual status of the controller, position data or previously collected counter data.
c) *Direct commands*, a set of commands which allow immediate control of the MC's hardware.
d) *Program commands*, which serve to build programs which perform complex positioning and data collection tasks.

Commands of the categories **a)** to **c)** consist of a single character string. During normal operation, these commands will be executed immediately on receipt. During program execution, only a subset of these commands will be accepted by the controller. Details on this will follow later in this section.

Commands of category **d)** are used to define a control program for the MC which consists of one or more program lines. Program lines are *not* executed immediately on receipt. Instead, the are stored in the MC's memory and kept there until you clear the memory or switch the mains power off. A control program will be executed when you finally give the corresponding START command.

As already mentioned earlier, the term 'Program Line' in the sense of a MC has a different meaning compared to a normal computer program (text-) line. A MC program line may contain the definition of up to five different actions, which will be executed in the order listed below:

1: I/O-port control (Input or Output)
2: Filter- or Half-Screen control (if applicable)
3: Positioning
4: Impulse Counting (if applicable)
5: Delay

A program line is transferred to the controller as a set of several single command lines. The number of command lines which are necessary to build a MC program line depends on the number of used axes and the task that has to be performed by the program line.

The following example shows the 14 command lines that build a single program line for a controller which is equipped with eight axes and all available options:

```
OUT255;                  // set all I/O-port bits //
1:A1S5000L5000B10;       // move axis 1 to absolute position 10 //
2:A2S5000L5000B10;       // move axis 2 … //
3:A3S5000L5000B10;
4:A4S5000L5000B10;
5:A5S5000L5000B10;
6:A6S5000L5000B10;
7:A7S5000L5000B10;
8:A8S5000L5000B10;
FI1;                     // select filter 1 //
HS2;                     // select half screen 2 //
CNT.1;                   // count detector signal for .1 seconds //
DELAY5;                  // delay program execution for 5 seconds//
NL;                      // this is the end of the program line //
```

6.2.1 The Command Set

Some of the commands lines require additional parameters. Some are obligatory, a fact which is indicated by square brackets [<parameter>], some are optional, which is indicated by braces {<Parameter>}.

6.2.1.1 Configuration Commands

Configuration commands will be executed immediately on receipt. Configuration commands must not be transferred to the controller during program execution.

> PLEASE NOTE: On receipt of configuration commands, the controller changes the settings only temporarily. If you want to make the changes permanent, you have to transfer the UPDATE; command after completion of the configuration. If you do not use UPDATE; the configuration changes stay in effect until you switch off the controller or press the reset button. In this case, the previously active configuration is restored.

Command	Syntax Sample	Comment
CONF	CONF[Axis]:[Value]; CONF1:0;	Defines the type of positioning device 0=Circle 1=Linear 2=Slit Screen
FFAST	FFAST[Axis]:[Value]; FFAST1:5000;	Manual FAST motor frequency [Hz].
FREF	FREF[Axis]:[Value]; FREF1:7500;	REF-position search frequency [HZ].
FRUN	FRUN[Axis]:[Value]; FRUN1:500;	Manual RUN frequency [Hz].

GN	GN[Axis]:[Value]; GN1:1;	Gear factor denominator
GZ	GZ[Axis]:[Value]; GZ1:1000;	Gear factor numerator
LSAT	LSAT[Axis]:[Value]; LSAT1:0;	Limit switch operation Status 0=Standard1=Inverted
MDL	MDL[Axis]:[Value]; MDL1:1;	Motor rotation sense 0=Standard 1=Inverted
NOFS	NOFS[x]:[v]; NOFS6:45;	Set reference position offset value of axis 'x' to 'v'. This value will be displayed after power on or reference position search. See also: ZERO.
UPDATE	UPDATE;	Store configuration parameter permanently

6.2.1.2 Query Commands

After receipt of a status or data request, the MC immediately starts the transmission of the requested information.
If communication takes place across the serial interface, MC starts data transfer immediately after receipt of request command, if the handshake line CTS is at appropriate status (if activated by jumper).

Command	**Syntax Sample**	**Comment**
?C	?C;	Request for content of counter buffer (latest counter value).
?CNT	?CNT;	Request for counter data.

NOTE: Counter data are 8 bit unsigned integers, ranging from 0 to 65535 which will be transferred as character strings with variable length; delimiter depends on configuration <CR>, <LF> or <CR>+<LF>.

?GETP	?GETP;	Request for program memory content.

Transferred data are character strings with variable length; delimiter depends on configuration <CR>, <LF> or <CR>+<LF>.
Interface differences:
GPIB: EOI is asserted with the last data byte.
Serial: Character string 'CEND;' is transferred after the last program line to indicate the end of data transfer.

?IO	?IO;	Request for I/O-port status.
?LN	?LN;	Request for line number of actually processed program line.
?P	?P{Axis}; ?P5;	Request for actual position of a particular axis or all axes at the same time.

?S	?S{Axis}; ?S2;	Request for axis status: Bit 0: Axis ready Bit 1: Axis at ref. point Bit 2: Lim. switch ES+ active Bit 3: Lim. switch ES- active Bit 4/5/6: not used Bit 7: Controller ready
?SRQ	?SRQ;	Request for SRQ message.
?V	?V;	Request for software version.

Please Note: During program execution, only the commands **?IO; ?LN; ?P; ?S;** and **?SRQ;** are applicable.

6.2.1.3 Direct Commands

Similar to the configuration commands, these direct commands are executed immediately after receipt. Such a command must be sent to the MC only, when its status is "AXIS READY" or "MC READY", see above.

Command	**Syntax Sample**	**Comment**
BEEPOFF	BEEPOFF;	Disable acoustic signal that indicates 'program end'
BEEPON	BEEPON;	Enable acoustic signal.
CA	CA[Axis]; CA1;	Set display to active axis.
CCNT	CCNT;	Clear content of counter memory.
CLR	CLR;	Clear content of program memory.
CTRLIO	CTRLIO[Value]; CTRLIO1;	Watch I/O-port. If this function is enabled, program execution and any movement will be terminated immediately if one of the input ports is set to high. Value: 0 (disabled) or 1 (enabled) ATTENTION: Possible loss of motor steps due to the abrupt termination of a running positioning task.
DISPOFF	DISPOFF;	Disable permanent update of the position display during positioning. Using this function may accelerate positioning tasks which execute a lot of very short positioning intervals.
DISPON	DISPON;	Enable position display update during positioning.

ESCLR	ESCLR{Axis}; ESCLR1; ESCLR;	Clear limit switch error status bits 2 and 3 of an individual axis or of all axes at a time. See command ?S;.
FAST	FAST[Sign]; FAST+;	Move active axis continuously at slew speed. Use **Q;** command to stop movement.
***FI**	*FI[#]; *FI4;	Select filter; #=1..6 (requires installed filter option).
***HS**	*HS[#]; *HS1;	Select half-screen; #=0..4 (requires installed half-screen option).
IO	IO[Value]; IO255;	Set I/O-port status; Value=0..255
LCDOFF	LCDOFF;	Disable position display.
LCDON	LCDON	Enable position display
LIN	LIN[Line]; LIN20;	Set line number of subsequent program command. Line=1…50.
LOAD	LOAD;	Re-load previously SAVEd program memory content. See also: SAVE.
LOCAL	LOCAL;	Set MC to LOCAL mode, i.e. unlock front panel keyboard. See also: REMOTE.
POS	POS[x]:[p];	Set actual position of axis 'x' to value 'p' and update the position display.
Q	Q;	Abort program execution and/or stop any movement.
REF	REF{Axis}; REF1;	Search reference position of specified axis. Omit axis parameter to search reference position of all axes simultaneously.
REMOTE	REMOTE;	Set controller to REMOTE mode, i.e. lock front panel keyboard (except RESET key). See also: LOCAL.
RUN	RUN [Sign]; RUN+;	Move active axis at run (slow) speed. Use **Q;** command to stop movement.
SAVE	SAVE;	Save program memory content. See also: LOAD.
	Please note: SAVE transfers the actual content of the program memory to a protected part of the MC's memory, which will not be affected, i.e. cleared, when you press <RESET> or perform a GPIB 'DEVICE CLEAR'. However, the content of the controller's program memory is lost when the mains power supply of the controller is switched OFF.	
START	START{x}:{n}{[*][r]}; START:; START:4; START1:5; START2:10*3;	Start program of axis 'x' starting from line 'n' and repeat the whole task 'r' times. 'x' omitted: Start all axes simultaneously; 'n' omitted: Start at line 1; 'r' omitted: Single execution.
STEP	STEP[Sign]; STEP+;	Move actual axis for one single motor step.
ZERO	ZERO{x}; ZERO1;	Set actual position of axis 'x' to NOFS. See also: NOFS. Omit 'x' to set the position of all axes simultaneously.

The following commands are allowed even during program execution: **CA[Axis]; *FI[#]; *HS[#]; IO[Value]; Q;**.

6.2.1.4 Program Commands

Program commands are *not* executed immediately on receipt. Instead, the are stored in the MC's memory and kept there until you explicitly clear the program memory content or switch the mains power off. A program will not be executed until you finally transfer the START command.

As mentioned already, a single program line may trigger several actions at the MC, which will be executed in a certain order, regardless of the order of arrival of the corresponding commands:

1: I/O-port control (Input or Output)
2: Filter or Half-Screen selection (if applicable)
3: Execution of a positioning command
4: Activation of the Impulse Counter (if applicable)
5: Program execution delay

Defining the positioning task:

[Axis]:{A}{+/-}[Distance][S][Start Speed]{[L][Slew Speed][B][Acceleration]};

A: Absolute positioning if stated, otherwise relative.
S: Start speed [Hz]: **10 Hz < f_{START} < 25.000 Hz**
L: Slew speed [Hz]; **1000 Hz < f_{RUN} < 64.000 Hz**
B: Acceleration and Deceleration ramp [Hz/ms]. Has no effect, if no slew speed is given. You have to select one of the following fixed set of acceleration values:

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	17	18	20	22	25	29	33	40	50	68	100	200	

Examples:

1:A+15S500L2500B10;
Move axis 1 to absolute position 15 deg (or mm, depending on configuration; see CONF command). The motor will start with 500 Hz, accelerates to 2500 Hz with 10 Hz/ms and decelerates correspondingly at the target position.

2:.01S200;
Move axis 2 by .01 deg (or mm, depending on configuration; see CONF command) relative to the actual position at a constant speed of 200 Hz.

Command	Syntax Sample	Comment
CNT	CNT[Interval]; CNT.1;	Enable counter gate for given time interval. Valid counter gate intervals [seconds]: 0.1 1 10 100 0.2 2 20 200 0.5 5 50 500
DELAY	DELAY[Interval]; DELAY30;	Delay program execution for given time interval [seconds].
END	END;	Indicates 'End-of-Program'.

FI	FI[#]; FI4;	Select Filter; #=1…6. See also: Chapter 4.3.
GSB	GSB[n]{[*][r]}; GSB10; GSB100*5000;	Execute subroutine at line 'n' and repeat this program part 'r' times. 'r' omitted: Single execution. Range of 'r': 1…32767
HS	HS[#]; HS2;	Select Half-Screen; #=0…4. See also: Chapter 4.4.
IN	IN{Bit}{[.][Value]}; IN; IN3; IN0.1;	Read/act on I/O-Port status Bit=0..7 Value=0 or 1
	Returns the value of a certain bit of the input port. IN; without parameter returns the status of all bit bits at the same time (return value: 0…255). If 'Value' is given with a certain 'Bit', program execution will pause unless the corresponding input bit is set to the given value. ***GPIB***: The controller asserts a SRQ to indicate the availability of the bit/byte status information.	
JMP	JMP[n]; JMP10;	Unconditional jump to program line 'n'. **Please Note:** A JMP must be considered a separate program line, i.e. a NL; must follow this command.
NL	NL;	Indicates 'End-of-Program-Line'. Each program line must be terminated by NL;. Detailed example Programs will follow later in this section.
OUT	OUT[Value]; OUT128;	Set output port status as byte. Value: 0…255
RES	RES[Bit]; RES0;	Reset a single output port bit '0'.
RET	RET;	Indicates 'End of Subroutine'. **Please Note:** A RET must be considered a separate program line, i.e. a NL; must follow this command.
SET	SET[Bit]; SET0;	Set a single output port bit to '1'.

6.3 Starting a Program

You may start a program either manually, using <START> at the front panel keyboard, or remotely by transferring the **START** command (see above) across the interface. In order to abort program execution, you may either <STOP> on the front panel keyboard or transfer the **Q;** command.

Upon <START> at the front panel keyboard of a MC with two axes, you will be prompted as follows:

```
1:+0.000 DEG                          START
INPUT AXIS (1-2); <ENTER>=ALL:
```

You have the choice of either starting a single axis or all axes simultaneously. Just <ENTER> without input, if you want to start all axes.

```
1:+0.000 DEG                          START
FIRST LINE TO EXECUTE: 1
```

The second step allows you to enter a certain line number where the controller shall start program execution. If you have programmed multiple positioning tasks that start at different program lines, you may select a particular program by entering the corresponding line number.
After entering the number of repetitions, you may start the execution of the positioning program with a final <ENTER>.

```
1:+0.000 DEG                                START
<ENTER> TO START, <STOP> TO QUIT
```

7 GPIB Service Request (SRQ)

If you are using the GPIB interface for communication with the MC, you will receive a Service Request (SRQ) on the occurrence of one of the following events:

STATUS (HEX)	(DEC)	EVENT
41	65	Program finished/REF point ok
42	66	Limit Switch Axis 1 +
43	67	Limit Switch Axis 1 -
44	68	Limit Switch Axis 2 +
45	69	Limit Switch Axis 2 -
46	70	Limit Switch Axis 3 +
47	71	Limit Switch Axis 3 -
48	72	Limit Switch Axis 4 +

```
1:+0.000 DEG                                START
REPETITIONS: 1
```

49	73	Limit Switch Axis 4 -
4A	74	Limit Switch Axis 5 +
4B	75	Limit Switch Axis 5 -
4C	76	Limit Switch Axis 6 +
4D	77	Limit Switch Axis 6 -
4E	78	Limit Switch Axis 7 +
4F	79	Limit Switch Axis 7 -
50	80	Limit Switch Axis 8 +
51	81	Limit Switch Axis 8 -
52	82	Limit Switch Error
60	96	IO-Port BIT condition true
C1	193	I/O-port (Byte) available
C2	194	I/O-port (Bit) available

Bit 7 of the status byte is set, i.e. the status byte value > 80_{H}, a text message is available which you can request with the '?SRQ;' command.

8 Program Examples

In the following section, you will see some sample programs with attached comments. As already mentioned, commands have to be transferred to the controller line by line, terminated by a trailing <CR>+<LF>.

Comments, indicated by a leading '//', and empty lines, inserted for better readability, must not be transferred to the MC. Keep in mind to avoid spaces and lower-case letters within command lines.

Example 1
Changing the configuration

This example program consists of configuration commands only. This type of commands will be executed immediately on receipt:

```
CONF1:0;            //Axis 1: Goniometer; position display units are [deg].
CONF2:1;            //Axis 2: Linear Table; position display units are [mm]
NOFS1:90;           //Axis 1: Reference offset 90 deg
NOFS2:0;            //Axis 2: Reference offset 0 mm
GZ1:1000;           //Axis 1: Gear ratio definition:
GN1:1;              //     1000 Motor steps correspond to 1 deg (GZ/GN)
GZ2:500;            //Axis 2: Gear ratio definition:
GN2:1;              //     500 Motor steps correspond to 1 deg (GZ/GN)
FREF1:10000;        //Axis 1: REF-search speed 10000 Hz
FREF2:8000;         //Axis 2: REF-search speed 8000 Hz
FFAST1:7500;        //Axis 1: Manual FAST speed 7500 Hz
FFAST2:7500;        //Axis 2: Manual FAST speed 7500 Hz
FRUN1:1500;         //Axis 1: Manual RUN speed 1500 Hz
FRUN2:1500;         //Axis 2: Manual RUN speed 1500 Hz
MDL1:0;             //Axis 1: Motor rotation direction: Normal
MDL2:1;             //Axis 2: Motor rotation direction: Inverted
LSAT1:0;            //Axis 1: Limit Switch assignment: Normal
LSAT2:1;            //Axis 2: Limit Switch assignment: Inverted (required due to
                    //     inverted motor rotation direction of axis 2)
UPDATE;             //Store parameters changes permanently
```

Without transferring the 'UPDATE;' command, the configuration changes are active *temporarily*, i.e. until the MC is switched off or you press the <RESET> button. In this case, the previous configuration will be active again.

Example 2
Step scan (uses the controller as configured above); Axis 2 does not perform any movement.

```
CLR;                     //Clear program memory
CCNT;                    //Clear counter memory
CA1;                     //Set position display to axis 1

GSB10*20;                //Repeat subroutine at line 10 20 times
NL;

1:A0S500L10000B10;//Move axis 1 to absolute position 0
NL;
END;                     //End of main program

LIN10;                   //Line 10

1:+.1S1500;              //Move axis 1 for 0.1 deg at start speed.
CNT.5;                   //Count detector signal for 0.5 sec
DELAY1;                  //Delay program execution for 1 sec
NL;

RET;                     //End of subroutine
NL;
```

If you would read out content of the controller's program memory, you would receive the following command list:

```
GSB10*20;
NL;
1:A+1.0S500L10000B10;
2:+0.0;
NL;
END;
LIN10;
1:+0.1S1500;
2:+0.0;
CNT0.5;
DELAY1;
NL;
RET;
NL;
END;
```

As already mentioned, direct commands will be executed on receipt and not stored in the controller's memory. Therefore, CLR; and CA1; will not appear in the list.

Example 3
Step Scan similar to the program above with additional motion of axis 2.

```
CLR;                      //Clear program memory
CCNT;                     //Clear counter memory
CA1;                      //Set position display to axis 1

GSB10*20;                 //Repeat subprogram at line 10 20 times
NL;
1:A0S500L10000B10;  //Move axis 1 to absolute position 0 deg
2:+1S500L5000B50;         //Move axis 2 relative for 1 mm
NL;
END;                      //End of main program

LIN10;                    //Line 10
1:+.1S250;                //Move axis 1 relative for 0.1 deg with 250 Hz
2:+.2S500;                //Move axis 2 relative for 0.2 deg with 500 Hz
CNT2;                     //Count detector signal for 2 seconds
DELAY1;                   //Delay program execution for 1 sec
NL;

RET;                      //End of subroutine
NL;

SAVE;                     //Save program
START:*20;                //Repeat program 20 times
```

After successful execution of the program, 20*20 counter values available for 'download'. Use command ?CNT; to initiate the data transfer at the controller.
Reading out the content of the controller's program memory with GETP; would return the following:

```
GSB10*20;
NL;
1:A+0.0S500L10000B10;
2:+1.0S500L5000B50;
NL;
END;
```

```
LIN10;
1:+0.1S250
2:+0.2S500
CNT2;
DELAY1;
NL;
RET;
NL;
END;
```

9 Annotations about Step Motor Drives

Nowadays, the technology of stepping motor drives has reached a very high level. However, under certain circumstances, you may encounter positioning errors that could be avoided in most cases if you pay attention to the content of the following paragraphs.

Why problems may arise

Positioning errors usually result from a more or less obvious loss of motor steps during positioning. That deviation may drastically increase depending on the number of executions of single positioning tasks. The most extreme case is a total standstill of the positioning device. The reasons for such problems are manifold.

If we assume that the electronic circuit of the step motor drive is working properly, the most frequent reasons for positioning problems are the following:

a) *The motor/driver board combination is under-dimensioned for the desired task.*
The drive unit of a positioning device may be simply overloaded. Especially over time, some mechanic components of positioning devices may increase the required torque due to wear.

b) *The motor supply current has not been adjusted properly.*
The drive current of step motors needs to be adjusted at the corresponding driver board. If you bought controller and positioning hardware separately, changed positioning devices between controllers or exchanged motor connections, you have to make sure the motor current is set to the correct value before operating it. Motors may look similar, but they may need completely different current settings for proper operation.

> **ATTENTION**: Driving motors at current levels above the specified maximum phase current, may cause a permanent damage of the motor.

c) *The positioning speed profile is not selected suitably.*
Each motor owns individual speed limits that depend basically on the drive current, the type of power board and the required torque. A start frequency that is too high, an acceleration/deceleration ramp that is too steep, excessive slew speed or a combination of these may result in positioning errors.

It is hardly possible to give generally applicable rules how to handle this kind of trouble. Despite all theoretical considerations on positioning problems like that, the simple 'trial-and-error' method is probably the best and quickest way to solve them.

> **Please Note:** If positioning devices and controllers have been ordered from Huber as a complete positioning system, the components have been carefully aligned and adjusted at our factory. A corresponding configuration data sheet is delivered with the controller.

Over time, it may be necessary to check and re-adjust drive parameters. Especially under extreme working conditions, e.g. tilted use or increased torque due to heavy and/or unbalanced loads, drive properties may vary.
In some cases, the size of parts or limited space influences the selection of components, i.e. it is unavoidable to drive motors at their, or even above their limits. In this case, even slight changes of the operating conditions may result in positioning errors.

Frequencies, Currents, Resonances

A step motor can follow a continuous train of pulses as long as the load torque is less than the maximum torque available (MTA). Of course, but: The MTA depends on individual motor properties, the type of circuit used for power supply as well as on the applied frequency.

Commonly, the frequency range of a step motor is divided into two parts: The range between zero and the so called 'start-stop frequency' (start frequency range) and the range between start-stop frequency and the maximum motor frequency (acceleration frequency range).

The Start Frequency Range

The start-stop frequency is the theoretical maximum clock frequency, a step motor can execute without acceleration/deceleration ramp without loosing motor steps. As you can imagine, this value strongly depends on most of the parameters mentioned above.

In terms of the MC, the manual RUN frequency of the MC (i.e. the positioning speed that is used when you press the RUN key at the front panel) must be set to a value somewhere below the start-stop frequency. The same holds for the selection of the start speed of programmed positioning tasks.

The Acceleration Frequency Range

Positioning at frequencies above this imaginary start-stop frequency requires the use of suitable start frequencies and acceleration-/deceleration ramps.
For manual positioning by means of the front panel keyboard, the setting of the manual RUN frequency additionally serves as the start frequency for the manual FAST positioning mode. The acceleration/deceleration ramps for the manual FAST mode are calculated from these two values by the controller.
In contrast to that, the acceleration/deceleration ramps (as well as the frequencies of course) for a programmed positioning task can be set individually.

If the theoretical values of these frequency ranges are not available, you have to find out suitable settings by trial-and-error. Start at low values (200 Hz) and increase the frequency step by step until you encounter positioning errors. Select a value somewhat below the speed where the motor started to show problems.

Resonances

A further point that has to be considered, is the mechanical design of positioning devices. To reach the maximum accuracy and repeatability, most of the positioning devices are equipped with some kind of spring loaded drive system, which is more or less susceptible to resonance effects.

There are many and diverse ambient conditions which also have an influence on the extent of the resonance susceptibility: Motor type, positioning speed, required torque, type of driver board, applied drive current, mounting position, load, temperature, etc. Additionally, if you have a multi-axis system, it may behave different when you move axes separately or simultaneously.

However, if you encounter resonance problems, which are usually clearly discernible by a characteristic rough sound at certain speed ranges during positioning, you should first try to locate the frequency ranges where resonance occurs.

Subsequently, you should make sure that you do not use a value from this frequency range as the start- or slew speed of your positioning task. Just crossing these resonance ranges during acceleration or deceleration of a positioning task will usually not result in a positioning error, i.e. in a loss of motor steps.

In order to improve the behavior of your positioning device, try to vary the speed-settings, and/or the steepness of the acceleration ramp. Additionally, a variation of the drive current (within the spec's!) of the corresponding motor may improve the resonance behavior as well.

Another thing could also be helpful: Have a look at your positioning hardware. The aging of lubricants may cause problems. Especially positioning devices involved in vacuum applications may drastically change their behavior over time.

APPENDIX

A Command List

B Manual Phase Current Adjustment

C Rear Panel Connectors - Pin Assignment

D Standard 2/4-Phase Motor Cable

E Standard 5-Phase Motor Cable

F Optoelectronic Zero Point Control 9100

G Power Boards

APPENDIX A COMMAND LIST

CONFIGURATION

COMMAND	SYNTAX	ACTION
CONF	CONF[Axis]:[Value];	define type of positioning device
FFAST	FFAST[Axis]:[Value];	manual FAST speed
FREF	FREF[Axis]:[Value];	REF search speed
FRUN	FRUN[Axis]:[Value];	manual RUN speed
GN	GN[Axis]:[Value];	gear-ratio denominator
GZ	GZ[Axis]:[Value];	gear-ratio numerator
LSAT	LSAT[Axis]:[Value];	limit switch assignment
MDL	MDL[Axis]:[Value];	motor rotation direction
NOFS	NOFS[Axis]:[Value];	reference offset
UPDATE	UPDATE;	store parameter permanently

Query

?C	?C;	get counter buffer
?CNT	?CNT;	get counter data
?GETP	?GETP;	get program data
?IO	?IO;	get status of input port
?LN	?LN;	get actual line number
?P	?P{Axis};	get actual position
?S	?S{Axis};	get controller status
?SRQ	?SRQ;	get SRQ text message
?V	?V;	get software version

Direct

BEEPOFF	BEEPOFF;	'program finished'-signal off
BEEPON	BEEPON;	'program finished'-signal on
CA	CA[Axis];	select actual axis
CCNT	CCNT;	clear counter memory content
CLR	CLR{Axis};	clear program memory content
CTRLIO	CTRLIO[Value];	watch I/O-port status
DISPOFF	DISPOFF;	stop updating the position display
DISPON	DISPON;	continue updating the position display
ESCLR	ESCLR{Axis};	clear limit switch event status bit
ESCLR	ESCLR{Axis};	clear limit switch event status bit
FAST	FAST[Direction];	move actual axis at FAST speed
***FI**	*FI[#];	select Filter
***HS**	*HS[#];	select Half-Screen
IO	IO[Value];	set output port (byte)
LIN	LIN[Line];	set line number
LCDOFF	LCDOFF;	disable position display
LCDON	LCDON;	enable position display
LOAD	LOAD;	re-load program
LOCAL	LOCAL;	set LOCAL mode
POS	POS[Axis]:[Position];	set position display
Q	Q;	STOP all axes immediately
REF	REF{Axis};	search reference position
REMOTE	REMOTE;	set REMOTE mode
RUN	RUN[Direction];	move actual axis at RUN speed
SAVE	SAVE;	save program
START	START{Axis}:{Line}{[*][Rpt.]};	program start

STEP	STEP[Direction];	move actual axis STEPwise
ZERO	ZERO{Axis};	set axis to NOFS

Program

Positioning Command : [Axis]:{A}{+/-}[Distance][S][f_{START}]{[L][f_{RUN}][B][Ramp]};

CNT	CNT[Time];	define counter gate
DELAY	DELAY[Time];	define delay time
END	END;	define End-Of-Program
FI	FI[#];	select filter
GSB	GSB[Line]{[*][Rpt.]};	subroutine call
HS	HS[#];	select Half-Screen
IN	IN{Bit}{[.][Status]};	return or react on I/O-port status
JMP	JMP[Line];	unconditional jump
NL	NL;	new program line
OUT	OUT[Value];	set output port (byte)
RES	RES[Bit];	reset output port bit
RET	RET;	define End-of-Subroutine
SET	SET[Bit];	set output port bit

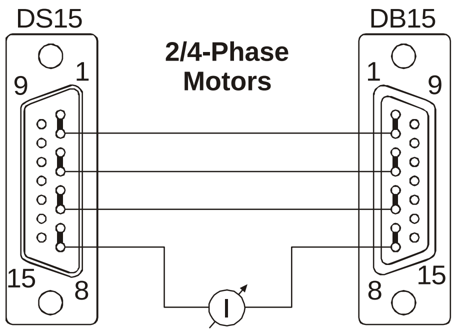
APPENDIX B Manual Phase Current Adjustment

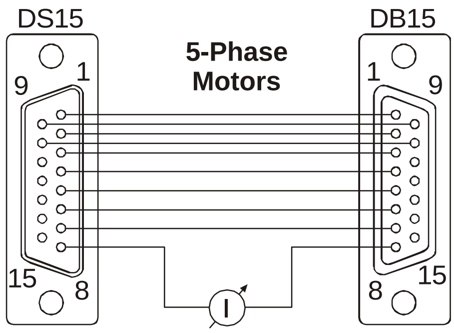
In some cases, it may be necessary to measure the phase current of a particular step motor. In order to do this, you will need a suitable adapter connector according to the circuit diagram shown below.

You should use a digital current meter at measuring position 'AC'. The current output adjustment must be executed during motor movement in manual **RUN**-mode.

> **PLEASE NOTE**: The manual RUN frequency must be set to 200 Hz for 2/4-phase motors and 250 Hz for 5-phase motors respectively. Otherwise, the multimeter displays an incorrect phase current value.

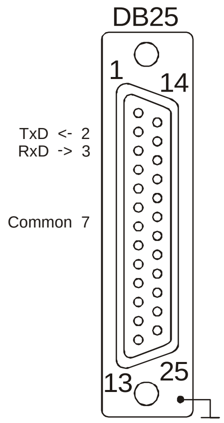
This procedure is not required if the driver boards allow the current to be adjusted to discrete values by means of DIP switches or jumpers.



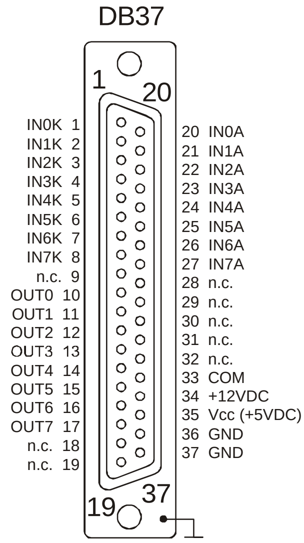


APPENDIX C Rear Panel Connectors - Pin Assignment

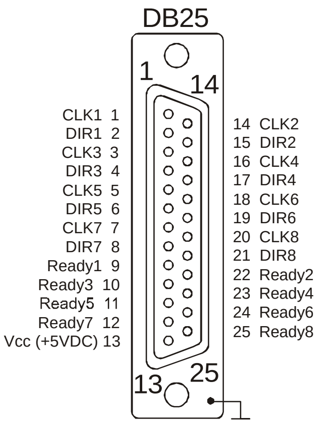
Serial Interface (RS232 C)



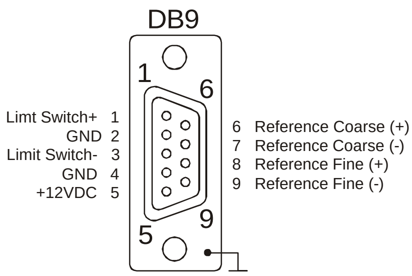
I/O-Port



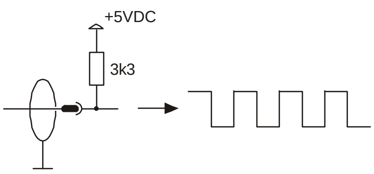
Motor Signals Out (9013...9018)



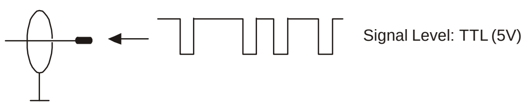
Signals (Limit/Reference)



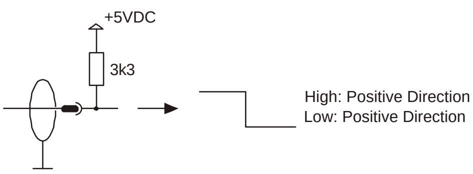
Clock Output



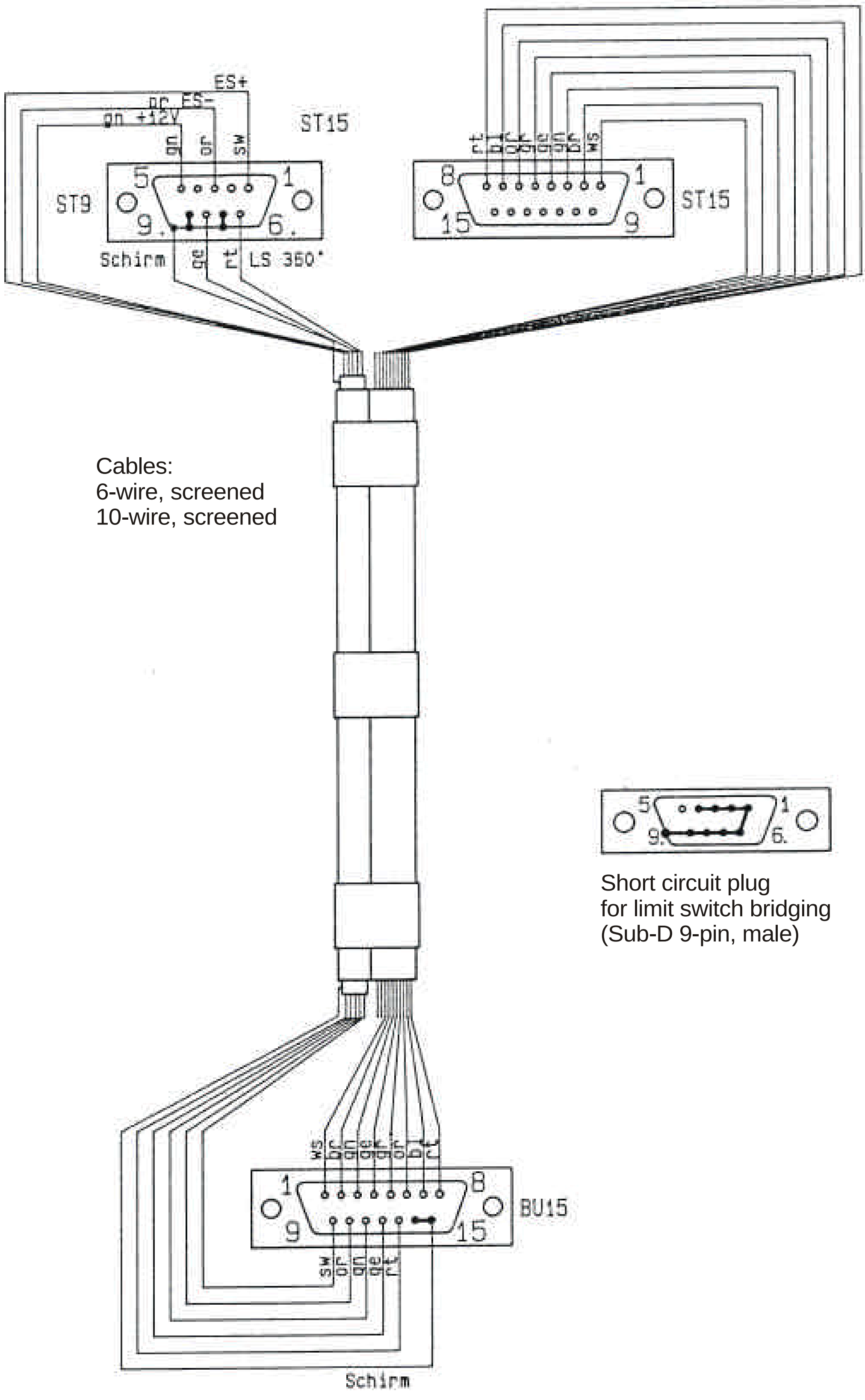
Counter Input



Direction Output



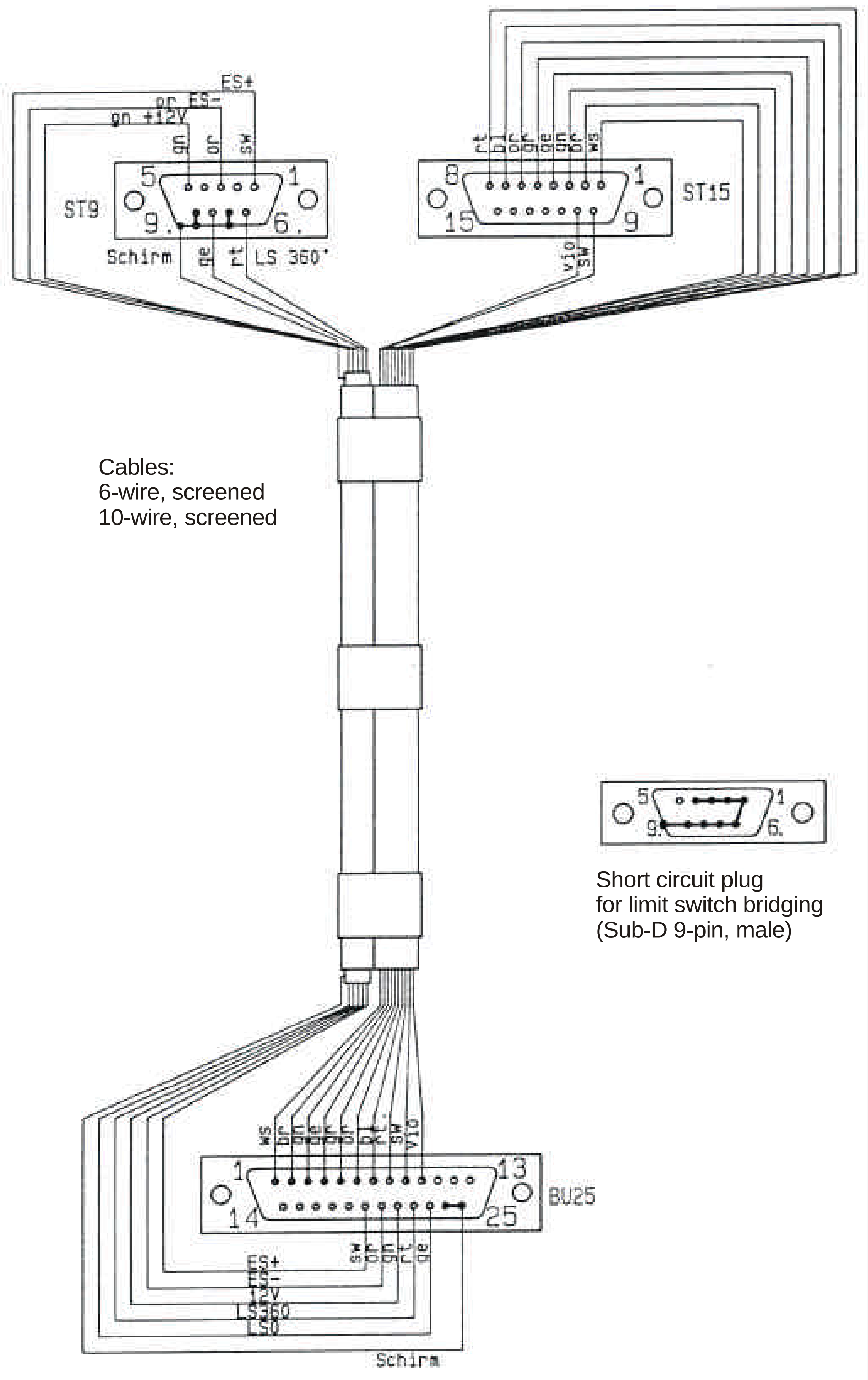
APPENDIX D Standard 2/3/4-Phase Motor Cable Pin Assignment



Cables:
6-wire, screened
10-wire, screened

Short circuit plug
for limit switch bridging
(Sub-D 9-pin, male)

APPENDIX E Standard 5-Phase Motor Cable Pin Assignment



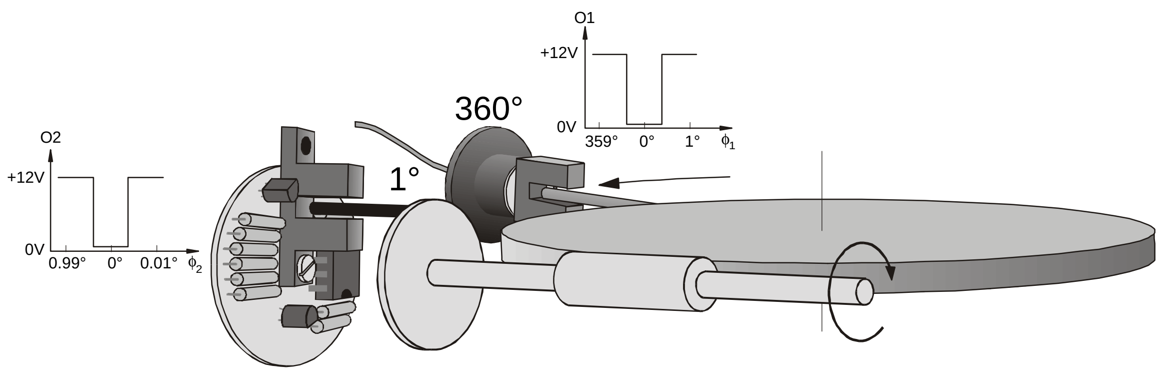
Cables:
6-wire, screened
10-wire, screened

Short circuit plug
for limit switch bridging
(Sub-D 9-pin, male)

Appendix F - Optoelectronic Zero-Point Control 9100

The co-operation of two independent light barriers allows the reproducible installation of the Goniometer's reference position. The first (360°-) light barrier serves to indicate the immediate proximity of the reference position, the second (1°-) light barrier permits the exact and reproducible fine-adjustment of the reference position.

The 360°-light barrier is located in the housing of the worm-wheel gear, the 1°-light barrier for the fine-adjustment is located at the end of the driving shaft on the opposite side to the stepping motor. Worm-wheel and driving shaft are equipped with fine metal pins which trigger the light barriers when they pass the ray path. The amplifier circuit generates independent output signals, one for each light barrier.
The output contacts O1 (360°) and O2 (1°) usually show a signal level of +12V DC. This signal drops to 0V when a pin interrupts the ray path and triggers the light barrier.



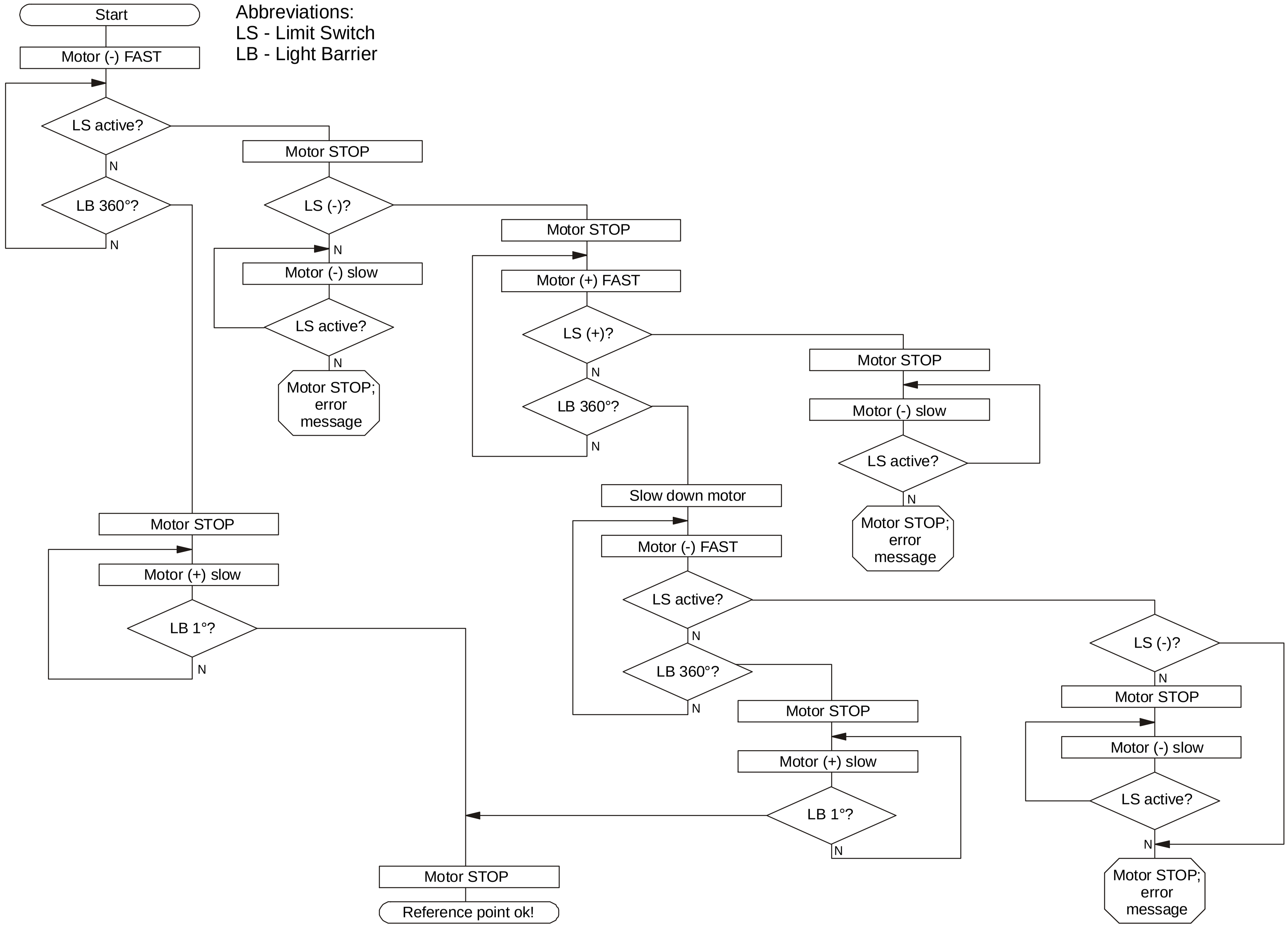
A suitable evaluation of these two signals allows an exact and reproducible adjustment of the reference position of the Goniometer. Usually, the 360°-light barrier signal is used to slow down the driving motor to an adequate start-stop speed.

For the design of an adjust-the-reference-position procedure, you have to consider the finite diameter of the trigger pins. If you approach the reference position from opposite sides, the trigger event will appear at different locations.
Therefore, a search procedure should always approach the reference position with the same direction of movement.

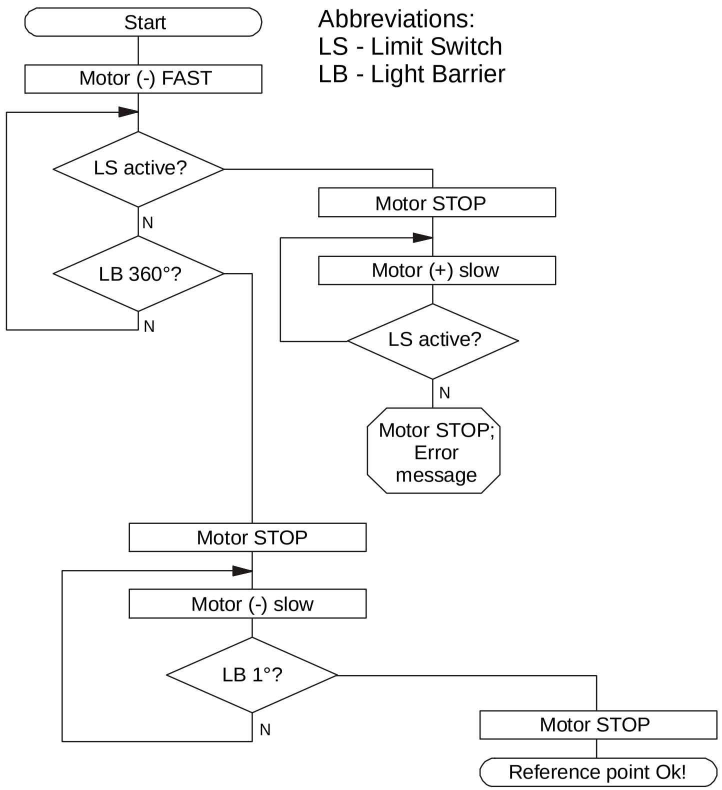
Another point to consider is the following: Depending on the type of Goniometer, it may happen that the trigger pin of the 360° light barrier has already left the ray path before the 1° light barrier generates its signal event. In other words: To install the reference position, it is probably not sufficient to connect the two light barrier signals by a logical AND-function.

The following flow chart shows the reference position search procedure of the HUBER Stepping Motor Controller MC. To be independent of the actual position of the Goniometer with respect to the reference point, the function of the limit switches is included in the procedure.

Flow chart of the SMC 9000 reference position search procedure for goniometers:

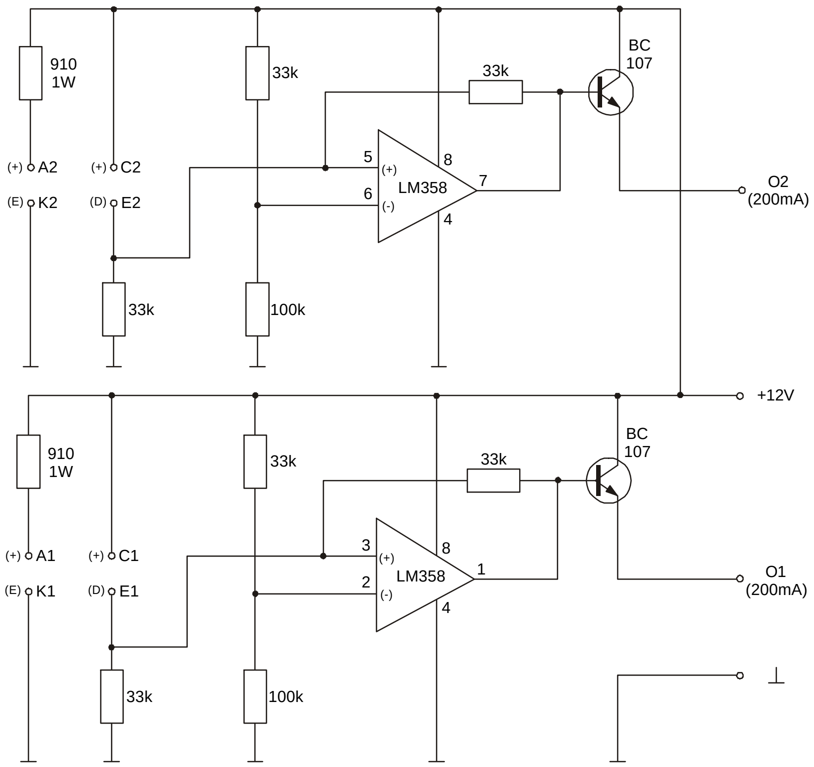


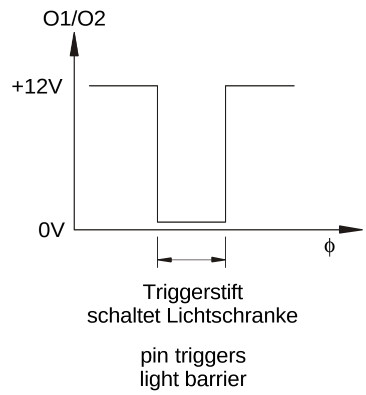
Flow chart of the SMC 9000 reference position search procedure
for linear tables and slit screens:



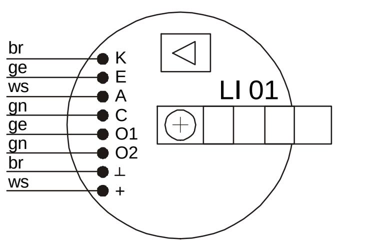
Abbreviations:
LS - Limit Switch
LB - Light Barrier

Verstärkerplatinen LI01/LI05
- Schaltplan
Amplifier Boards LI01/LI05
- Circuit Diagram



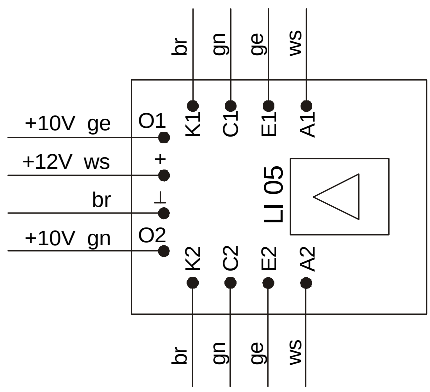


- Layout und Verdrahtung
- Layout and wiring



Lichtschranke 1° auf der Platine;
Lichtschranke 360° extern.

Light barrier 1° on board;
light barrier 360° external.



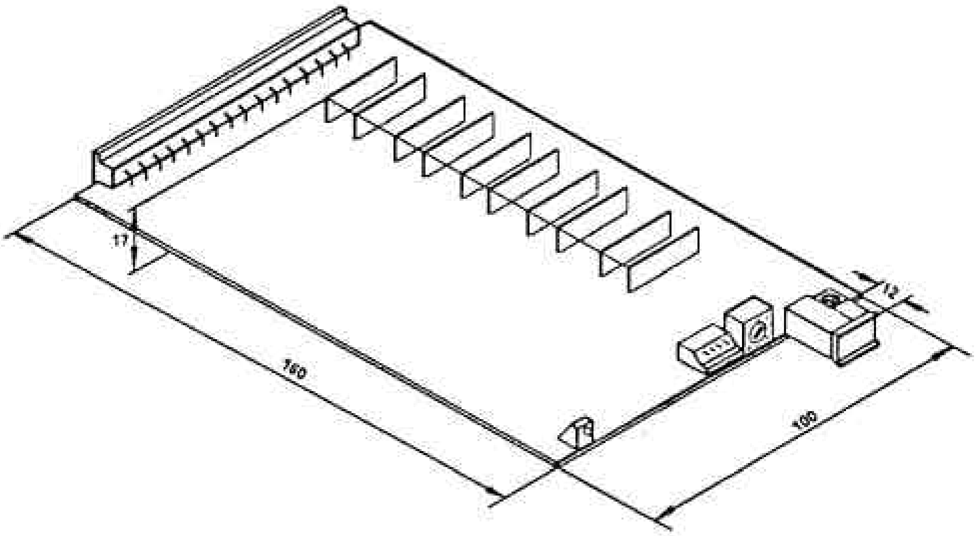
Beide Lichtschranken, 1° und 360°, extern.
Both light barriers 1°and 360° external.

APPENDIX G Power Boards

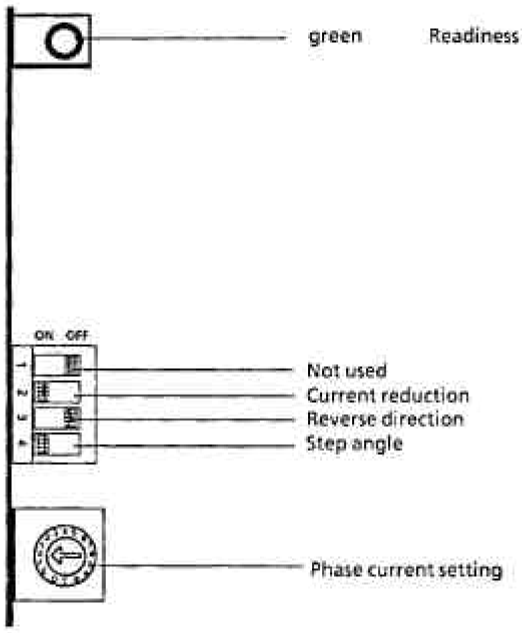
Standard Models

SIG Positec/Berger Lahr	D225	(5-Phase)
SIG Positec/Berger Lahr	D450	(5-Phase)
SIG Positec/Berger Lahr	D550	(5-Phase)
SIG Positec/Berger Lahr	D920	(3-Phase)
Phytron	ZMP 92-70/ZMP Mini	(2-Phase)
pp-electronic	SME100	(2-Phase)

D225



D 225



6.1 Phase current (given in in A)

I (A) *	0.21	0.27	0.33	0.38	0.43	0.48	0.53	0.58	0.63	0.68
Position	0	1	2	3	4	5	6	7	8	9
I (A) *	0.74	0.8	0.85	0.9	0.95	1.0				
Position	A	B	C	D	E	F				

* Typical values; deviations resulting from different motor inductivities are possible

6.2 Current reduction

Switch position	ON		OFF	
Pulse frequency	< 10 Hz	> 10 Hz	< 10 Hz	> 10 Hz
Motor current I	$I_{nom} \times 0.7$	I_{nom}	I_{nom}	I_{nom}

6.3 Step angle

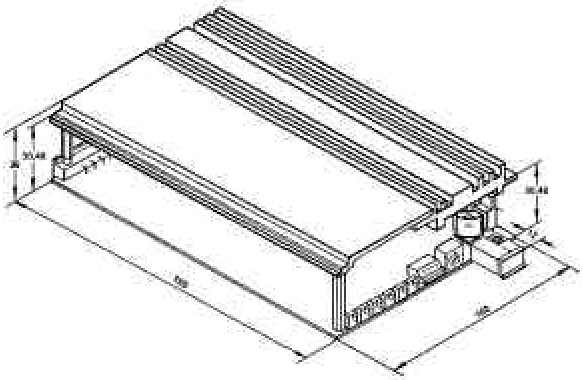
Switch position	ON	OFF
Step angle	Half step 1000 steps per rotation (≙ = 0.36°)	Full step 500 steps per rotation (≙ = 0.72°)

6.4 Sense of rotation *

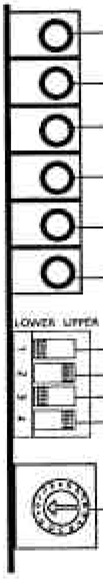
Switch position	ON	OFF
Signal input current applied	clockwise rotation	counterclockwise rotation
Signal input currentless	counterclockwise rotation	clockwise rotation

* viewed from front to shaft

D450



D 450



green	Readiness	LED 1
red	Short circuit, overload	LED 2
red	Excessive temperature	LED 3
red	Under-/overvoltage	LED 4
red	Phase interruption	LED 5
red	No function	LED 6

LOWER UPPER

	Basic setting
Boost or PWM current control	PWM current control
Current reduction	Current reduction active
Reverse direction	Clockwise direction
Step angle	Step angle: half step

Phase current setting 0.55 A

7.1 Phase current (given in A)

I (A)	0.55	0.70	0.85	1.0	1.15	1.3	1.45	1.6	1.75	1.9
Position	0	1	2	3	4	5	6	7	8	9
I (A)	2.05	2.2	2.35	2.5	2.65	2.8				
Position	A	B	C	D	E	F				

7.2 Current reduction

Switch position	LOWER		UPPER	
Pulse frequency	< 10 Hz	> 10 Hz	< 10 Hz	> 10 Hz
Motor current I	I_{nom}	I_{nom}	$I_{nom} \times 0.8$	I_{nom}

7.3 Step angle

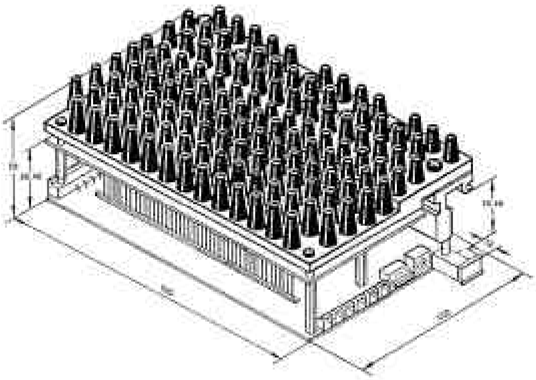
Switch position	LOWER	UPPER
Step angle	Full step 500 steps per rotation (= ≙ 0.72°)	Half step 1000 steps per rotation (= ≙ 0.36°)

7.4 Sense of rotation

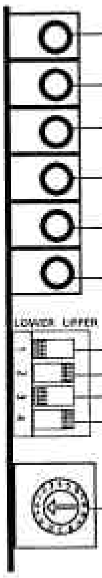
Switch position	LOWER	UPPER
Signal input current applied	counterclockwise	clockwise
Signal input currentless	clockwise	counterclockwise

* viewed from front to shaft

D550



D 450



green	Readiness	LED 1
red	Short circuit, overload	LED 2
red	Excessive temperature	LED 3
red	Under-/overvoltage	LED 4
red	Phase interruption	LED 5
red	No function	LED 6

Boost or	<u>Basic setting</u>
PWM current control	PWM current control
Current reduction	Current reduction active
Reverse direction	Clockwise direction
Step angle	Step angle: half step

Phase current setting 0.55 A

7.1 Phase current (given in A)

I (A)	0.55	0.70	0.85	1.0	1.15	1.3	1.45	1.6	1.75	1.9
Position	0	1	2	3	4	5	6	7	8	9

I (A)	2.05	2.2	2.35	2.5	2.65	2.8				
Position	A	B	C	D	E	F				

7.2 Current reduction

Switch position	LOWER		UPPER	
Pulse frequency	< 10 Hz	> 10 Hz	< 10 Hz	> 10 Hz
Motor current I	$I_{nom} * 0.6$	I_{nom}	I_{nom}	I_{nom}

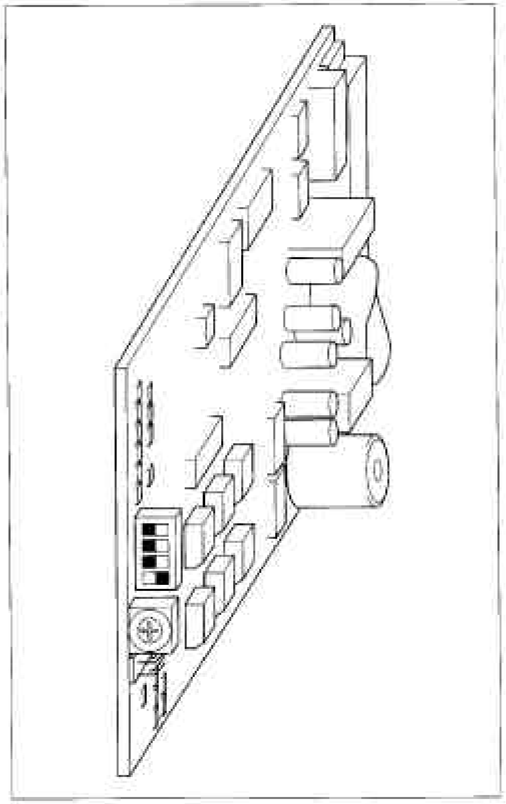
7.3 Step angle

Switch position	LOWER	UPPER
Step angle	Half step 1000 steps per rotation (≙ 0.36°)	Full step 500 steps per rotation (≙ 0.72°)

7.4 Sense of rotation *

Switch position	LOWER	UPPER
Signal input current applied	clockwise rotation	counterclockwise rotation
Signal input currentless	counterclockwise rotation	clockwise rotation

* viewed from front to shaft



Power Control Card
for 3-phase Stepping Motors

D 920

with Micro-step

Doc. no.: 220.920/Docu
Ident. no.: 00441110003
Edition: b135 August 97

Wiring

DANGER
The supply voltage must be disconnected whenever wiring work is carried out.

ATTENTION
Run motor and signal cables separately and shield them on both ends.

The 32-pin motor and signal connector according to DIN 41612 is located on the rear of the card.
Wire the card as shown in fig. 3.

ATTENTION
Free, unassigned pins must not be wired.

NOTE
At the supply voltage, motor and ground connectors, always wire both, or all four pins to ensure sufficient current loadability.
The ground connector must be connected to protective ground in order to achieve increased noise immunity.

NOTE
Use an isolating transformer according to DIN VDE 0551, part 1/09.89 or EN 60742: 1989.

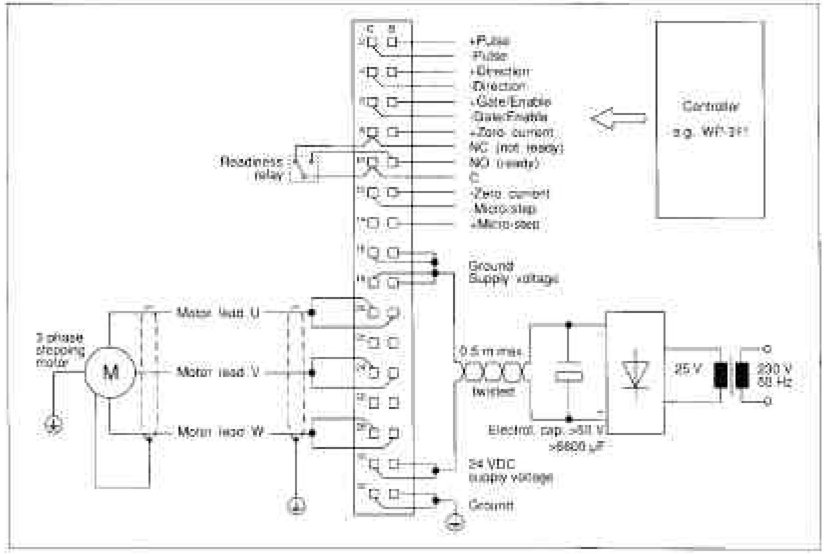
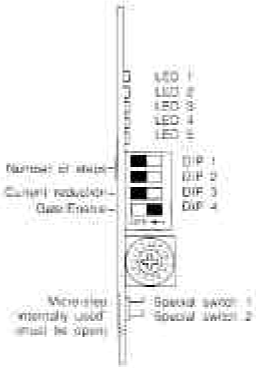


Fig. 3 Motor and signal connector wiring

ATTENTION
The settings of the switches must not be changed while under voltage.

2. Set the number of steps with the DIP-switches 1 and 2 and on the micro-step special switch or via the micro-step signal input.



Micro-step	Micro-step	DIP-switch 1	DIP-switch 2
Special switch = open* Signal = 0	Special switch = closed Signal = 0		
Special switch = closed Signal = 1	Special switch = open Signal = 1		
200	2000	ON	OFF
400	4000	ON	ON
500	5000	OFF	ON
1000*	10000	OFF*	OFF*

Signal input 0 = deenergized, 1 = energized
* Factory setting

3. Set the current reduction with DIP-switch 3.

Current reduction	DIP-switch 3
On	OFF*
Off	ON

* Factory setting

4. Set the function of the gate/enable signal input on the DIP-switch 4.

Function selection	DIP-switch 4
Enable	OFF
Gate	ON*

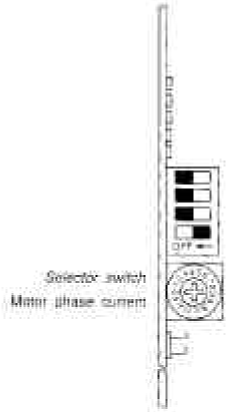
* Factory setting

5. Switch on the 24 VDC supply voltage.
If the card is operating properly, the LED 1 (Ready) lights up and the readiness relay is activated after switching on.

ATTENTION
Before disconnecting the supply voltage, ensure that any vertical axis loads are prevented from falling down (e.g. use motor with brake).

Setup

Before connecting the 24 VDC supply voltage, the following adjustments must be made on the card.

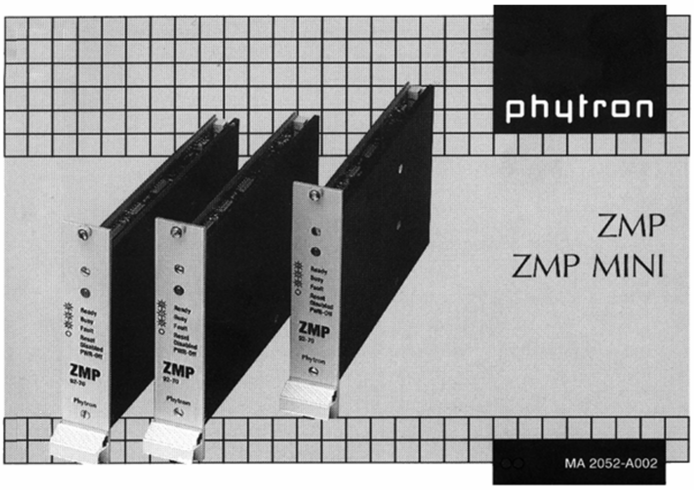


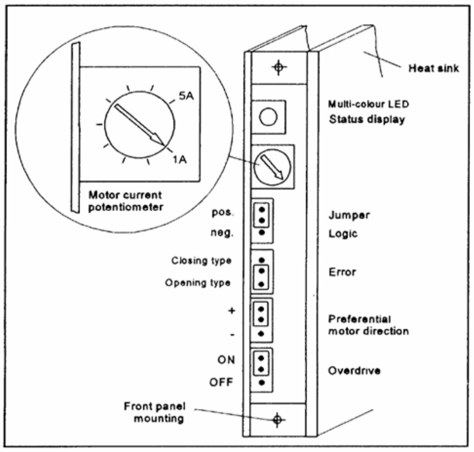
1. Set the motor phase current on the selector switch in accordance with the motor type plate.

Position	Phase current [A]
0*	1.45
1	1.75
2	2.05
3	2.30
4	2.60
5	2.90
6	3.20
7	3.50
8	3.75
9	4.05
A	4.35
B	4.60
C	4.90
D	5.20
E	5.50
F	5.80

* Factory setting

ATTENTION
The set phase current must be equal to or less than the nominal phase current specified on the motor type plate (the lower the set phase current, the lower the motor torque).





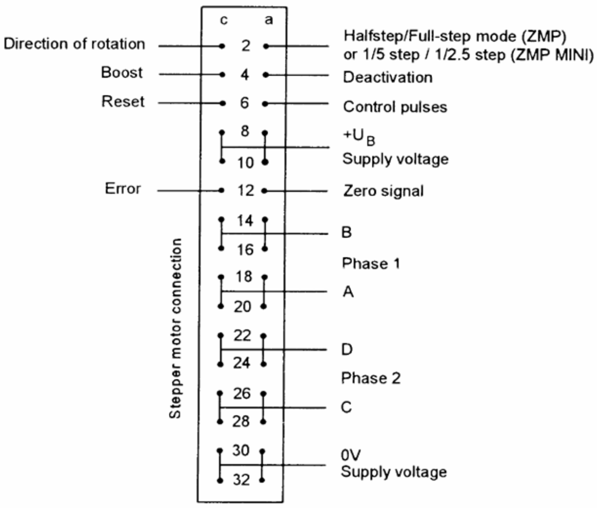
Current adjustment

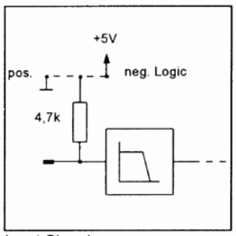
The motor run current is set by means of a scaled potentiometer which can be accessed after removal of the ZMP module's front panel.

If the control pulses are interrupted for a lapse of time >40 ms [1], the power stage automatically switches to the stop current. The stop current is set to 50 % [1] of the adjusted run current.

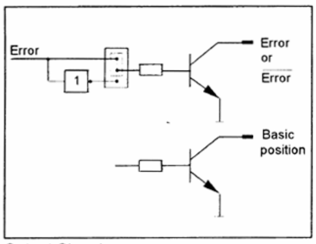
Range of motor currents:

ZMP/ZMP MINI 92-70	*ZMP/ZMP MINI 182-140*
1 - 5 A_{rms}	*2 - 10 A_{rms}*
with Boost: 1,3 - 6,5 A_{rms}	*with Boost: 2,6 - 13 A_{rms}*





Input Signals



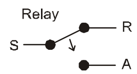
Output Signals

SME100

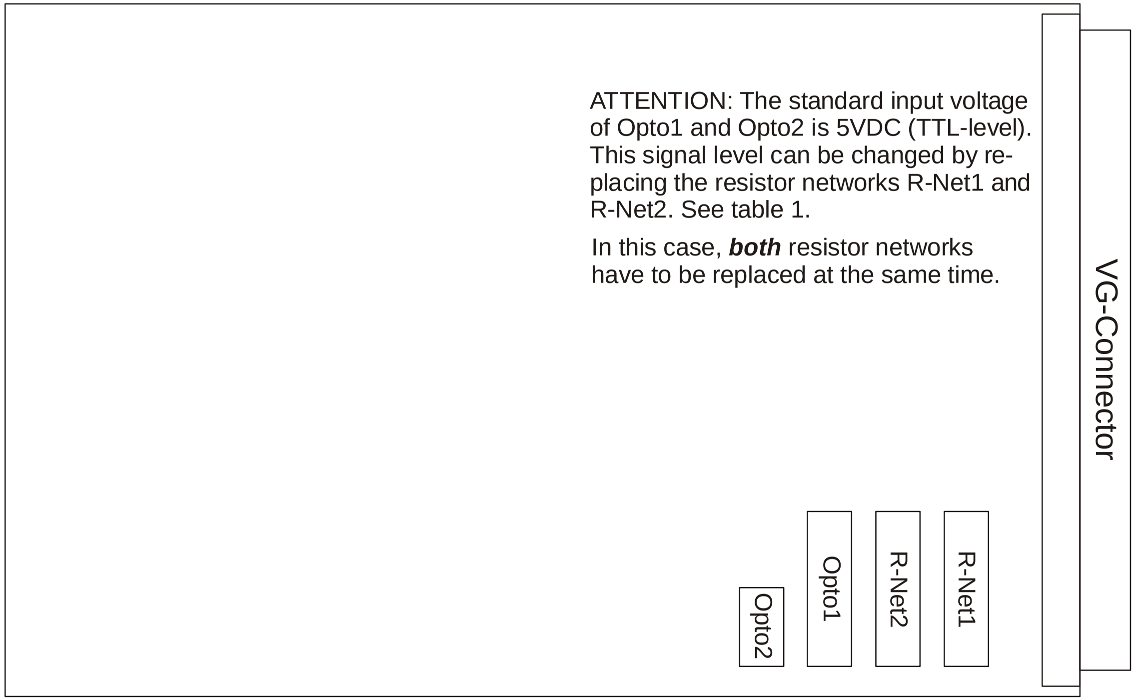
Rev. 1.0
July 2000

Pin Assigment

	c		a	
VMot+	●	2	●	n.c.
VMot+	●	4	●	VMot+
n.c.	●	6	●	n.c.
/Phase 1	●	8	●	/Phase 1
Phase 1	●	10	●	Phase 1
/Phase 2	●	12	●	/Phase 2
Phase 2	●	14	●	Phase 2
- Dir	●	16	●	- Zero Current
+ Dir	●	18	●	+ Zero Current
- Clock	●	20	●	+ Clock
n.c	●	22	●	Relay S
Relay R	●	24	●	Relay A
+ Boost	●	26	●	- Boost
+ Half-/ Full Step Mode	●	28	●	- Half-/ Full Step Mode
GND	●	30	●	GND
GND	●	32	●	GND



Top View (heat sink not shown)



ATTENTION: The standard input voltage of Opto1 and Opto2 is 5VDC (TTL-level). This signal level can be changed by re-placing the resistor networks R-Net1 and R-Net2. See table 1.

In this case, ***both*** resistor networks have to be replaced at the same time.

Front View

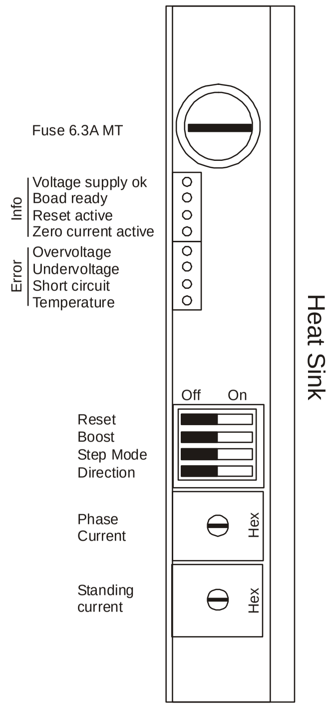


Table 1

Voltage	5V	12V	24V
Resistance	100R	330R	680R

Opto-Coupler Circut Diagram

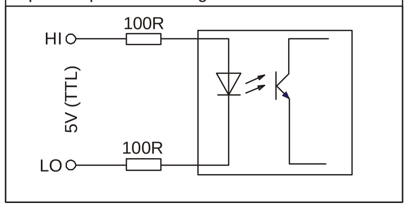


Table2

Hex	Phase Current[mA]	... with Boost
0	0	0
1	220	550
2	600	850
3	900	1200
4	1200	1500
5	1500	1750
6	1800	2000
7	2100	2300
8	2400	2600
9	2700	3000
A	3000	3300
B	3300	3600
C	3600	3900
D	3900	n .a.
E	4200	n .a.
F	4500	n. a.