SP MINI

phytron®

Stepper Motor Power Stage Including Supply Unit

Manual 1127-A003 GB

customized solutions *in motion*

SP MINI

Stepper Motor Power Stage

Including Supply Unit

MA 1127-A003 GB

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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

Contents

1 SP MINI POWERPACK Stepper Motor Power Stage

SP MINI POWERPACK is the ministep stepper motor power stage for highest demands. The supply unit is integrated, SP MINI POWERPACK is therefore connected directly to the mains voltage 230 V_{AC} (option 115 V_{AC}).

SP MINI control signals may be provided from control units delivering the step pulses and +/- direction signals or from PC's equipped with a stepper motor interface. The power stages can be connected to 4-, 6- or 8-lead two-phase stepper motors. Also the SP MINI supports the operation of stepper motors with a permanent magnet motor brake.

- SP MINI vario power packs exist in 3 versions for the following maximum phase currents:

  SP MINI 92-70: 9 A_{peak}
  SP MINI 72-70: 7 A_{peak}
  SP MINI 52-70: 5 A_{peak}

  The maximum phase current A_{peak} flows, when only one motor phase is energized and BOOST is activated.
- Optimum motor drive by means of rotating field synchronized current regulation based on the patented SYNCHROCHOP principle
- Setting switches for setting the run current into 16 increments
- Use of the maximum torque with the BOOST and OVERDRIVE functions in the higher frequency range
- Step resolution setting switch: Full step, half step, 1/2.5 and 1/5 step.
  The initial motor direction and the positive or negative input signal logics are also set by this setting switch.
- Electrical insulation of inputs and error output by means of opto-couplers
  We recommend controlling via RS422 push-pull drivers to ensure high immunity against disturbances. It is also possible to drive the unit by means of open-collectors.
- Direct connection to the mains voltage:
  Electrical insulation is provided by a toroidal core transformer.
- Multiple color status LED
- Electronic monitoring of overheating, short-circuits and voltage drops
- Easy-to-mount design:
  Flat Vario-housing for wall mounting in electrical cabinets
  Mounting brackets for various mounting positions
  All connections on one side

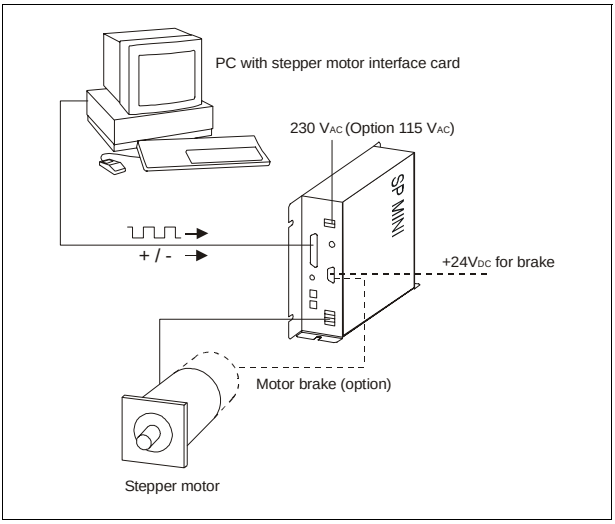


Fig. 1: PC – SP MINI – Stepper motor

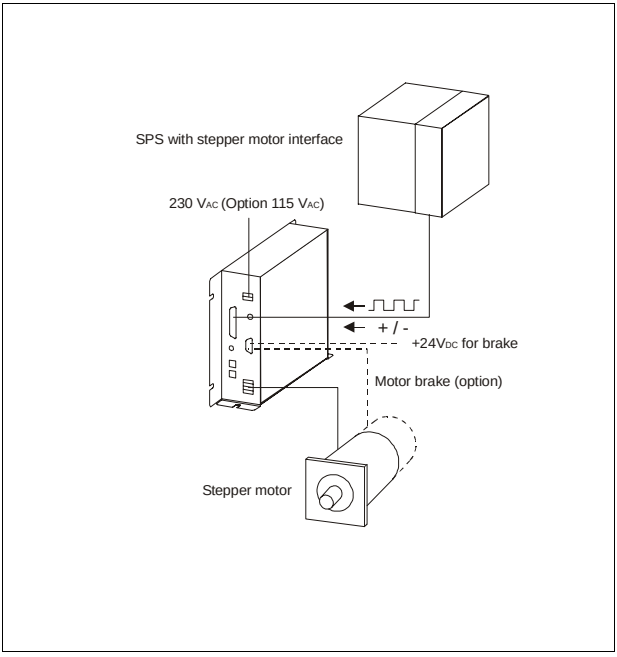


Fig. 2: SPS – SP MINI – Stepper motor

1.1 Technical Characteristics

1.1.1 Overview

Supply voltage [V_{AC}]	230 V_{AC} ±10 % 50-60 Hz (Option 115 V_{AC})
	Fuse: T 2.5 A (230 V_{AC}), T 5 A (115 V_{AC})
	Disturbance filter (EMI filter) integrated
Stepper motor	2-phase-stepper-motors with 4-, 6- or 8-lead wiring scheme Winding inductance per phase: min. 0.5 mH 200 W max. power requirement
Step resolution	Full step, Half step, 1/2,5, 1/5 step. Programming by means of the setting switch S1.
Motor currents	Run current is set in 16 increments by setting switch S2.
Max. motor currents	SP MINI 92-70: 9 A SP MINI 72-70: 7 A SP MINI 52-70: 5 A
	The maximum motor current flows at switch position F (S2) when only single motor phase is energized and BOOST is activated.
Duty	70% for a S6 duty cycle according to VDE 0530
Ambient temperature	0 to 40 °C
Max. heat sink temperature	+ 85 °C (185 °F)
Max. motor cable length	50 m
Min. motor cable area	1 mm^2 per 10 Ampere motor current.

Inputs	The input logic is set by setting switch S1 (see chap.5.2)	
	The inputs are optocoupler-isolated and can be controlled via a RS 422 line signal or an open collector signal (see chap. 3).	
CONTROL PULSES	Maximum frequency: 100 kHz, minimum pulse width: 5µs	
MOTOR DIRECTION +/-	When the optocoupler is energized, the motor rotates in the reverse direction (as compared to the preferential motor direction selected).	
BOOST	When the optocoupler is energized, the motor current is set to 130 % of the run current.	
DEACTIVATION	When the optocoupler is energized, the motor current is cut off.	
RESET	A RESET causes resetting of all error messages and initialization of the monitoring circuits.	
BRAKE	When the optocoupler is energized, the brake supply voltage is connected to the brake. The brake is released as long as this input is activated.	
Outputs	Optocoupler, open-collector Darlington type outputs I_{max} = 20 mA, U_{max} = 30 V, $U_{CE\ sat}$ for 20 mA < 1 V	
READY	This output indicates that the SP MINI module is ready to operate.	
ERROR	This common error output is opened if an error signal occurs	
Motor brake (optional connection)	Stepper motors with permanent magnet motor brake 24 V_{DC} /max. 0.75A. The brake supply voltage must be externally supplied to the X3 connector. The brake is controlled by an input (X2).	
Connectors	I/O signals	25-pole D-SUB socket
	Motor brake	9-pole D-SUB connector
Screw terminals	Motor	4pol. Print lead-through terminal DMKDS 2,5 plus PE-threaded terminal end
	Mains	2pol. Print lead-through terminal DMKDS 2,5 plus PE- threaded terminal end
Weight	4.5 kg	

1.1.2 Dimensions / Mounting Position

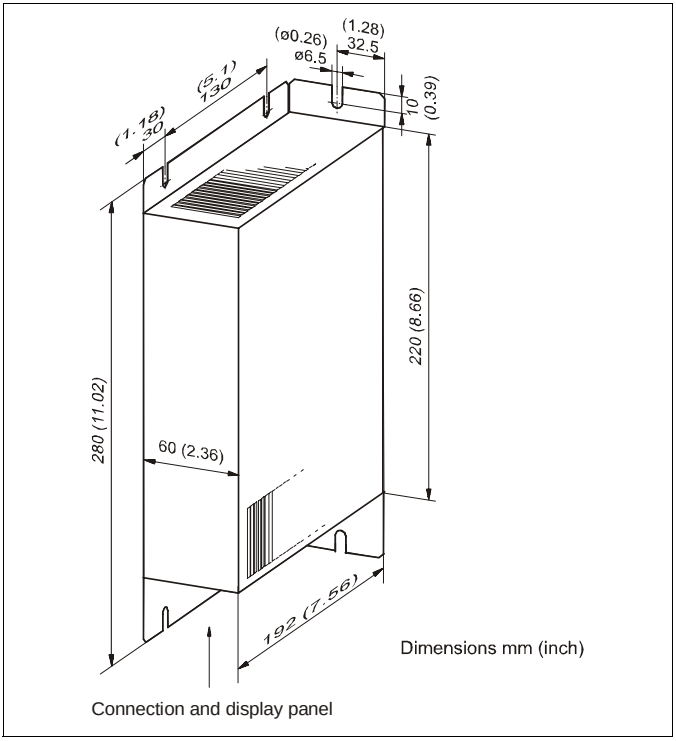


Fig. 3: Dimensions SP MINI

Mounting instructions

The SP MINI must be mounted in the electric cabinet to allow correct air circulation. Fig. 3 shows the preferred mounting position. Vertical mounting provides better ventilation.

1.1.3 I/O Connector X2

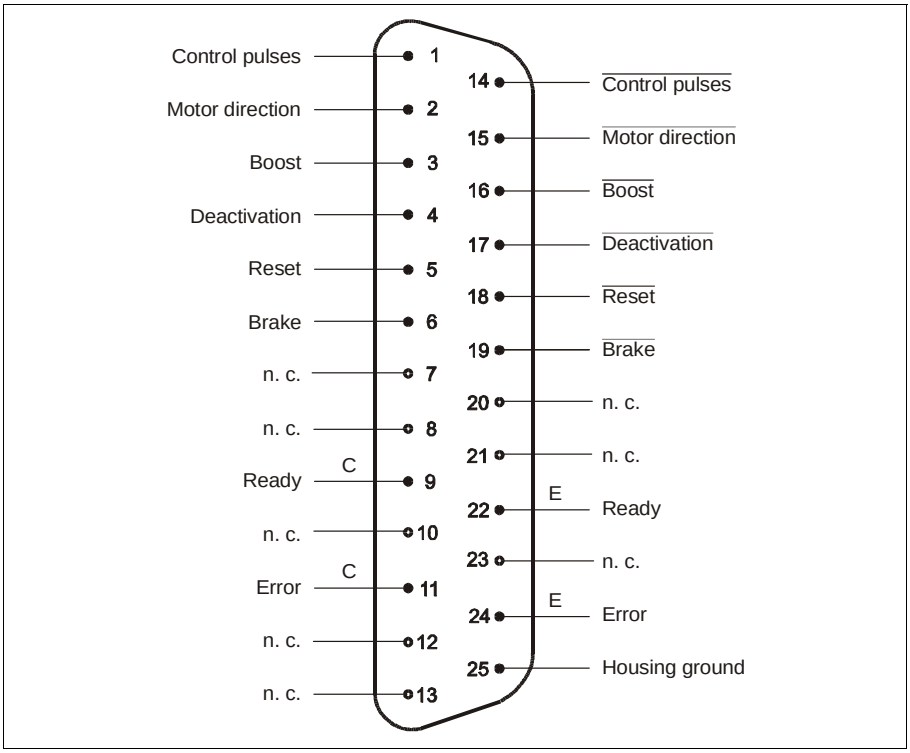


Fig. 4: 25-pole D-SUB connector according to DIN 41652

Inputs and outputs: please refer to pages 21 to 27

Attention:
Use shielded cables only!

1.1.4 Connection to Type SPS Control Units (PLC)

As the SP MINI power stages are equipped with galvanically separated inputs and outputs, they can be connected to any control unit equipped with a stepper motor interface. The example below shows the cable connections to type **IP 267** and **IP 247** control units.

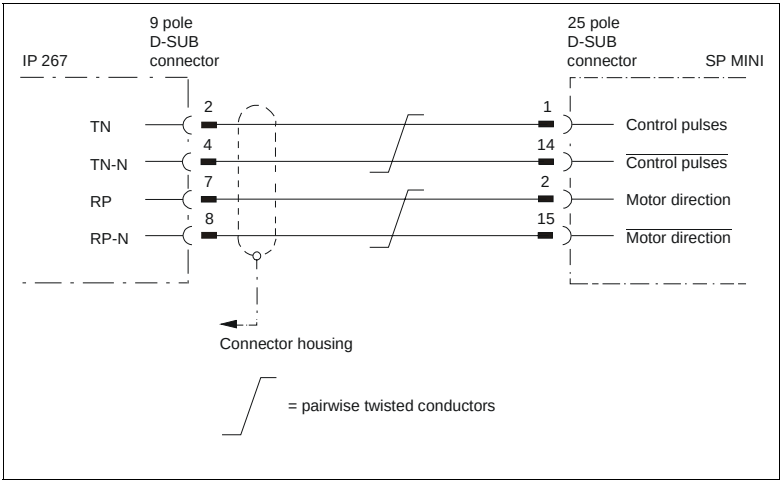


Fig. 5: Cable connections IP 267 – SP MINI

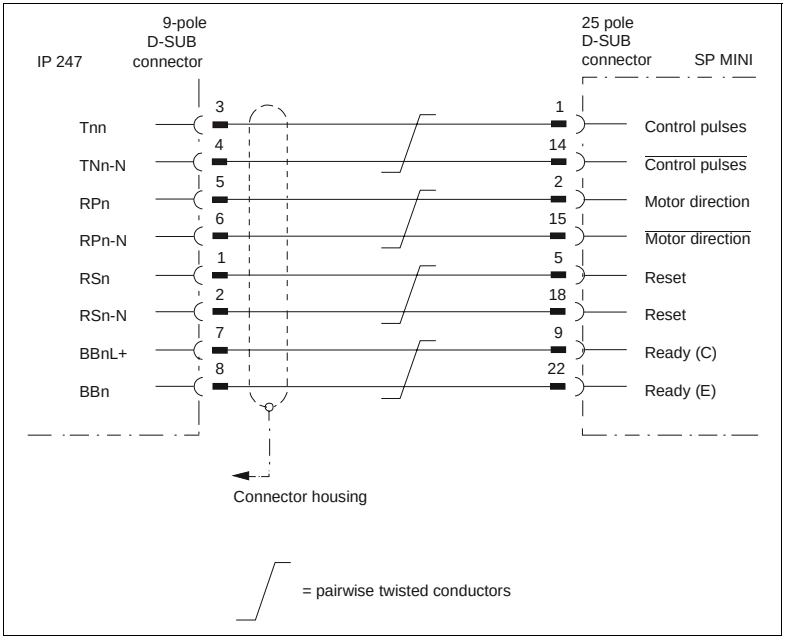


Fig. 6: Cable connections IP 247 – SP MINI

1.1.5 Screw Terminal Motor Connection X4

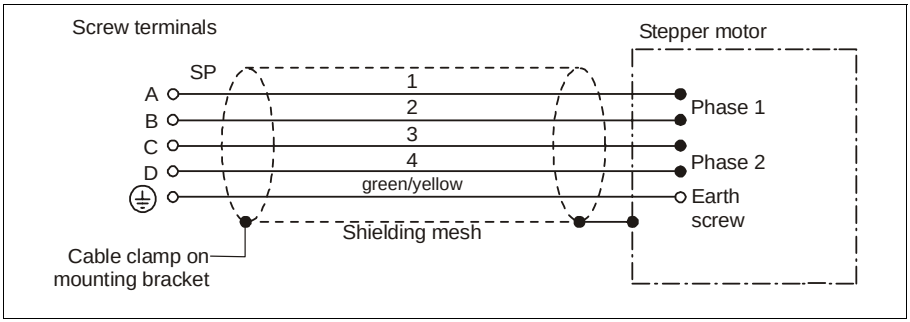


Fig. 7: Motor connection SP MINI

Important!

When connecting the shielded motor cables to the screw terminals, the contact resistance must be as low as possible.

We recommend to use cables with crimp terminals according to DIN EN 50 027.

1.1.6 Screw Terminal Mains Connnection X1

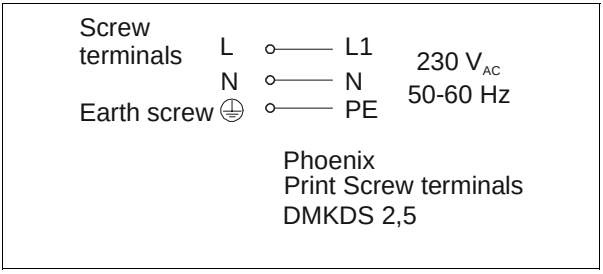


Fig. 8: Mains connection 230 V_{AC}

1.2 Description of Operation

The SP MINI POWERPACK stepper motor power stage wiring diagram can be divided into three zones:

- the power stage, including power transistors, drivers, current regulators and a special IC performing the overall regulation functions.
- the supply module which generates the internal service voltages
- the supply unit with disturbance filter (EMI filter), rectifier and filtering circuits

Schematically, the operating principle of the SP MINI power stages consists of a current regulation of both phase currents by chopped amplifiers synchronized with the rotating field (synchronized with the control pulses) - patented SYNCHROCHOP principle developed by Phytron. The chopper frequency of the amplifiers is 20 KHz which enables noise-free stepper motor operation at a standstill.

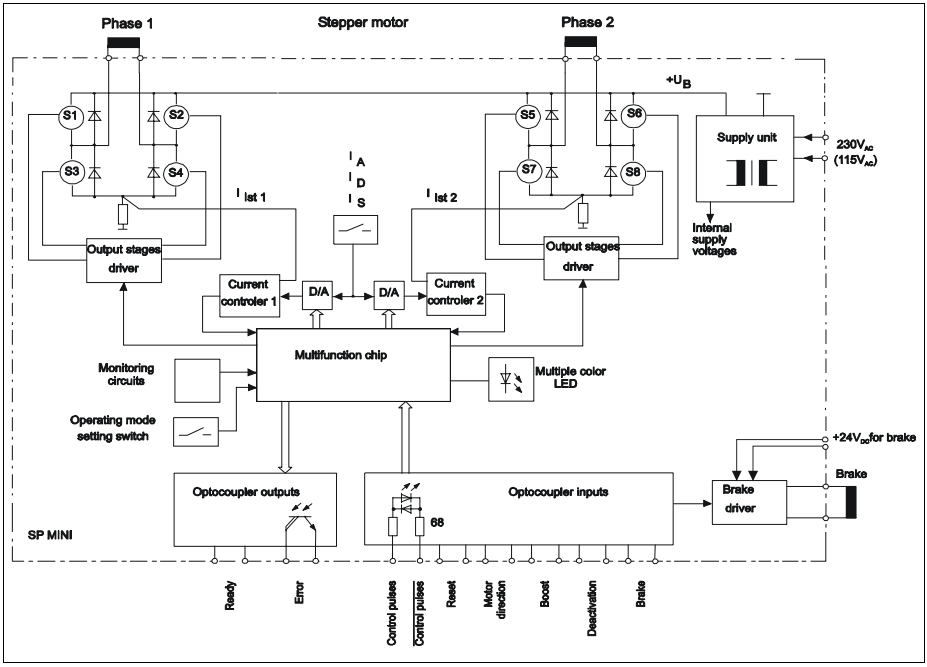


Fig. 9: Block diagram

1.2.1 Full Step / Half Step / Ministep Modes

The full step mode is the operating mode in which a 200-step motor is driven to effect 200 steps per revolution. The full step mode always energizes both stepper motor phases.

The motor 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. However, compared to the full step mode, the half-step mode reduces the output torque. Therefore, Phytron has developed a "half-step mode with torque compensation": as long as the motor phases are energized, the current is increased by √2. Compared to the full step mode, the torque delivered is almost the same, and the resonance of the full step mode is suppressed.

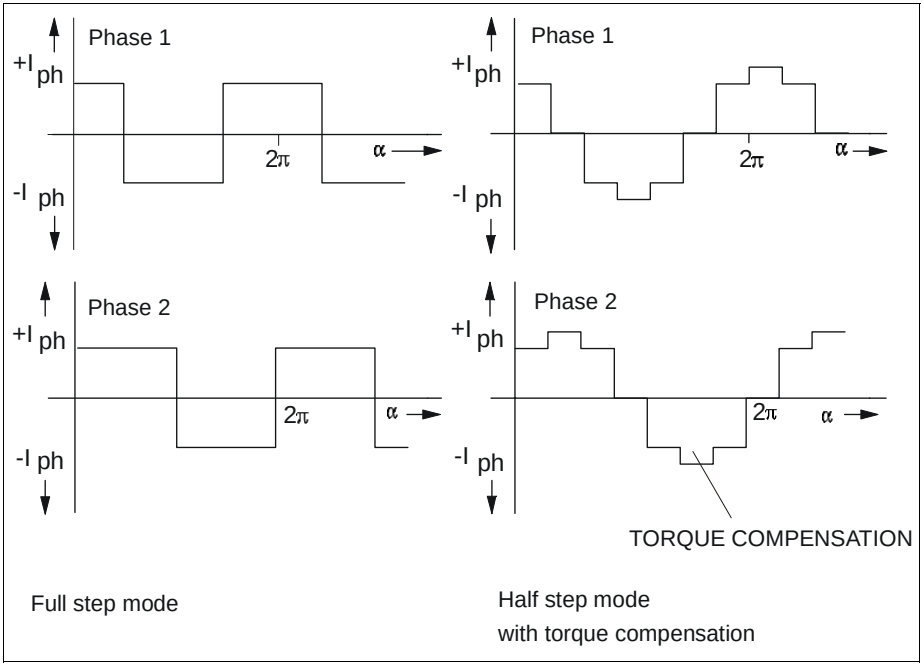


Fig. 10: Phase current curves

Remark:

The current and loss values indicated in Phytron's motor data sheets always refer to the energizing of both stepper motor phases.

The figure below shows the magnitude and the direction of the holding torques during one revolution of a 4-step motor, with and without torque compensation.

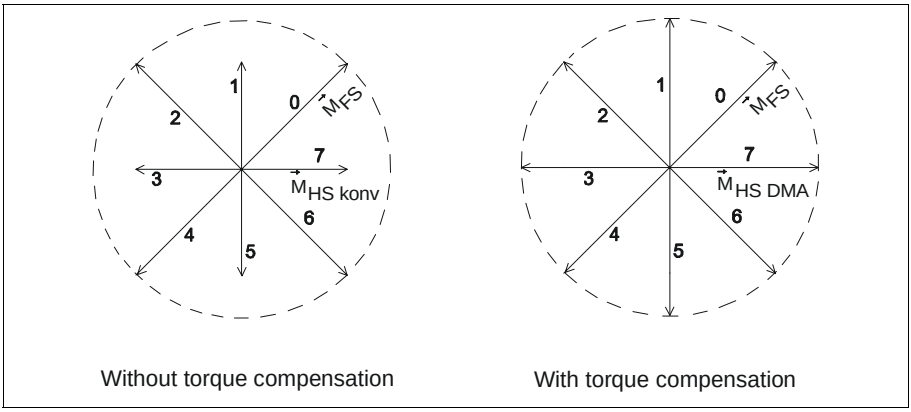


Fig. 11: Holding torques without/with torque compensation

In the full step mode, both phases are energized, in the half-step mode, 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:

$$|M_{FS}| = |M_{HS}| \bullet \sqrt{2}$$

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

When used in the ministep mode, the SP MINI power stages furthermore increase the step resolution by a factor of 2.5 or 5.

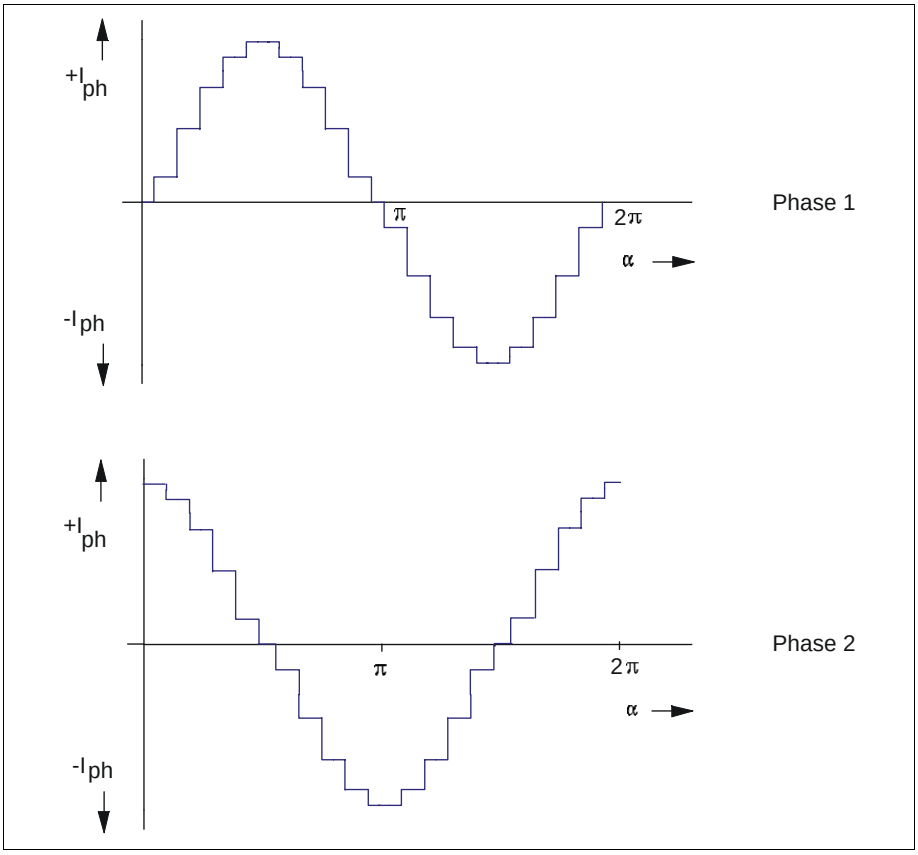


Fig. 12: Ministep 1/5

Various advantages are obtained by the almost sine-shaped ministep mode current:

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

1.2.2 BOOST

The motor torque required during acceleration and deceleration is higher than that required during continuous motor operation (f_{max}).

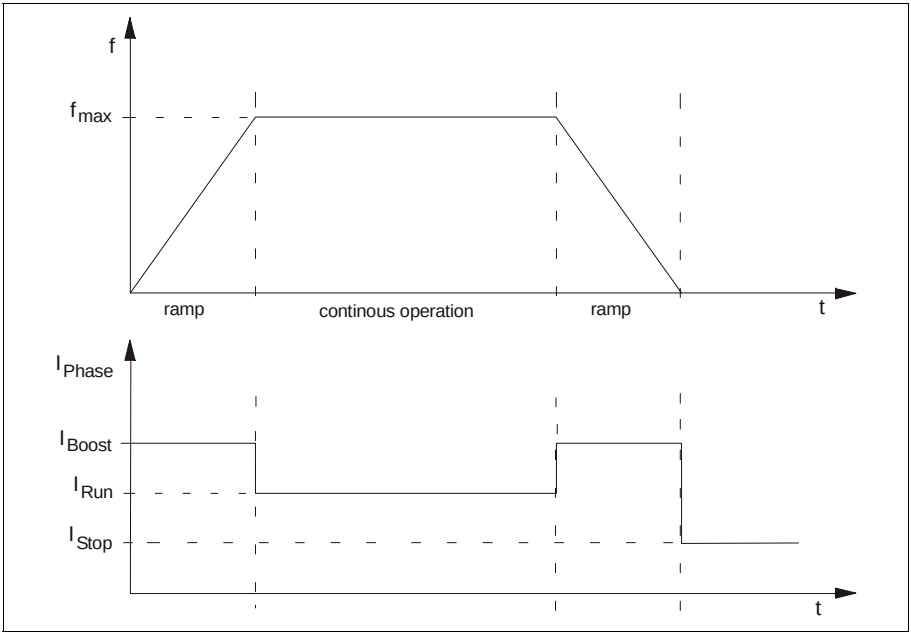


Fig. 13: BOOST

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 for the ramps and the continuous operation of the motor.

- Continuous operation: run current
- During acceleration and deceleration : BOOST current = run current + 30%
  The BOOST current is switched on and off by input BOOST. The function is on when the input optocoupler is energized while switch S1 is set to ‘positive input logic’.

1.2.3 OVERDRIVE

In addition to the standard BOOST function, the SP MINI power stages include a dynamic BOOST function: OVERDRIVE. This function increases the torque within the higher frequency range:

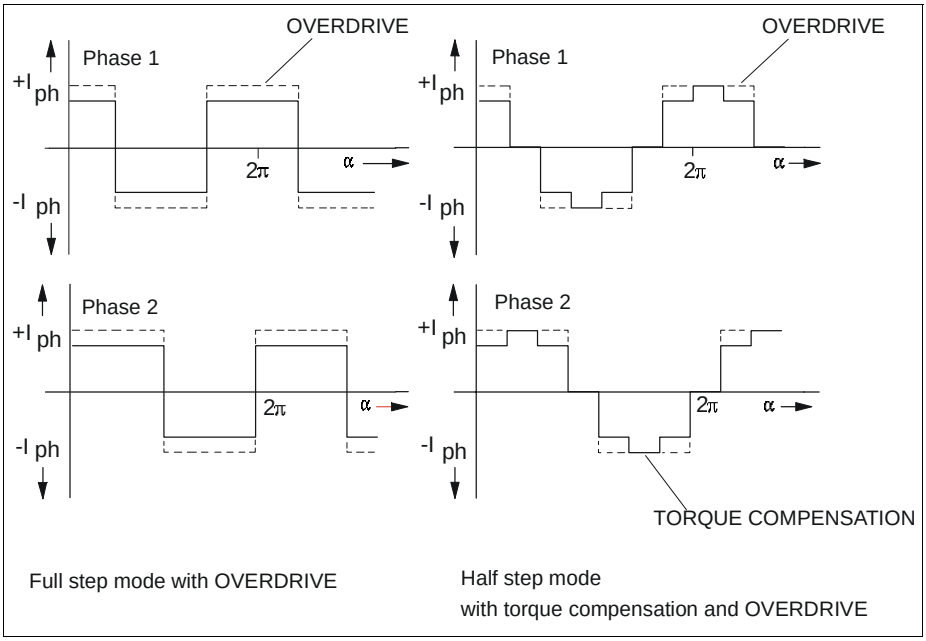


Fig. 14: Schematic curves of the phase currents with OVERDRIVE

For control pulse frequencies above 1 KHz in the full step mode (i.e.: 300 rev./min for a 200-step motor), the OVERDRIVE function automatically increases the phase current by factor 1.4.

2 Motor Connection

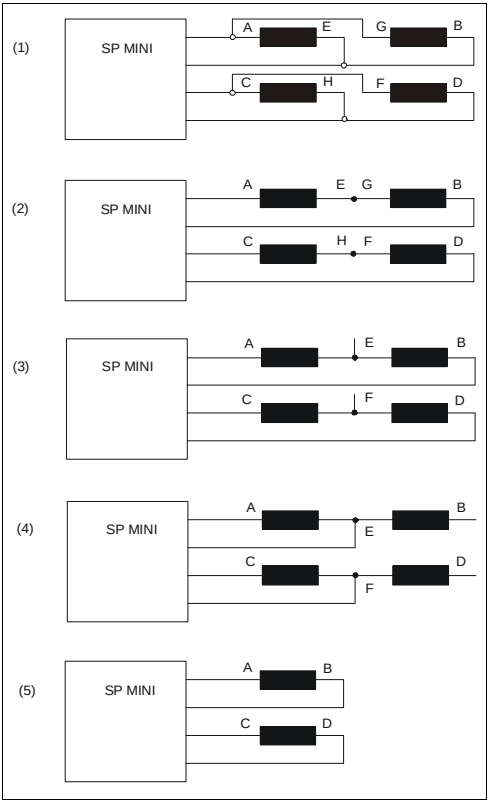
2.1 Connection of Different Types of Stepper Motors

Type SP MINI POWERPACK power stages can be used to drive various types of two-phase stepper motors.

For 8-lead stepper motors, two types of connections can be used: serial (1) or parallel (2) wiring of the motor windings.

For 6-lead stepper motors, the windings cannot be connected in parallel. It is recommended to connect these motor windings in series (3). If the motor cannot be connected as per figure (3), it can be connected with only 2 windings, as shown in (4).

It is not possible to connect 5-lead stepper motors to SP MINI power stages.



(1) 8-lead stepper motor, connected as 4-lead stepper motor (standard) Windings connected in parallel

(2) 8-lead stepper motor connected as 4-lead stepper motor Windings connected in series

(3) 6-lead stepper motor Windings connected in series

(4) 6-lead stepper motor use with 2 windings if connection (3) cannot be effected

(5) 4-lead stepper motor

Fig. 15: Motor connection

2.2 Motor Cables

The motor cable cross section should be dimensioned corresponding to the preset current. We recommend to use cables with a cross section adapted to the power stage's peak current.

Rule of thumb under normal operating conditions and in case of free cable laying:
1 mm^2 per 10 Ampere motor current.

Important:

Insulate all unused motor wires individually!

2.3 Motor Brake

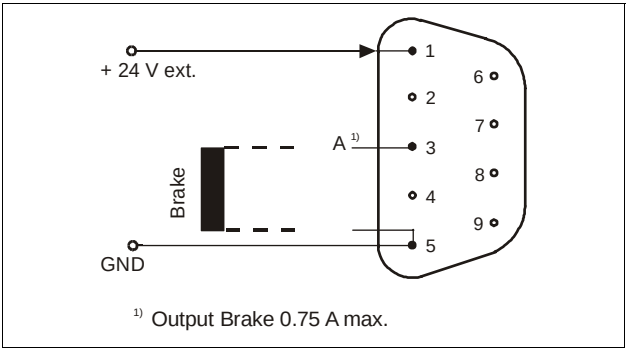


Fig. 16: Connector X3 motor brake

Connect the brake to X3 connector. The brake supply voltage (24 V_{DC}) has to be externally supplied to X3 connector. The motor brake must only charge the input with 0.75 A. When the input at connector X2 BRAKE is active, the brake is energized.

The brakage is activated when there is no voltage supplied to the brake. The permanent magnet attracts the built-in anchor disk in the axial direction towards a friction disk and thus generates a torsion-free friction connection. When the brake is supplied, the attracting force on the anchor is neutralized. The friction surfaces in contact are separated by a riveted spring, without residual torque, whatever the mounting position.

Important:

The motor brake is not energized, if the inputs RESET or DEACTIVATION or the output ERROR are activated.

The anchor disk of the motor brake is moved mechanically. Therefore a time lapse (approx. 50 ms) after the control signal should be observed. The required time lapse depends on type and size of the brake.

3 Inputs

The following inputs are protected by optocouplers: CONTROL PULSE, MOTOR DIRECTION, BOOST, DEACTIVATION, RESET and BRAKE. These signals are active when a current flows through the optocoupler. The differential voltage between input signal and negated input signal must be above 2.5 V to ensure input activation.

The input signal logic can be changed by switch S1:
Setting 0 to 7: positive logic
Setting 8 to F: negative logic

3.1 Push-Pull- or OC-Controlling

High immunity is obtained when driving the module with RS422 control signals, as the lines are permanently supplied. This type of control signal is particularly recommended for connections over long distances.

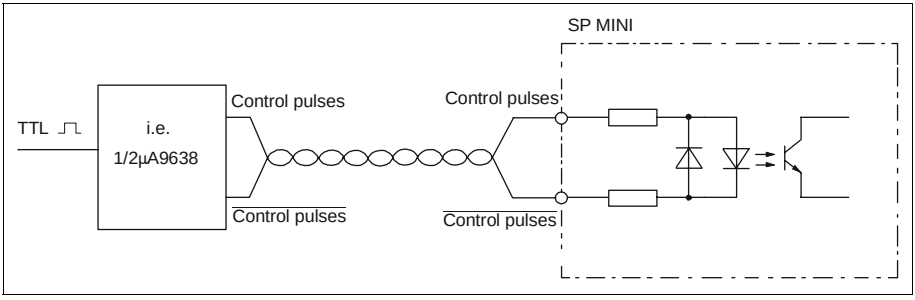


Fig. 17: RS422 Push-pull driver

Alternately, the control signals can be of the open collector type:

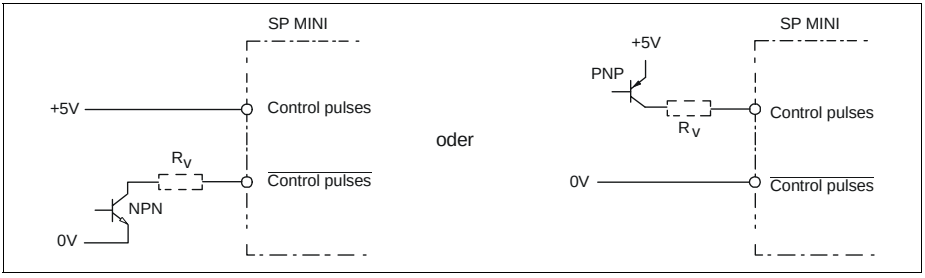


Fig. 18: Open collector controlling

3.2 Logic Level

The SP MINI POWERPACK is delivered with 5V input level.

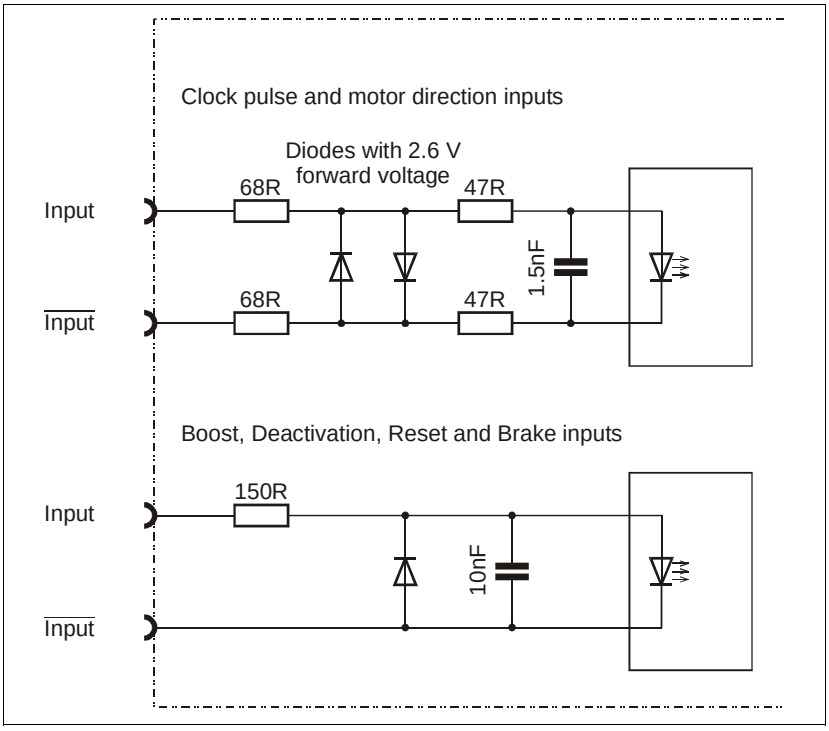


Fig. 19: Input wiring diagram for +5V logic voltage

For 24 V input level connect external protective resistors to the input.

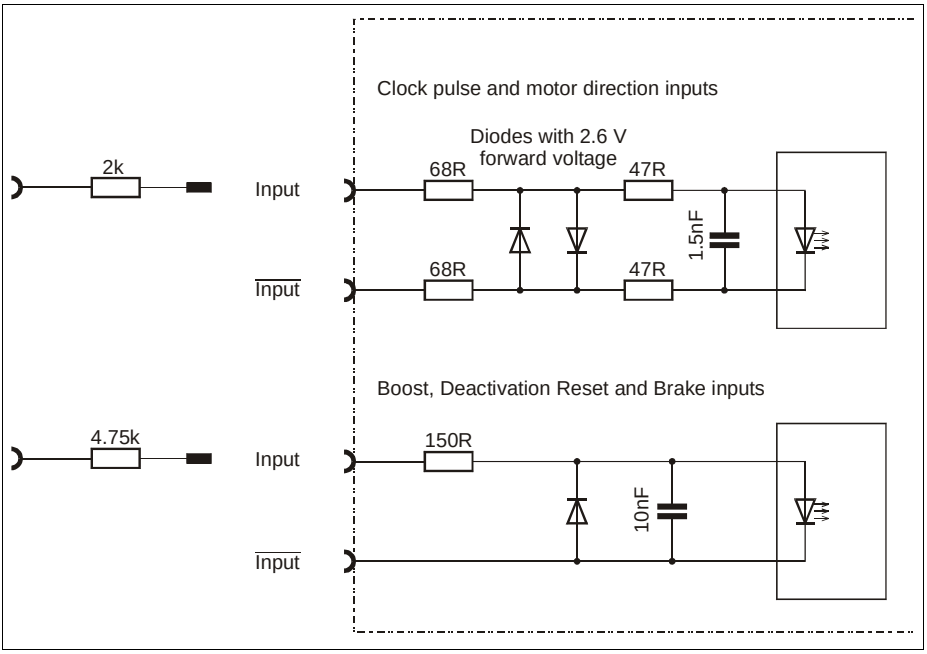


Fig. 20: Input wiring diagram for +24V logic voltage

Signal level	**5 V**	**24 V**
High	3 – 5.5 V	20 – 30 V
Low	< 0.4 V	< 3 V
Necessary driver current	max. 10 mA (at 3 V)	max. 10 mA (at 20 V)
	max. 30 mA (at 5.5 V)	max. 20 mA (at 30 V)

3.3 CONTROL PULSES

The maximum control pulse frequency is 100 kHz.

One ≥ 5 µs pulse causes one motor step. With the control pulse signal, the unit switches from the stop current into the run current and the step is executed. If the time lapse between pulses is above 40 ms, the SP MINI automatically switches back to the stop current.

Caution:

- If the BOOST is activated, always flows a higher current (run current + 30 %, stop current + 30 %). To keep the motor temperature as low as possible, the BOOST input should only be activated during motor acceleration and deceleration.

- The control pulses must not be interrupted suddenly for frequencies above the start stop frequency. This would cause mispositioning.

Remark:

The start-stop frequency is the maximum frequency at which a motor at a standstill can be started without mispositioning. Normally, the start-stop frequency ranges between 200 and 2,000 Hz. The actual value depends on the motor itself and the system connected; e.g. for large motors connected to heavy loads, this frequency is lower.

3.4 MOTOR DIRECTION +/-

This signal sets the direction of rotation for the motor: as long as this input is not activated, the motor runs in the preferential direction. As soon as current flows through the optocoupler, the motor direction is reversed. This signal must only be modified when the motor is at a standstill or when it is driven with a frequency within the start-stop frequency range. This signal must not be modified during 1 µs before and 4 µs after the control pulse. Changing the motor direction at higher motor speeds will cause step losses and/or stop the motor.

The preferential motor direction can be changed by means of the setting switch S1. (please refer to table on page 29).

3.5 BOOST

When the BOOST input is activated, the run current is increased by 30 % (=BOOST current). During motor acceleration and deceleration, the BOOST current can be activated and, therefore, a higher torque is obtained.

The BOOST function is activated when a current flows through the corresponding input optocoupler (at setting switch 'positive input level').

There is no time limit for the use of the BOOST function.

Caution:

If the BOOST is activated, always flows a higher current (run current + 30 %, stop current + 30 %). To keep the motor temperature as low as possible, the BOOST input should only be activated during motor acceleration and deceleration.

3.6 DEACTIVATION

If this input is activated, the motor current is switched off (at setting switch 'positive input logic'). 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 then possible to slowly rotate the motor by hand.

Never try to rotate the motor externally (by hand) at a high speed. In this case, it operates as a generator and returns energy to the power stage. The DEACTIVATION input must not be used when the motor is running.

DEACTIVATION is also useful when highly sensitive instruments are installed close to the system. The magnetic disturbances generated by the power stage can thus be suppressed during measurements.

Caution:

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

Remark:

While the input DEACTIVATION is activated, the motor brake (if available) remains deactivated.

3.7 RESET

The RESET function resets the ERROR output. The LED color is changed to green or yellow.

Remark:

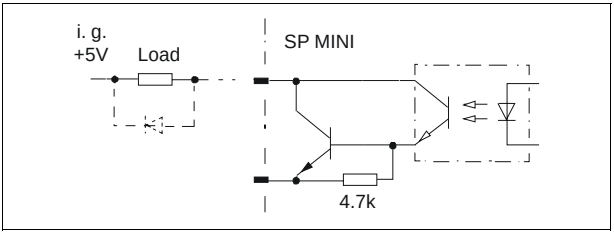
When the RESET signal is suppressed, a time lapse of approx. 500 ms is necessary before the power stage returns to the READY status. Before, no control signals should be applied, because motion commands can't be realized.

3.8 BRAKE

When the BRAKE input is activated the external supply voltage +24 V
(X3 Pin 1) is connected through to the output Pin3. This stops the brake action.
The motor brake is not energized when the inputs RESET or DEACTIVATION or the output ERROR are active.

4 Outputs

The optocoupler outputs of the SP MINI POWERPACK are connected to open collector Darlington transistors.



I_{max} = 20 mA

U_{max} = 30 V

$U_{CE\ sat} \leq 1$ V

Fig. 21: Output connection

In case of connection of highly inductive equipment (e.g. a relay or motor brake), a protective (free run) diode must be connected to these outputs.

4.1 READY

The "Ready" output is activated when the SP MINI POWERPACK power stage is ready to operate. For that, the power stage must be activated, i.e.: no signal on the DEACTVATION input.

Remark:

After suppression of the RESET signal, a time lapse of approx. 500 ms is necessary before the power stage generates the READY signal again. Before, no control signals should be set. As soon as the output READY is connected through, motion commands can be realized.

4.2 ERROR

The output transistor remains activated as long as there is no error signal. Therefore, power cuts or wire partings can be detected. This output is deactivated if certain limit values are exceeded. To avoid damaging the motor, the latter is deactivated.

Error signal limit values:

- Motor current > 14 A
- Motor supply voltage < 35 V
- Heat sink temperature > 85 °C (> 185° F)

To reset the ERROR signal, the RESET input must be activated or the mains switched off until the multiple color LED goes out.

5 Front Panel Controls

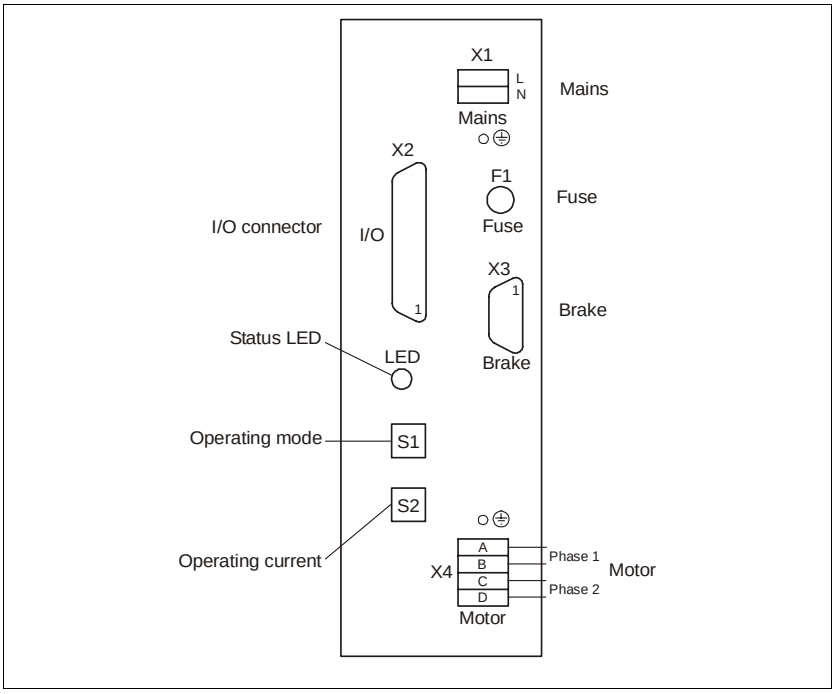


Fig. 22: Connection and display panel

5.1 Multiple Color LED

Farbe	Erklärung	
Green	Ready	The SP MINI POWERPACK is ready to operate and activated.
Yellow	Busy	The SP MINI POWERPACK receives control pulses from the control unit which drives it.
Red	Error	The motor current has exceeded 14 A. This has been caused by a short-circuit or another motor malfunction.
		The motor supply voltage is below 35 V. This error signal can also occur if the mains voltage drops too low or in case of irregular mains frequency.
		The heat sink temperature has exceeded 85 °C (185 °F).
LED off	Reset Disabled Power off	The LED does not light up, while there is a RESET signal, the power stage is deactivated or the power stage is powered off.

Please, also refer to paragraphs READY Output and ERROR Output, pages 26-27.

5.2 Setting Switches

The switches used to set the motor currents, step resolution and the motor direction and input logic are located at the module's connection panel.

Attention: These switches must only be activated when the module is disconnected from the mains!

- The motor current is always set to the 30% higher run current as long as the BOOST input is activated. If the BOOST input is not activated, the motor current corresponds to the current set by the setting switch S2.
- The stop current is normally set to 50% of the run current, to keep the motor temperature as low as possible, minimum stop current: 0.5 A
- The chart values are applicable if both motor phases are energized. If only one phase is energized, the current is equal to the chart value · √2.
- Maximal current I_{max} = Run current · 1,3 · √2

Setting Switches							
S1					S2		
Switch setting	Step resolution	Motor direction	Input logic	Steps/rev.[1)]	Run current [A_{eff}]		
					SP 92-70	SP 72-70	SP 52-70
0	Full step	+	POS.	200	1.0	0.8	0.6
1	Half step	+	POS.	400	1.3	1.0	0.7
2	1 / 2.5 step	+	POS.	500	1.5	1.2	0.9
3	1 / 5 step	+	POS.	1000	1.8	1.4	1.0
4	Full step	-	POS.	200	2.1	1.6	1.1
5	Half step	-	POS.	400	2.3	1.8	1.3
6	1 / 2.5 step	-	POS.	500	2.6	2.0	1.4
7	1 / 5 step	-	POS.	1000	2.9	2.2	1.6
8	Full step	+	NEG.	200	3.1	2.4	1.7
9	Half step	+	NEG.	400	3.4	2.6	1.9
A	1 / 2.5 step	+	NEG.	500	3.7	2.9	2.0
B	1 / 5 step	+	NEG.	1000	3.9	3.1	2.2
C	Full step	-	NEG.	200	4.2	3.3	2.3
D	Half step	-	NEG.	400	4.5	3.5	2.5
E	1 / 2.5 step	-	NEG.	500	4.7	3.7	2.6
F	1 / 5 step	-	NEG.	1000	5.0	3.9	2.8

1) for a 200-step motor

6 Putting-Into-Service

1.Check that the mains voltage is the same as on the SP MINI POWERPACK module's identification plate.

2. All connectors and screw terminals must only be connected or removed when the module is disconnected from the mains.

3. The setting switches must only be activated when the module is disconnected from the mains.

4. If the motor stops during acceleration, reduce the acceleration and/or maximum frequency values. This problem may also be caused by incorrect programming of the motor's rated current.

5. If the motor gets too hot, the motor current has probably been set too high. Excessive motor heating may also be caused by continuous use of the BOOST function.

6. If the motor has high resonance effects, select a higher step resolution. Resonsnces may also be reduced by modifying the control pulse frequency or the acceleration or by reducing the motor current.

7. If the motor does not position correctly, there can be disturbances received on the control pulse input. Check also for excessive acceleration and deceleration values. Please, refer to the remark on page 24.

7 CE - Sign

SP MINI Vario power packs are certified according to the applicable European Standards and may bear the CE mark.

SP MINI comply with EMC standards, such as EN 50081-1,-2 and 50082-1,-2.

These standards allow the use of SP MINI in residential and industrial environments. The unit includes all necessary filtering equipment.

Insulation dimensioning; according to VDE 0160. Certificate of conformity on request.

8 Accessories

The following accessories are delivered on demand:

Mating connector to the signal connector (25 pole D-SUB according to DIN 41652),
Mating connector to the brake (9 pole D-SUB according to DIN 41652),
Cable assembly for the mains, motor and control signal connection.

9 Quality Assurance System

To ensure a high and homogenous quality of the modules and instruments we deliver, we have set up a quality assurance system according to DIN/ISO 9001.

Each product is fully checked and effects a test run before shipment.

To avoid tong term defects due to ESD (electro-static discharge) of sensitive components, a great many ESD protective measures have been taken during manufacturing process - from the acceptance tests on arrival up to the shipment of the final product.

Important remarks:

Respect ESD protective measures while handling sensitive parts and components (EN 61340-5).

Only ship the modules and units in packaging adapted to ESD protection.

Defects due to incorrect handling or improper packaging during transportation will not be covered by our warranty.

QS 6/92

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