Ministep Power Stage
for Bipolar Control Mode

Any questions? Please contact us.

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1 MSX MINI

In this chapter you'll find a brief description of the MSX power stage.

1.1 Short Overview

Fig. 1: Front view of MSXMINI with panel

- **Motor currents from**
  1.1 to 5.1 A_{Peak} (MSX 52-120)
  2.3 to 10.3 A_{Peak} (MSX 102-120)
  3.4 to 15.4 A_{Peak}(MSX 152-120)
- **Supply voltage from 60 to 120 V_{DC}**
- **Step resolution from full step to 1/20 step**
- **Overdrive mode**
- **Easy current and step resolution setting by rotary switches**
- **Short-circuit proof over and between the phases and towards ground**
- **32-pin connector**
  acc. to DIN 41612, version D

Ministep power stages for two-phase stepper motors

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

Run and stop current can be set by rotary switches. Overdrive, Boost, Activation and Motor direction are activated by DIP switches.

Step resolution and phase current shape can be set by a rotary switch, too:
1/1, 1/2, 1/4, 1/5, 1/10 and 1/20 of a full step.

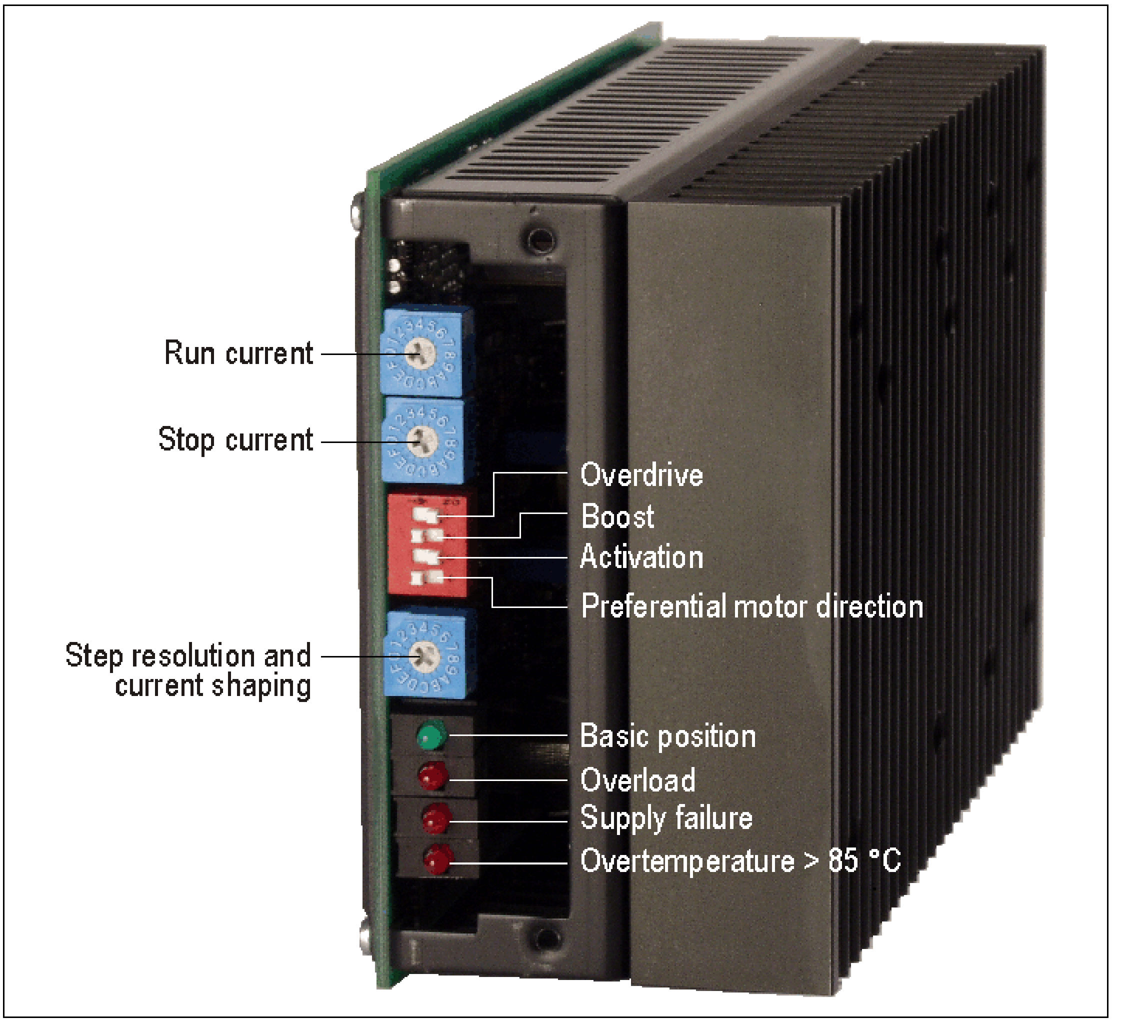


Fig. 2: Front view without panel

Motor currents from 1.1 to 15.4 A_{Peak}

Run and stop current can be individually set by rotary switches. The MSX automatically changes to the stop current, if there aren't any control pulse signals. The Boost current (130 % of the preset run current) can either be activated by the input $\overline{\text{Boost}}$ or is permanently switched on by DIP switch. The Overdrive is also activated by DIP switch.

DC Supply voltage

A DC voltage from 60 to 120 V_{DC} can be connected to the supply voltage pins.
Admissible range: 40 to 160 V_{DC}

Inputs

The inputs of the power stages MSX can be controlled with 5 V or 24 V input level via optocouplers.

The inputs $\overline{\text{Control pulse}}$, Motor direction, $\overline{\text{Boost}}$ and $\overline{\text{Activation}}$ are designed for Open-Collector controlling. The inputs are optically insulated from the MSX power supply voltage.

$\overline{\text{Reset}}$ can be added by plugging the J1 jumper on the board.

Outputs

Both MSX outputs $\overline{\text{Basic position}}$ and Error are optically insulated from the motor voltage, type open-collector Darlington.

Easy to mount and EMC compliant

The power stage MSX is designed for mounting in 19"/3U racks.
All wiring is connected to one 32-pin connector according to DIN 41612, version D.

1.2 Extent of Supply

The MSX is available in the following options:

Type MSX 120V	Version	ID-No.
MSX 52 (5 V) MSX 102 (5 V) MSX 152 (5 V)	Standard, replacement for MSO and MSO MINI	#10004902 #10004903 #10004904
MSX 52 (24 V) MSX 102 (24 V) MSX 152 (24 V)	Replacement for SMD	#10008751 #10008752 #10008753
MSX 52 (5 V-RESET) MSX 102 (5 V-RESET) MSX 152 (5 V-RESET)	Additional Reset input (Jumper plugged)	#10008754 #10008755 #10008756

Supplementary parts are available:

- Front panel (14 HP) with handle #10008562
- 32-pin connector #02000895
- G-MSX V1.1 adaptor board for easy connecting the MSX with connectors for motor cable, signal leads and supply voltage #10008712
- Damping SB 234 module for 90 V #02000748
- Damping SB 234 module for 120 V #02002165

Difference between MSX and MSO MINI		
	MSX	**MSO MINI**
Run and stop current setting	16-step rotary switches 0...F	4-pin DIP switches (16 combinations)
Reset input	Added input Reset by jumper	–
Pins 10ac of the 32-pin male multipoint connector	5 V or 24 V (see fig. 3)	+5 V_{DC}

1.3 Pin assignment

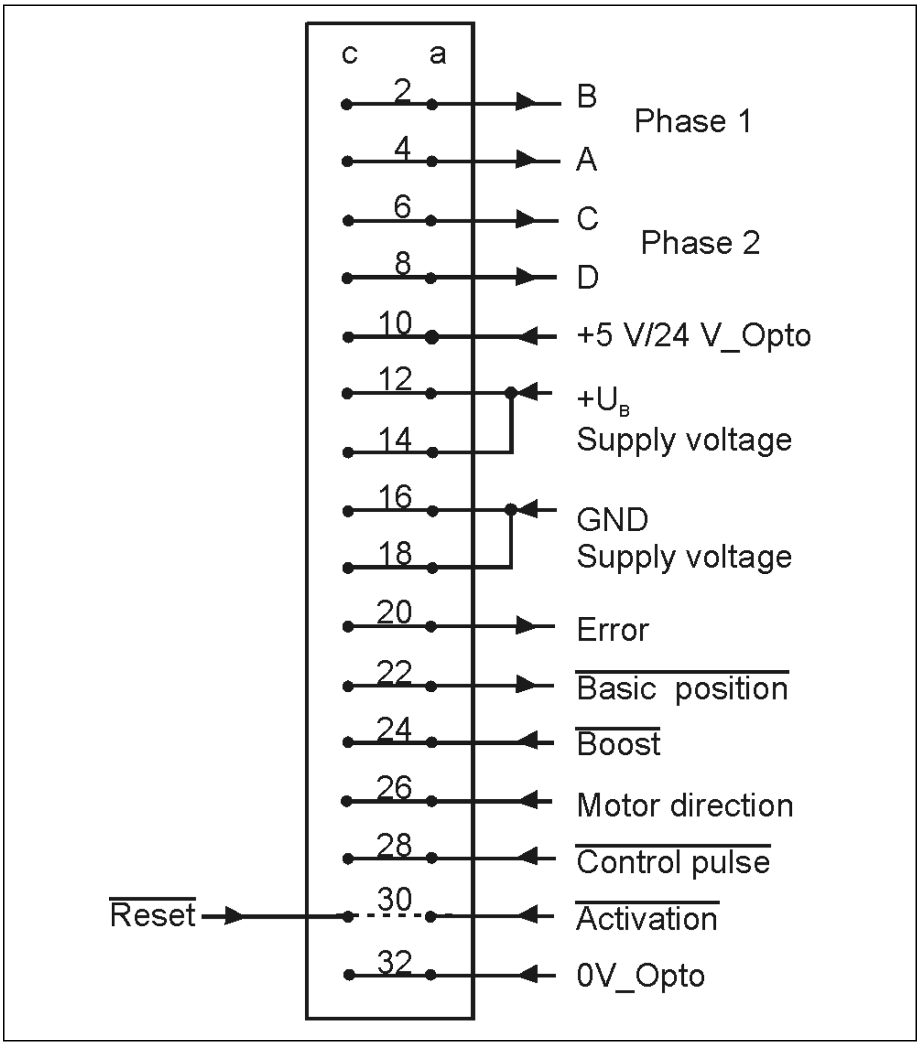


Fig. 3: 32-pin male multipoint connector acc. to DIN 41612, version D

Important:

The output currents must not exceed 10 $A_{r.m.s}$ during continuous operation to avoid overheating of the connector. Therefore, the BOOST function for phase current increase by 30% must not permanently used in MSX 152 with maximum current. Otherwise an additional ventilation of the connector is necessary.

1.4 Rotary Switches

Run and stop current, step resolution and current shaping can be set by the three setting switches behind the front panel.

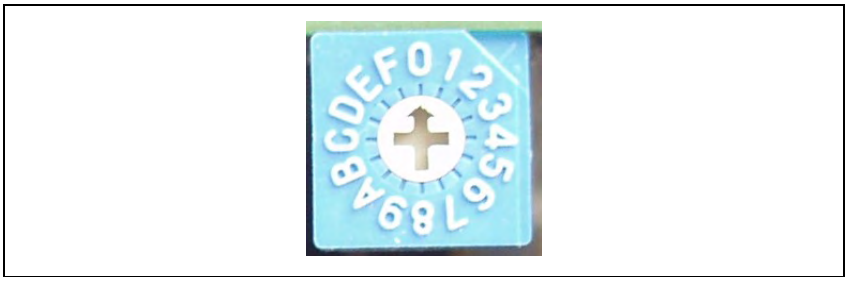


Fig. 4: 16-stepped rotary switch: setting 0...F

1.5 DIP Switches

Overdrive, Boost, Activation and Motor direction can be set by the four DIP switches behind the front panel.

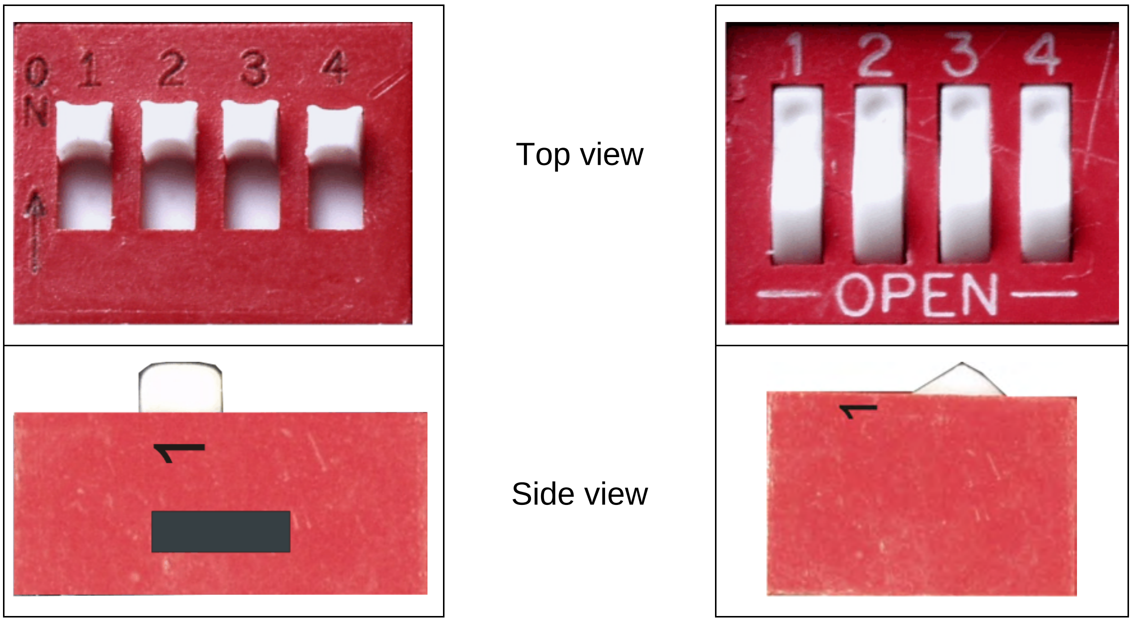


Fig. 5: Two types of DIP switches with switch position ON

1.6 LEDs

LED	shines	Meaning
Basic position (Zero Signal)	green	The signal Basic position is generated. Every 8 pulses in the half step mode etc.
Overload	red	Overload error in the MSX: A short-circuit over or between the motor phases or towards GND or $+U_B$ has occured.
Supply Failure	red	Supply voltage < 40 V or > 160 V • The supply voltage at the internal load capacitor has dropped under 40 V. • An electronic current limitation or a not adequate smoothing of the DC voltage can be the reason for a short time break of the supply voltage • The rotatory energy is supplied back as electric energy to the power stage. Overvoltage in the internal load capacitor will be the result. The error message ‘overload’ can be caused by operation with maximum power supply (120 V), by motor mass ineratia (> 1.3×10^{-4} kgm^2) and high speed (> 20 rev/s).
> 85 °C	red	The temperature at the heat sink of the transistors is too high (> 85° C). The power stage is powered off.

1.7 Block Diagram

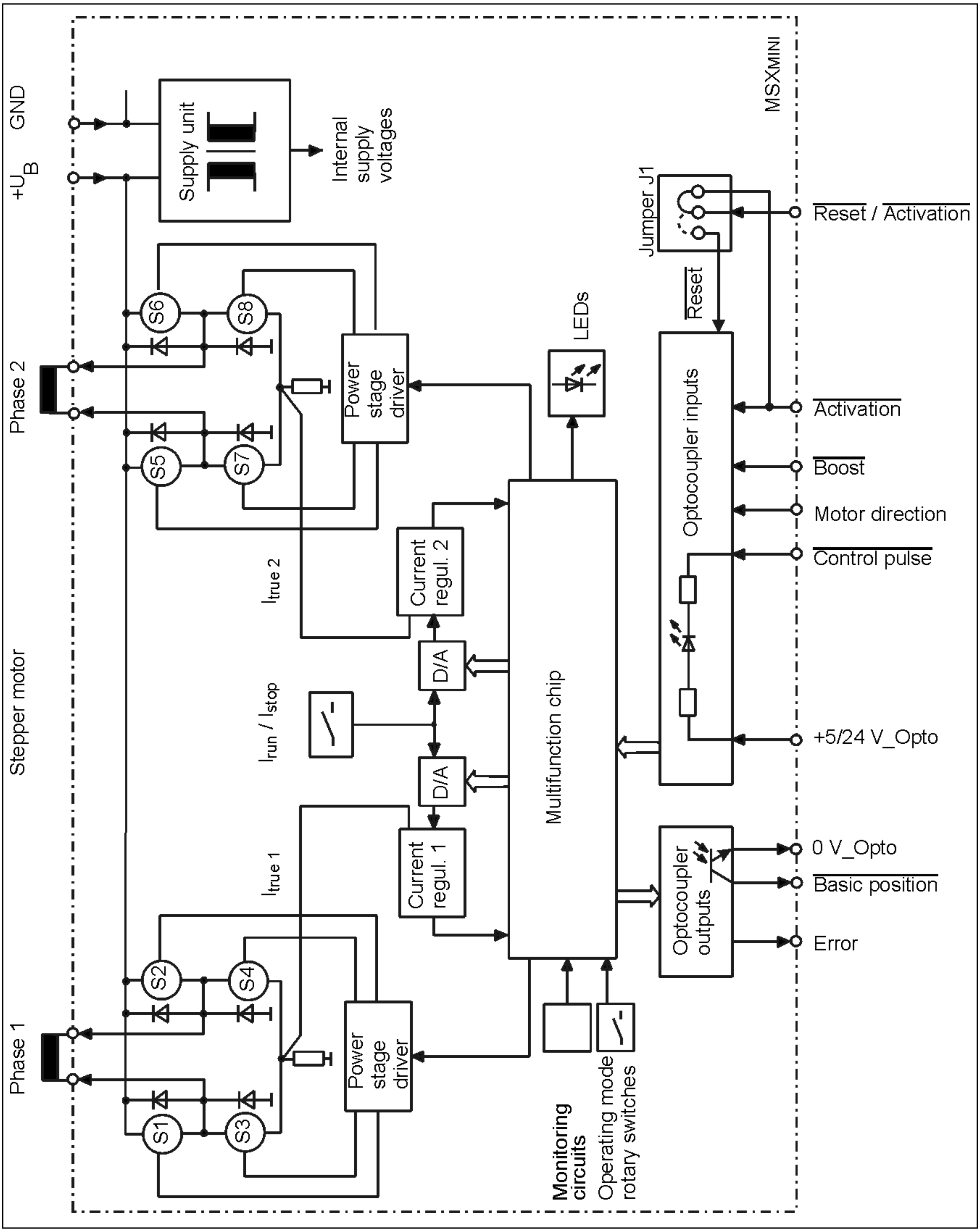


Fig. 6: MSX block diagram

2 Technical Data Table

Technical Data			
Stepper motor	Two-phase stepper motors with 4, 6 or 8-lead wiring scheme Winding resistance < 10 Ohm Winding inductance should be higher than 0.5 mH per phase		
Step resolution and Current shape	Step resolution and Current shape are set by rotary switch: Step resolution: 1/1, 1/2, 1/4, 1/5, 1/10, 1/20 of a full step with or without torque compensation (DMA), current shaping (CS), BLOW UP Factory settings: Rotary switch ‚6‘: Half step with DMA without CS		
Phase currents	Run and stop current can individually be set by rotary switches. Factory settings: Rotary switch run current: ‚F‘ Rotary switch stop current: ‚3‘		
	MSX 52	**MSX 102**	**MSX 152**
without Boost	0.8 to 2.8 $A_{r.m.s.}$	1.6 to 5.6 $A_{r.m.s.}$	2.4 to 8.4 $A_{r.m.s.}$
with Boost	1.0 to 3.6 $A_{r.m.s.}$	2.1 to 7.3 $A_{r.m.s.}$	3.1 to 10.9 $A_{r.m.s.}$
I_{max}	5.1 A_{Peak}	10.3 A_{Peak}	15.4 A_{Peak}
Supply voltage $+U_B$	nominal: +60 to 120 V_{DC} Admissible range: 40 to 160 V_{DC} Reinforced or double insulation between mains and secondary circuit.		
Supply voltage optocoupler	+5/24V_Opto towards 0V_Opto: 5 or 24 V		
$I_{Supply\ DC}$	The power requirement extensively depends on the motor current and the motor. The value is limited to:		
	3 A	6 A	10 A

Technical Data	
Inputs	All inputs include an optocoupler with series resistors for 5 V or 24 V-supply voltage. The signals are active, when the optocoupler is energized. Optocoupler input current is about 10 mA for MSX 5 V standard version or 5 mA for MSX 24 V version
$\overline{\text{Control pulse}}$	Maximum step frequency: 500 kHz Minimum pulse width: 1 µs The step is executed with the falling flank of the control pulse.
Motor direction	When the optocoupler is energized, the motor rotates in the reverse direction (as compared to the preferential motor direction selected).
$\overline{\text{Boost}}$	When the optocoupler is energized, the MSX increases the run and stop current by 30%.The Boost function can permanently be activated by the DIP switch.
$\overline{\text{Activation}}$	When the optocoupler is energized, the motor current is activated.
$\overline{\text{Reset}}$	Is available only, when J1 jumper is plugged in position RESET on the board. The power stage is set to an initial state. A signal Basic position is generated for each Reset.
Outputs	Optically insulated from the motor voltage, Type Open-Collector I_{max} = 20 mA, U_{max} = 45 V, $U_{CE\ sat}$ at 20 mA < 0.6 V
$\overline{\text{Basic position}}$	Zero crossing of the internal ring counter is signalized; active LOW (see chap. 9.1) Basic position signal after
Full step	every 4th control pulse
Half step	every 8th control pulse
1/4 step	every 16th control pulse
1/5 step	every 20th control pulse
1/10 step	every 40th control pulse
1/20 step	every 80th control pulse

Technical Data			
Error	Supply voltage < 40 V_{DC} or > 160 V_{DC} Overtemperature (T > 85° C) Overcurrent, short circuit The power stage is deactivated in case of an error message.		
Cooling	**MSX 52**	**MSX 102**	**MSX 152**
	Convection	Convection under appropriate conditions, if not, fan with 50 m^3/h air flow	Fan with 50 m^3/h air flow
Ambient temperatures	Operation: 4 to +40 °C *) Storage: –25 to +55 °C Transport: –25 to +85 °C *) We recommend an additional cooling in case of higher operation temperatures.		
Environmental requirements	The MSX has been designed for degree of pollution 2 acc. to EN 50178.		
Admissible heat sink temperature	max. 85 °C The power stage is deactivated if the admissible heat sink temperature is exceeded. The LED shines red.		
Maximum motor lead length	max. 50 m		
Lead cross section of the motor cable	Dependent on the motor current and the motor lead length: 0.1 mm^2 per 1 Ampere motor current		
Connector	32-pin connector acc. to DIN 41 612, version D		
Weight with front panel	about 970 g		

3 To Consider Before Installation

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

3.1 Qualified Personnel

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

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

WARNING !

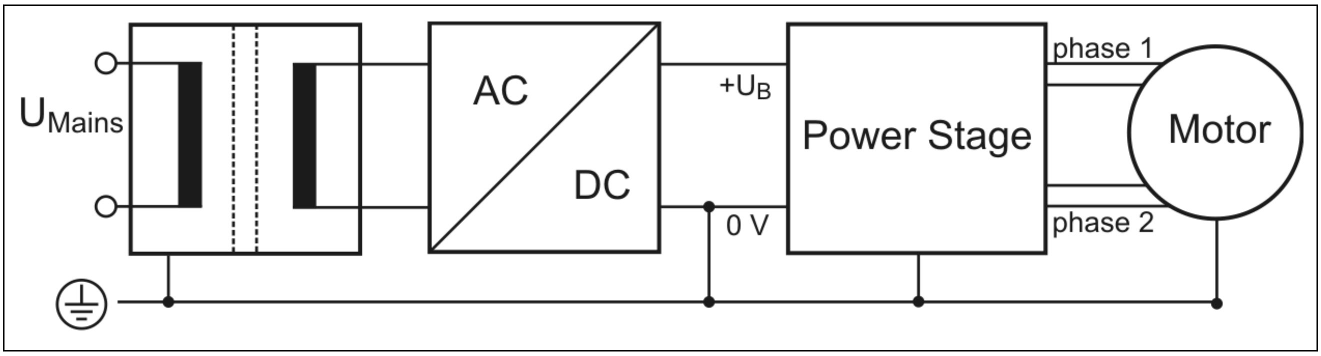
By persons without the proper training and qualification damages to devices and persons might result!

3.2 Safety Instructions

1. The MSX must only be operated if MSX housing and motor housing are connected to protective earth.
2. The transformer **must** be constructed with reinforced or double insulation to avoid dangerous touch voltages (50 V_{AC} and 120 V_{DC}) in case of an error.
3. **If you need to remove the front panel or to open the device:**
   Up to 3 minutes after turning off the supply voltage, dangerous voltages may still exist within the device.
4. As long as the MSX is connected to supply voltage, a hazardous voltage level is present at the concerned pins, even if the motor is not wired.
5. Always switch off the supply voltage if you connect or disconnect any wires or connectors at the MSX.
   Most important:
   Do not unplug the MSX while powered. Danger of electric arcing.
6. Clearing the inputs $\overline{\text{Activation}}$ or $\overline{\text{Reset}}$ is no safe separation in the emergency case.
   The voltage supply has to be interrupted for switching off the drive safely.
7. The surface of the MSX may reach temperatures of more than 85 °C during operation. Danger of injury if touching the surface!

3.3 Protective Measure for Power Stage Operation

The MSX must be operated according to VDE 0100 part 200 with protection by automatic disconnection. Therefore, the motor, power stage, `0 V` and each equipment has to be grounded.



When protection by automatic disconnection (EN 61140, VDE 0100, part 410) is used for power stages with definite voltage > 50 V_{AC} or $+U_B$ > 70 V_{DC}, it is necessary:

Only use motors, which are checked according to EN 60034-1 (500 V_{AC} + twice determined voltage).

The motors must have a protective conductor clamp (EN 60034).

3.4 Putting into Service

- Check the output voltage of the supply unit before plugging in the MSX unit.

- Never plug or unplug the unit when powered.

- Excessive heating of the motor is probably caused by setting too high motor current. High motor temperature could also be caused by permanent activation of the Boost function.

- If the motor stops during acceleration, reduce the acceleration and/or the maximum frequency at the control pulse input. Motor stop may also occur if the nominal motor current is set incorrectly.

- In case of strong motor resonance, various measures can be taken:
  – Select a higher step resolution
  – Change the run frequency
  – Change the acceleration frequency
  – Reduce the motor current
  Resonance effects occur more often in the full step mode.

- If the positioning of the motor is incorrect, this may be caused by perturbations on the pulse input, or by excessive acceleration or motor run frequencies. If the deceleration is too high, the motor risks mispositioning by multiples of 4 steps (desynchronisation).

- If the supply unit is equipped with a regulation transformer, the voltage of which increases slowly, a ‘supply voltage’ error can appear. The same error may appear when using a regulated supply unit with current limitation.

- If several red LEDs shine red after power on or if the green LED ‚Basic position‘ does not shine, the unit is probably out of order.

- Make always sure before disconnecting that all LEDs don‘t shine. The LED ‚Supply failure‘ must shine for a short time after power-down.

4 Dimensions

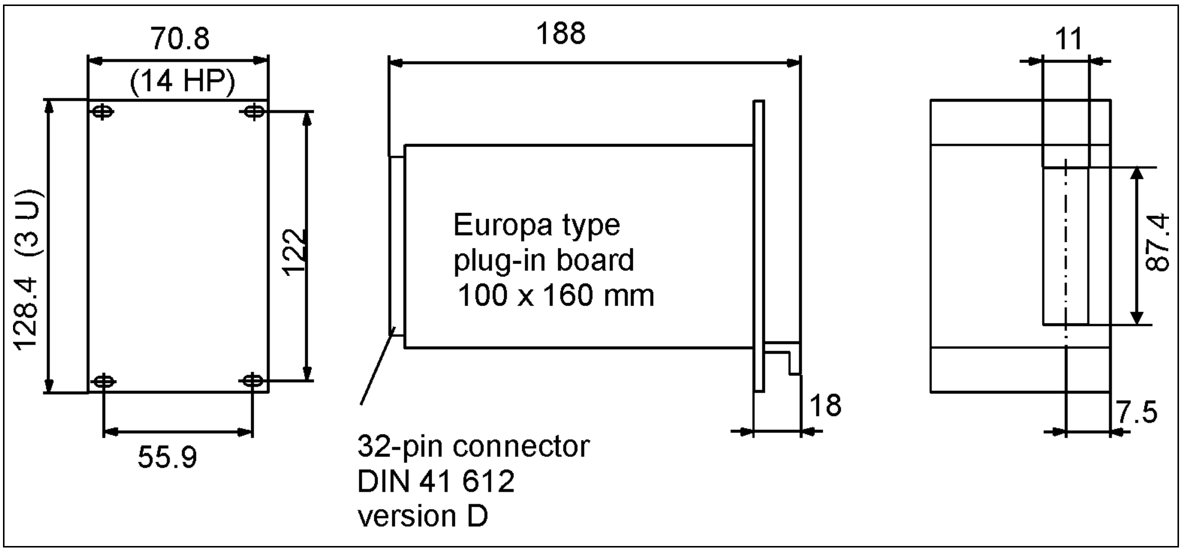


Fig. 7: Dimensions

5 Mains Supply Unit

The MSX power stage can be supplied by means of an unregulated filtered DC voltage from 60 to 120 V_{DC}.

Admissible voltage range: 40 to 160 V_{DC}

The voltage must not drop under 40 V or rise over 160 V, not even for a short time (> 1 msec). If the limits are exceeded the error output opens. The drive is deactivated at the same time.

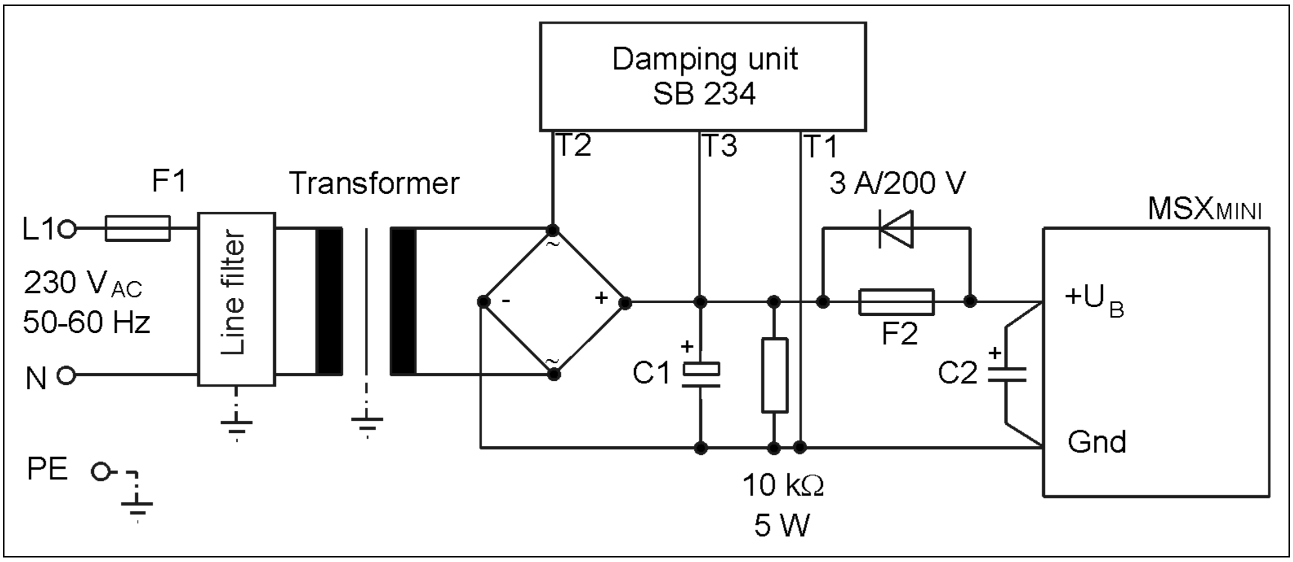


Fig. 8: Mains supply unit

A line filter is recommended with the following insert loss at 50Ω in the range of 0.15...30 MHz:

f/MHz	0.15	0.5	1	2	5	10	20	30
a/dB (line-to-ground) (asymmetr. signals)	36	47	42	42	40	42	42	45
a/dB (line-to-line) (symmetr. signals)	52	70	70	70	65	55	50	60

e. g. CORCOM 10ET1

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

The transformer must be constructed with reinforced or double insulation.

The calculation of the fuse F2 depends on the preset phase current and the motor load:
Withstand voltage >= 200 V

Recommended values:

MSX 52	MSX 102	MSX 152
T5 A	T8 A	T10 A

For the load capacitor, a value of 1,000 µF per Ampere of motor current should be calculated.

5.1 Calculation and Connection

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

1. **All** mating connector terminals indicated in the connecting diagram must be connected to the cable.

   Example: + U_B must be connected to the pins 12a, 12c, 14a and 14c.

2. The cable cross section of the supply wires depends on the motor current. We recommend: 0.1 mm^2 per 1 Ampere motor current. If possible, twist into pairs the mains supply leads and the phase leads.

3. If the supply leads between the mains and the MSX are longer than 500 mm, connect a capacitor (C2, approx. 68 µF/200 V - refer to figure 8) as close as possible to the connector. This capacitor must be adapted for switching applications and have a high ampacity (High Ripple Current) e.g. Rubycon series BXC, 68 µF /200 V. We recommend to parallel six capacitors with every 68 µF/200 V for increasing the life-time of the MSX capacitor to get a total of 408 µF/200 V.

4. Transformer, load capacitor:

	MSX 52	**MSX 102**	**MSX 152**
Transformer U I	 85 V_{AC} 5 A	 85 V_{AC} 10 A	 85 V_{AC} 14 A
Load capacitor C1	3300 µF	6800 µF	10 000 µF

   The power indications for the transformer and the load capacitor are "worst-case" values, i.e.: computed for a maximum motor power, permanent BOOST function, activation and a 100 % load factor.
   The true values must be determined in function of the real operating conditions.
   For the load capacitor, a value of 1,000 µF per Amp of motor current can be used.
   The thermal limit values of the transformer must never be exceeded.
   The internal resistance of the supply module must be good enough to avoid that the DC voltage drops more than 15 % below the peak value, at maximum load. It is obtainable with a transformer regulation of 3 %.

5. Rectifier:
   The rectifier must be adapted to dissipation losses up to 2 Watts per Amp.
   If necessary, mount a heat sink.

6. SB 234 damping module:
   The operating voltage range of the power stage is wide enough compared to the nominal voltage. Even in case of high voltage variations or voltage drops (motor feeds energy back and the load capacitor voltage increases), no error signal SUPPLY FAILURE should be generated. If despite these precautions such an error appears, in particular in multi-axis systems and/or systems with low inductance motors, the use of a type SB 234 damping module is recommended.
   If an error signal SUPPLY FAILURE arises, prior to any other action, check that the supply voltage is within the required nominal range (this includes voltage peaks).

5.2 Insulation Overview

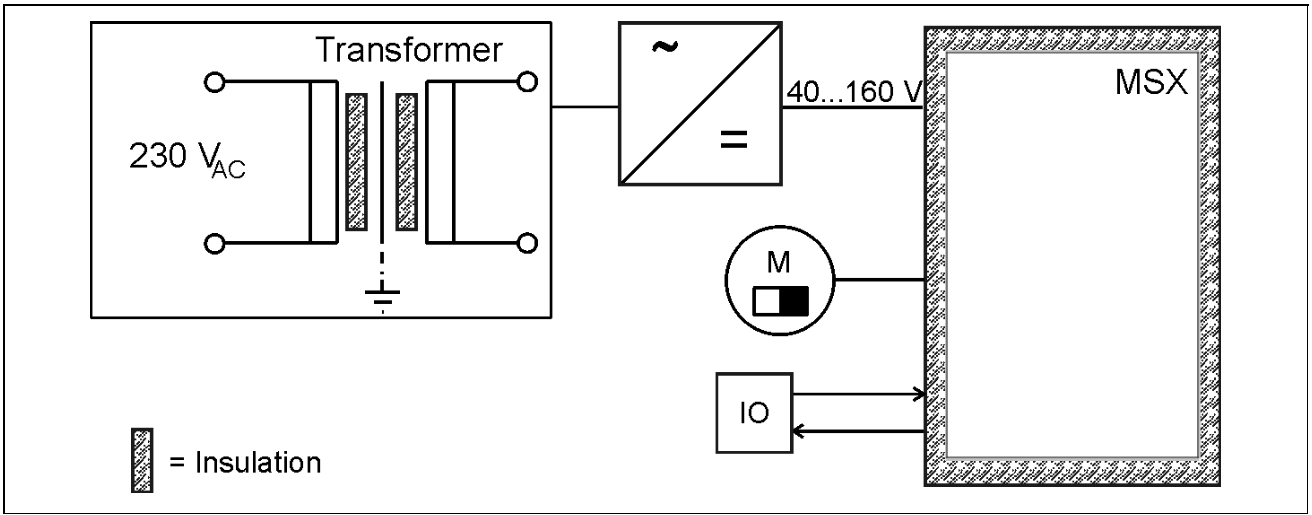


Fig. 9: Insulation MSX

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

The insulation of the MSX fulfills the requirements of a basic insulation for non-mains-circuits for voltages up to 200 V.

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

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

6 Motor Connection

The following chapter describes how to wire different types of Two-phase stepper motors. MSX stepper motor power stages may be connected to stepper motors with 1.1 to 15.4 A_{Peak} phase current.

The stepper motor winding resistance should be less than 10 Ohm for full power.

The winding inductivity of one phase should be above than 0.5 mH.

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

For 6-lead stepper motors, wiring scheme (3) with serial windings is recommended. If wiring scheme (3) cannot be used because of the motor construction, the motor may be operated with only two of the four windings energized according to wiring scheme (4).

Warning:

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

Motor time constant τ:

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

The total inductivity L_{total} is equal to the winding inductivity in a parallel circuit, because of interlinked inductivities.
L_{ges}= 4 x L applies to a serial circuit.

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

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

6.1 Shielding

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

The power supply unit in which the MSX is built-in and the motor should be connected to ground by a central earthing tab.

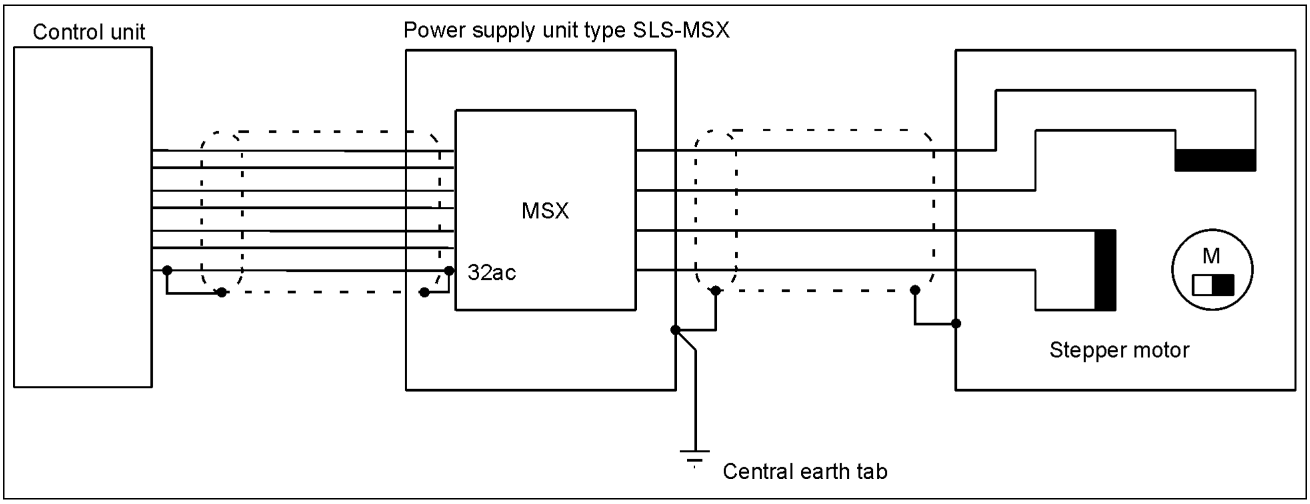


Fig. 10: Motor lead shielding

6.2 Wiring Schemes

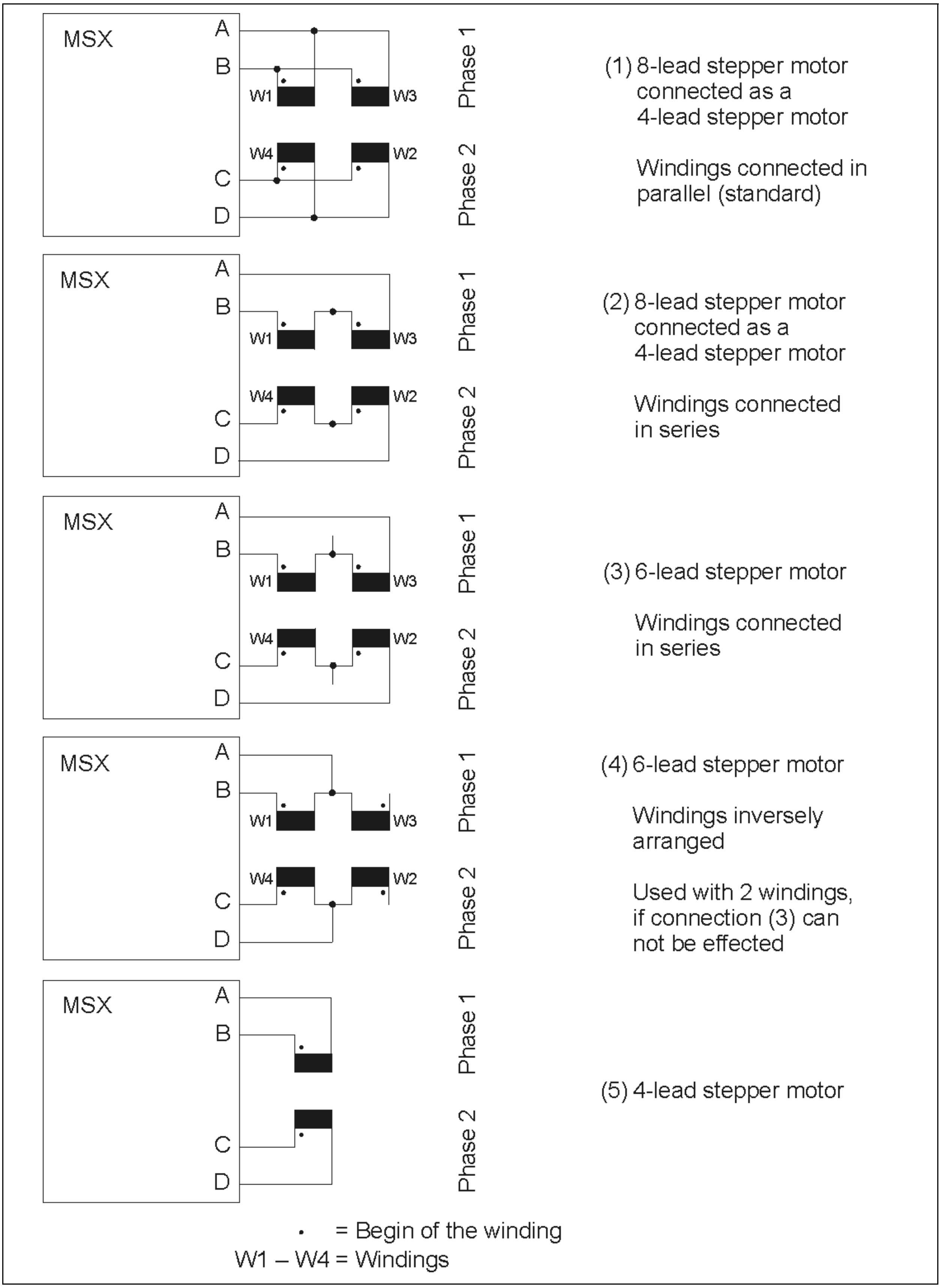


Fig. 11: Connection diagrams for 4-, 6- and 8-wire stepper motors

6.3 Motor Cable

We recommend to wire the stepper motor with a 5-lead cable with shielding mesh. For optimum electromagnetic compatibility (EMC), the cable should not be interrupted by additional connectors or screw terminals.

The protective earth wire (green/yellow) of the motor cable should be connected to the earthing screw near the motor connector of the MSX plug-in power stage unit. The green/yellow wire should be connected to the motor's earthing screw at the other motor cable end.

We recommend the following lead cross section of the motor cable**:**

Power stage	**Lead cross section**
MSX 52	0.75 mm^2
MSX 102	1.00 mm^2
MSX 152	1.50 mm^2

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

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

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

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

7 Rotary Switches and DIP Switches

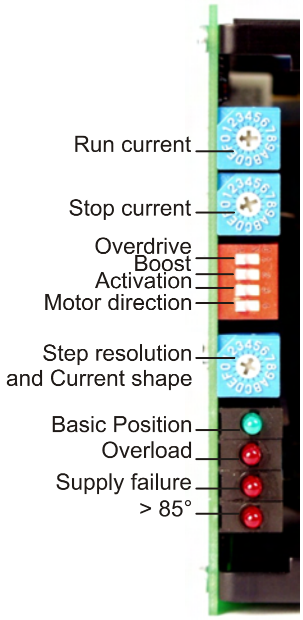
Run and stop current can be individually set by both rotary switches. Besides, Step resolution and Current shape can be selected by the third one.

Run and stop current is increased by 30 % with Boost.

Factory settings	
Rotary switches	**Position**
Run current	F
Stop current	3
Step resolution / Current Shape	6 (Half step with torque compensation without CS)
DIP switches	
1	Overdrive ON
2	Boost OFF
3	Activation ON
4	Motor direction OFF
Jumper	in Activation position (for options standard and GND)

7.1 Motor Current Rotary Switches

Run and Stop current rotary switches			
Switch position	Phase current in $A_{r.m.s.}$		
	MSX 52	MSX 102	MSX 152
0	0.8	1.6	2.4
1	0.9	1.9	2.8
2	1.1	2.1	3.2
3	1.2	2.4	3.6
4	1.3	2.7	4.0
5	1.5	2.9	4.4
6	1.6	3.2	4.8
7	1.7	3.5	5.2
8	1.9	3.7	5.6
9	2.0	4.0	6.0
A	2.1	4.3	6.4
B	2.3	4.5	6.8
C	2.4	4.8	7.2
D	2.5	5.1	7.6
E	2.7	5.3	8.0
F	2.8	5.6	8.4
Factory settings			



- The stop current is normally set to 40-50% of the run current, to keep the motor temperature as low as possible.
- The table values refer to current values, if both motor phases are activated. The current in one phase is calculated as: table value x $\sqrt{2}$
- Maximum run current/stop current : MSX 52 : 2.8 A x $\sqrt{2}$ x 1.3 = 5.1 A
  MSX 102 : 5.6 A x $\sqrt{2}$ x 1.3 = 10.3 A
  MSX 152 : 8.4 A x $\sqrt{2}$ x 1.3 = 15.4 A

If Step resolution or Current shape are changed during power-on, the switch position of the MSX is only taken in Basic position.

7.2 Step Resolution and Current Shape Rotary Switch

The rotary switch below the DIP switches is used to set the phase current profile.

Step resolution and Current Shape Rotary switch			
Switch position	**Current Shape**		
0	Full step		
1	Half step	with DMA	with CS
2	Ministep	sinusoidal	1/4 with CS
3	Ministep	sinusoidal	1/5 with CS
4	Ministep	sinusoidal	1/10 with CS
5	Ministep	sinusoidal	1/20 with CS
6	Half step	with DMA	without CS
7	Ministep	sinusoidal	1/4 without CS
8	Ministep	sinusoidal	1/5 without CS
9	Ministep	sinusoidal	1/10 without CS
A	Ministep	sinusoidal	1/20 without CS
B	Ministep	sinusoidal	1/4 with CS and BLOW UP
C	Ministep	sinusoidal	1/5 with CS and BLOW UP
D	Ministep	sinusoidal	1/10 with CS and BLOW UP
E	Ministep	sinusoidal	1/20 with CS and BLOW UP
F	Half step	conventionel	
	DMA= Torque compensation		
	CS= Current Shaping		
	BLOW UP= Optimization of the current shape		
	Factory settings		

The optimum current shape should be determined, in each case, by testing various adjustments.

7.3 DIP Switches

The DIP Switches are located behind the front panel beneath the rotary switches for changing the operating modes.

DIP-Switches		**Function**	**Position**	**Meaning**
	1	Overdrive	ON	Overdrive activated
	2	Boost	ON	Boost activated
	3	Activation	ON	Motor activation on
	4	Motor direction	ON	Reversal of the preferential motor direction
Factory setting: 1:ON, 2:OFF, 3:ON, 4:OFF				

8 Inputs

The control inputs $\overline{\text{Control pulse}}$, Motor direction, $\overline{\text{Boost}}$, $\overline{\text{Activation}}$ and $\overline{\text{Reset}}$ are electrically insulated by optocoupler from the MSX supply voltage ($+U_B$). This assures best noise suppression between control and power circuit. The signals are active, when current flows through the optocoupler.

8.1 MSX 5 V Standard and MSX 5 V RESET Inputs

All inputs include an optocoupler with series resistors 2 x 180 Ω. The optocoupler inputs are internally connected via 180 Ω to +5 V.

The MSX inputs are controlled via open-collector. The supply voltage of the optocouplers, 5 or 24 V, is connected to pin 10ac (admissible range: 4...32 V_{DC}).

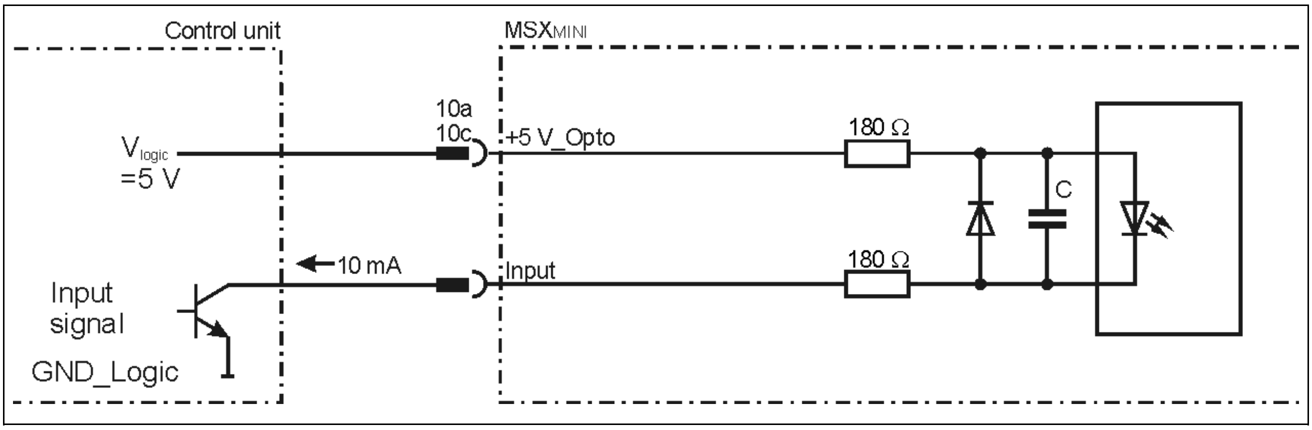


Fig. 12: Open Collector Controlling

8.2 MSX 24 V Input

All inputs include an optocoupler with series resistors 2 x 2.2 kΩ.

The MSX inputs are controlled via open-collector. The supply voltage of the optocouplers, of 24 V, is connected to pin 10ac.

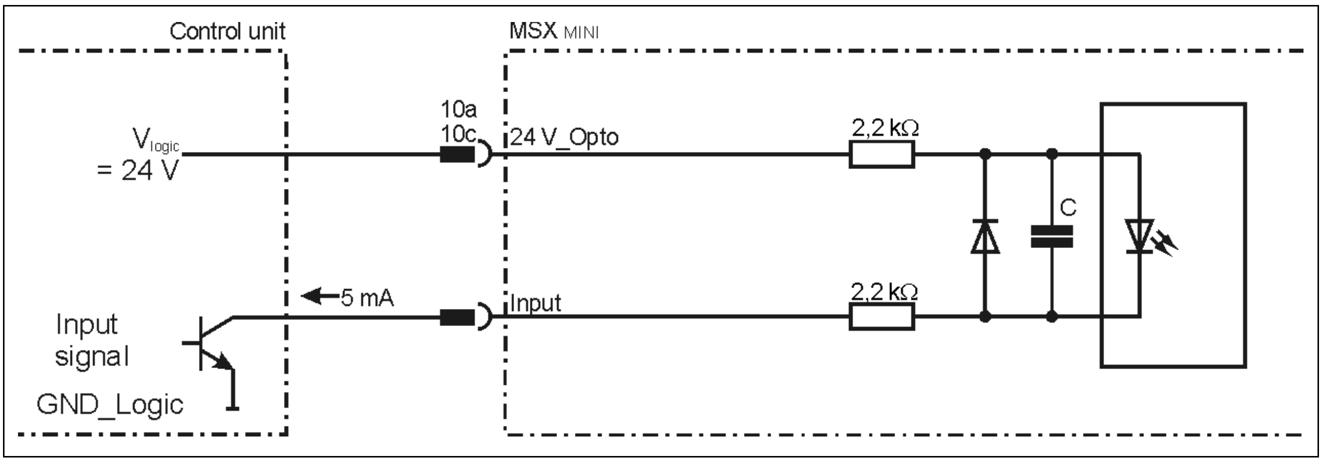


Fig. 13: Open Connector controlling of 24 V

8.3 Control pulse Input

Maximum step frequency: 500 kHz

Minimum pulse width: 1 µs

A negative control pulse of 1 µs causes a motor step. The step is done with the falling flank of the control pulse and the current is changed from run to stop current. If the time between two control pulses is more than 40 ms, the stop current is activated.

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

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

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

8.4 Motor Direction Input

This signal sets the direction of the motor.

If the input optocoupler is **not** energized, the motor rotates in the preferential direction. If the input optocoupler is powered, the selected motor direction is reversed.

The signal must only be modified when the motor is at a standstill or turns with the frequency within the start/stop frequency.

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

Important: The signal must be constantly active 1 µs after the falling flank of the control pulse (see fig.13).

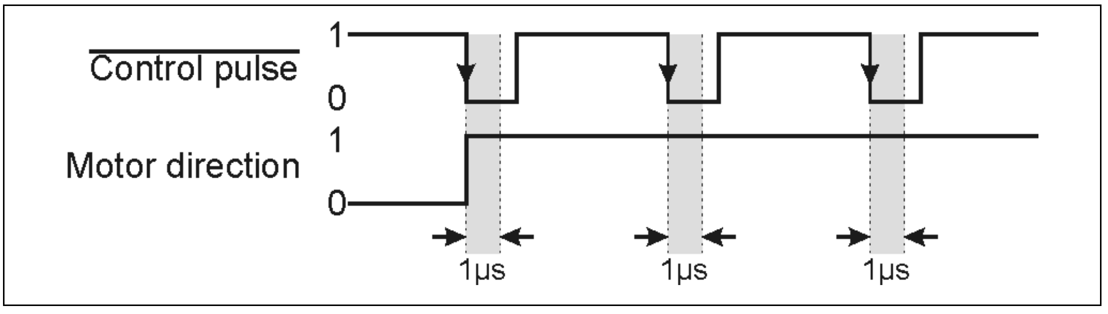


Fig. 14: Control pulse of MSX

The preferential motor direction is set by the MOTOR DIRECTION DIP switch (behind the front panel) relating to the logic level.

8.5 $\overline{\text{Boost}}$ Input

If the input optocoupler is energized the MSX changes Boost current. The power stage increases the run and stop current by 30%.

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

As long as the $\overline{\text{Boost}}$ input is energized, the run and stop current will always be 30% higher. The Boost function can permanently be switched on by the BOOST DIP switch.

Also see appendix A2.

8.6 $\overline{\text{Activation}}$ Input

If the input isn't activated (optocoupler isn't energized), the motor current is switched off.

This input (pin 30ac) is useful, for instance, during maintenance operations to switch the power stage off, without having to disconnect it physically from the mains. It is possible now to rotate the motor by hand slowly.

WARNING!

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

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

Important:

The $\overline{\text{Activation}}$ input can only be used, if the ACTIVATION DIP switch is switched off (OFF). When the J1 jumper on the board is plugged in position Reset, the $\overline{\text{Activation}}$ input can only be activated via pin 30a.
See chap. 1.2 and 1.6.

8.7 $\overline{\text{Reset}}$ Input

The $\overline{\text{Reset}}$ input only is available, when J1 jumper is plugged in position Reset on the board. $\overline{\text{Reset}}$ can be activated by the pin 30c.

See chap. 1.2 and figure 14.

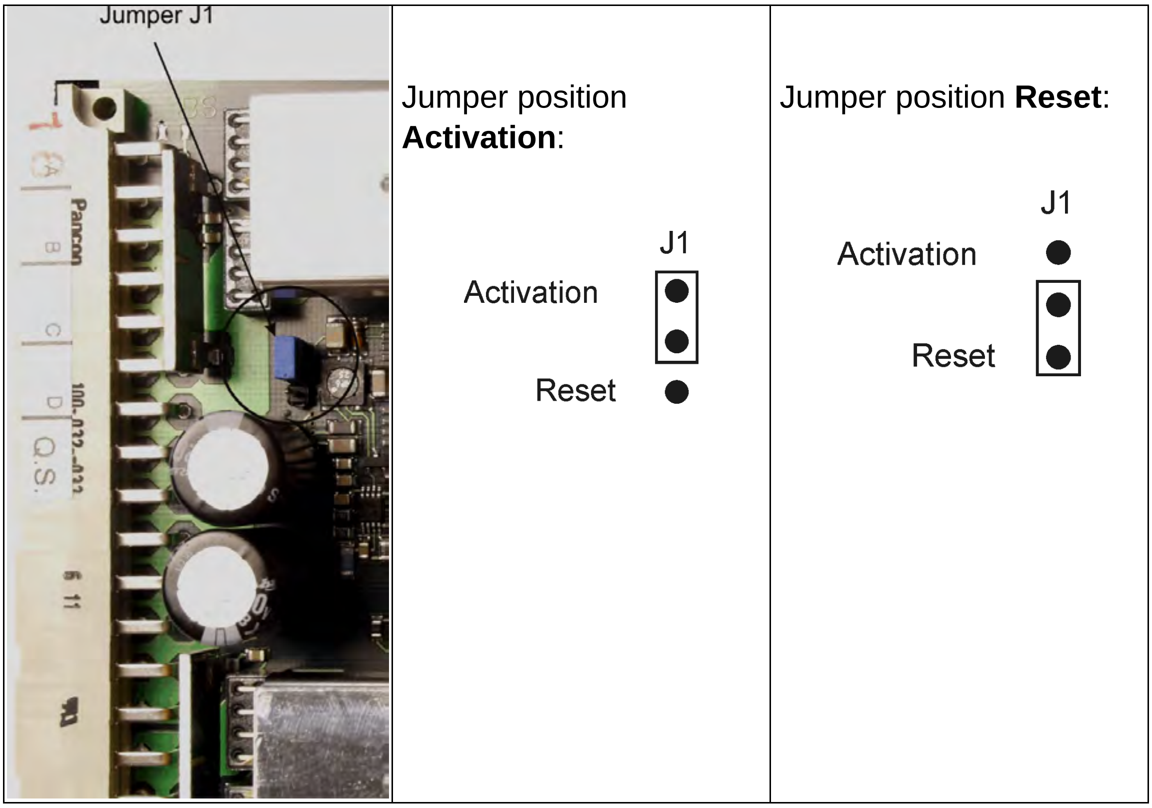


Fig. 15: Board with J1 jumper

The power stage is set to a defined initial state with $\overline{\text{Reset}}$ =0 (low active), that means that all error messages and the ring counter are reset. Then, the ring counter is in basic position. Both motor phases are energized by the same current value in basic position independent of the step resolution.

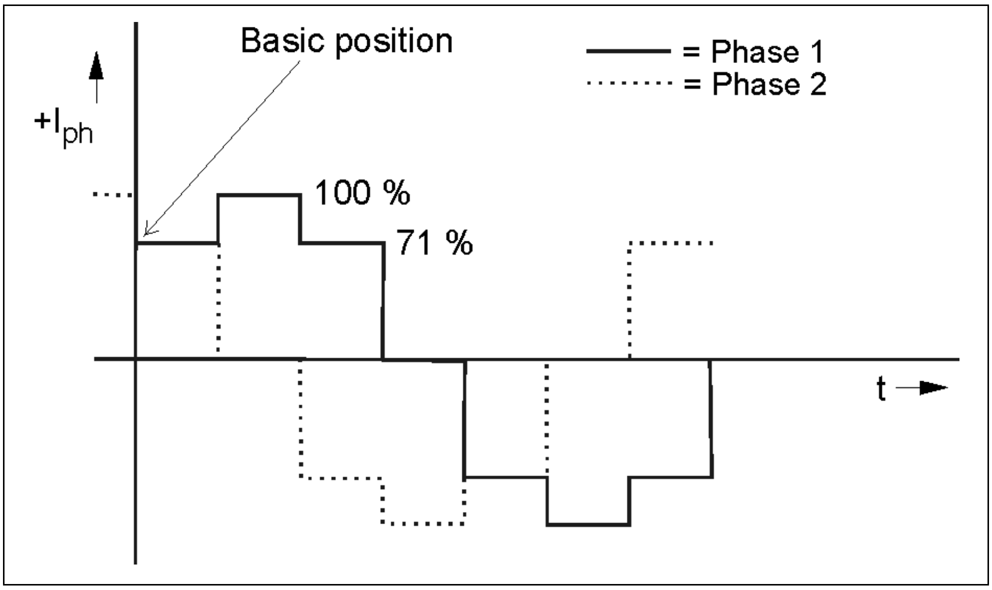


Fig. 16: Motor phases in basic position (half step)

9 Outputs

Open-Collector-Darlington outputs insulated by means of optocoupler

I_{max} = 20 mA, U_{max} = 45 V, UCE_{sat} at 20 mA < 0.6 V

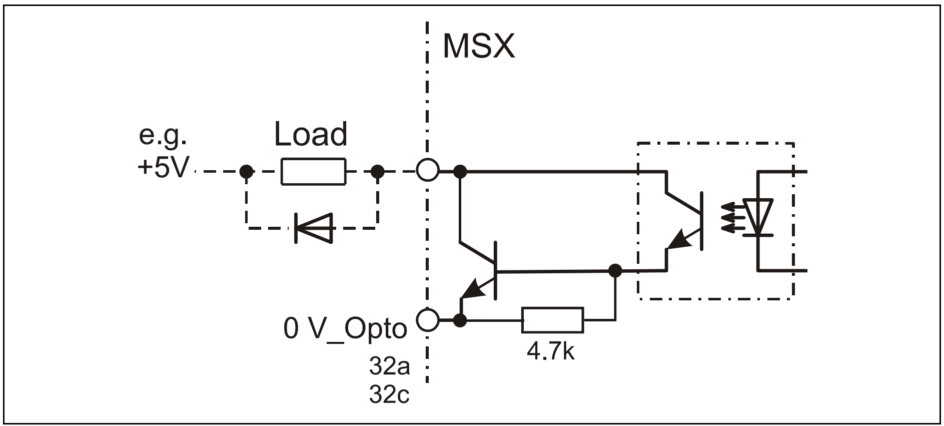


Fig. 17: Output wiring diagram

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

9.1 $\overline{\text{Basic position}}$ Output

This signal is generated when the internal ring counter passes through zero, after the unit is switched on and after a reset.

Every …. is generated	for the step resolution
4th control pulse	Full step
8th control pulse	Half step
16th control pulse	1/4-step
20th control pulse	1/5- step
40th control pulse	1/10- step
80th. control pulse	1/20- step

The basic position signal can be used in combination with a limit switch to determine the machine's zero.

$\overline{\text{Basic position}}$ (ZERO SIGNAL) is displayed by the green LED on the MSX front panel. Basic position is also signaled during switch-on, unless an error message.

Remark:

If the motor is not energized, the $\overline{\text{Basic position}}$ signal is generated anyway.

9.2 Error Output

The Error output is active high to detect power failure and cable break.

This output is active, when the following limits are exceeded or are fallen below. Simultaneously, the motor is deactivated:

Limits				Error message
	MSX 52	**MSX 102**	**MSX 152**	
Motor current	> 8.4 A	> 16.8 A	> 25.2 A	Overload
Supply voltage	< 40 V or > 160 V			Supply failure
Heat sink temperature	> 85°C			Overtemperature

The red LED OVERLOAD shines e.g. in case of motor short-circuit or if the time delay during deceleration is too long.

The red LED SUPPLY FAILURE shines, when the supply voltage is out of the admissible range 40...160 V. Danger of destroying the component in case of 200 V supply voltage!

The power stage needs sufficient time for cooling in case of ‚OVERTEMPERATURE’ (>85°C).

The supply voltage must powered off to reset the protective circuit after activation. Switch on again only then, as soon as all LEDs are off!

Alternatively, it is possible to plug the J1 jumper on position Reset and activate the $\overline{\text{Reset}}$ signal (low active) via pin 30c of the connector.

Appendix A: Technical Details

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

A1 FULL STEP / HALF STEP / MINISTEP

FULL STEP

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

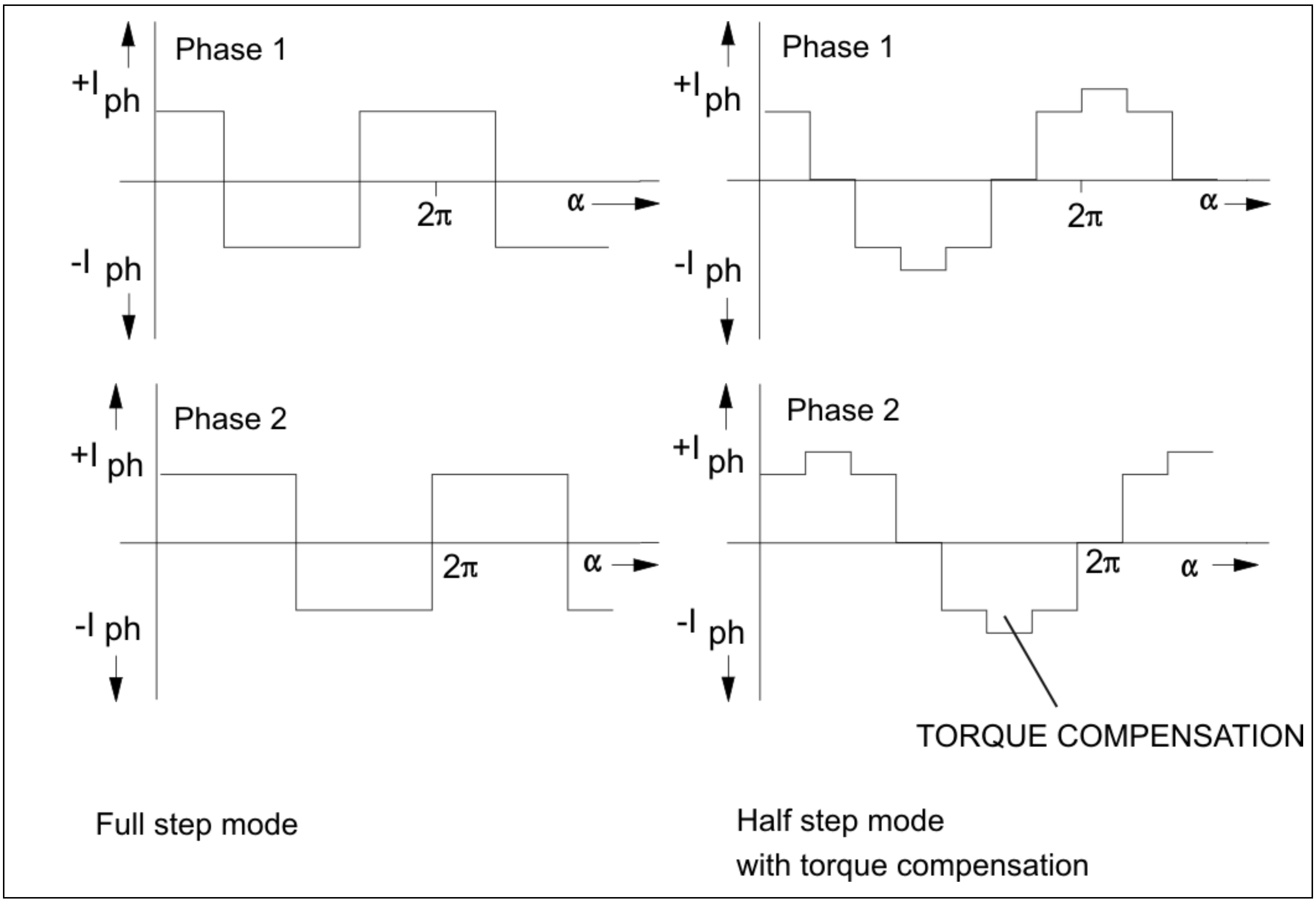


Fig. 18: Phase current curves

HALF STEP

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

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

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

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

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

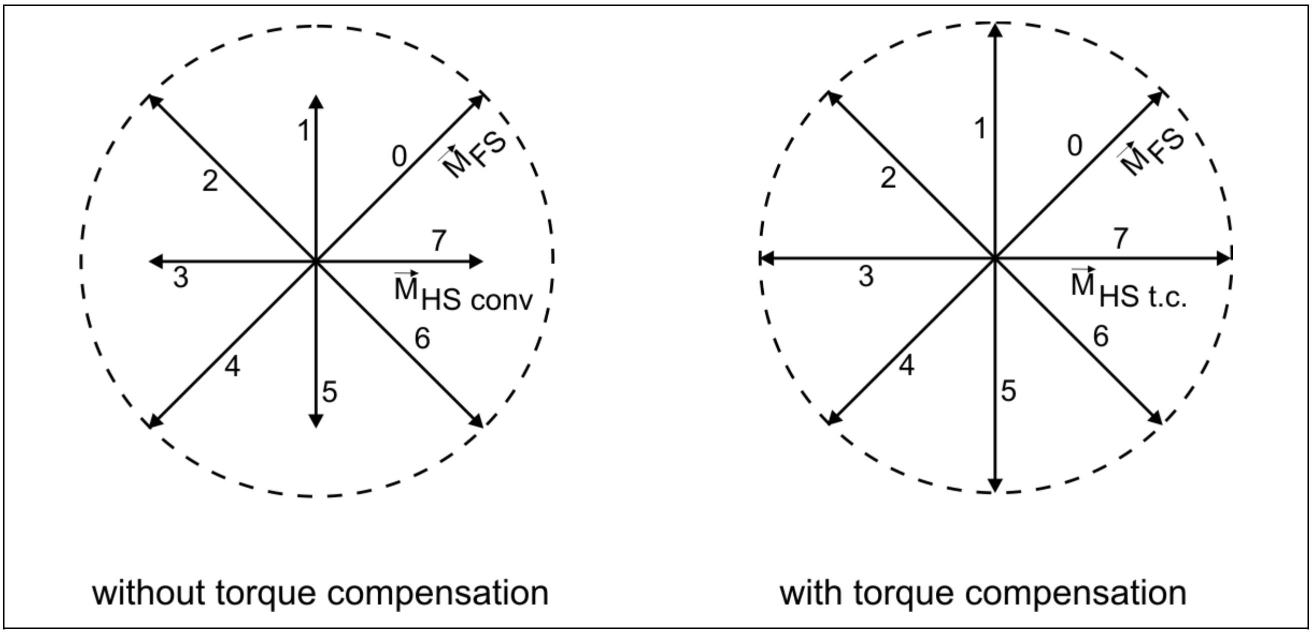


Fig. 19: Holding torques without/with torque compensation

MINISTEP

The MSX power stage increases the step resolution by a factor 2, 4, 5, 10 or 20 of a full step – MINISTEP MODE.

Various advantages are obtained by the MINISTEP MODE:

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

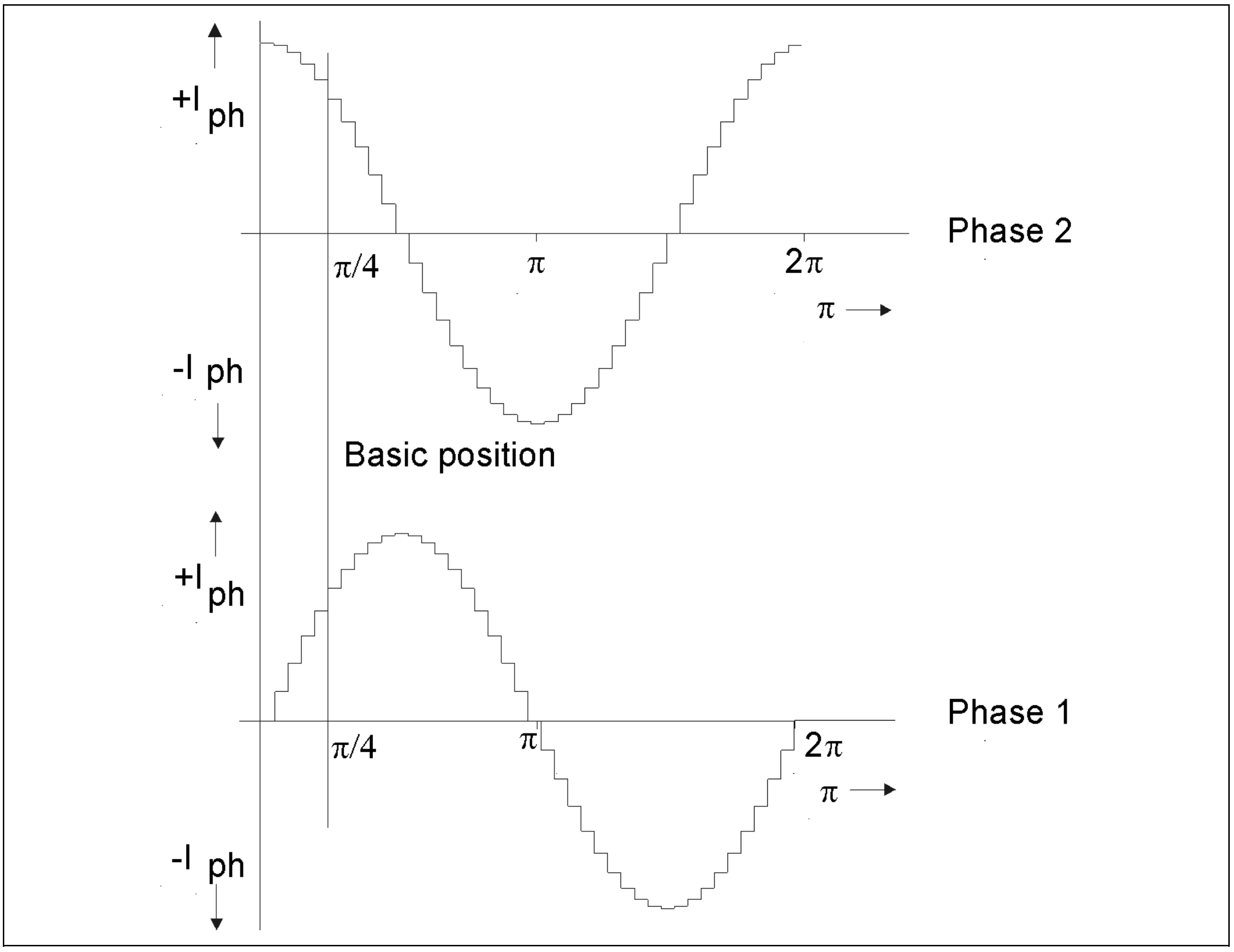


Fig. 20: Ministep 1/10 of a full step

A2 Boost

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

Therefore, different phase currents should be used:

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

The Boost signal is activated either by the $\overline{\text{Boost}}$ input or by DIP switch.

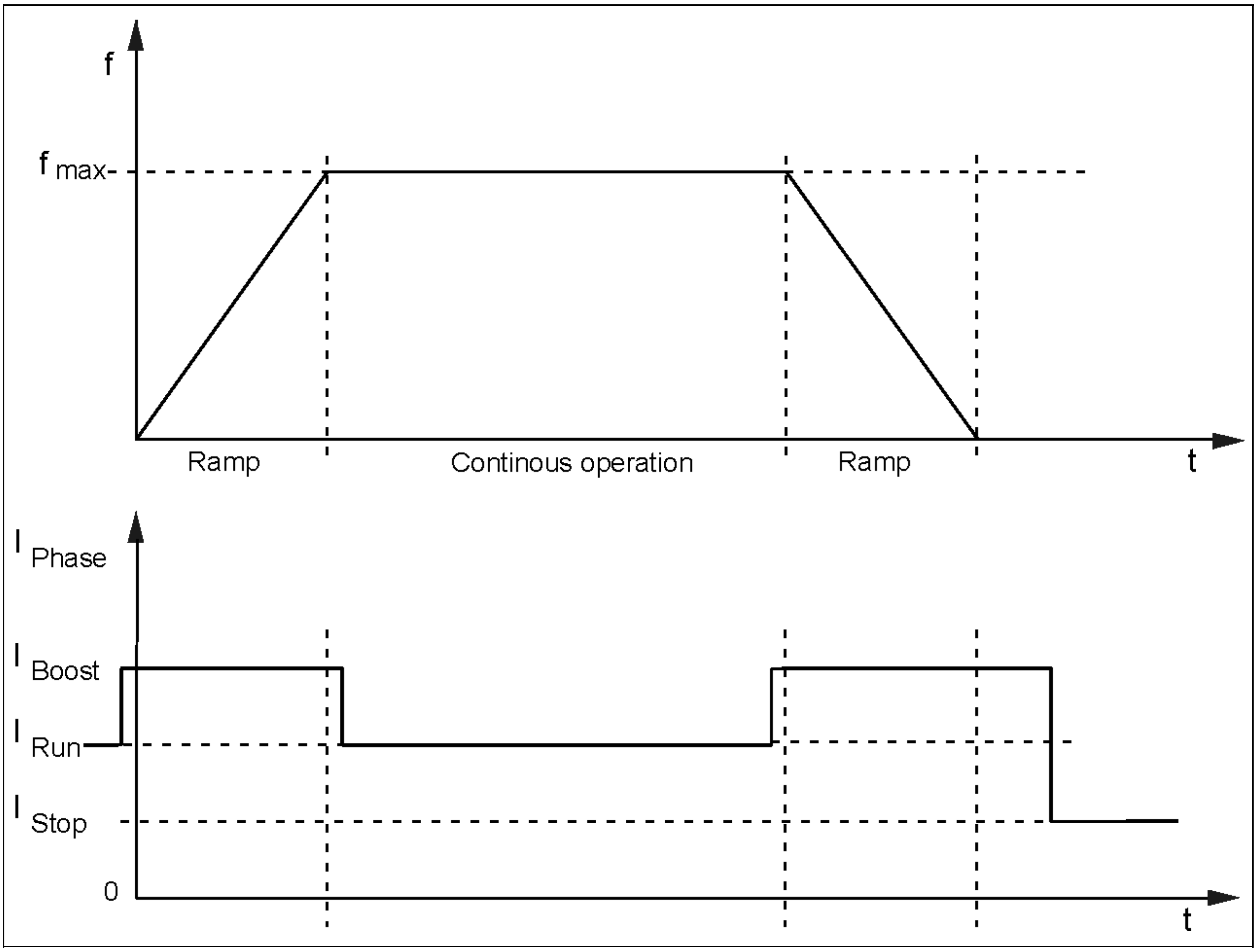


Fig. 21: Boost

A3 Overdrive

Overdrive is a dynamic boost function, which will be automatically switched on if this makes sense in regard of the current shape. Overdrive is activated by DIP switches.

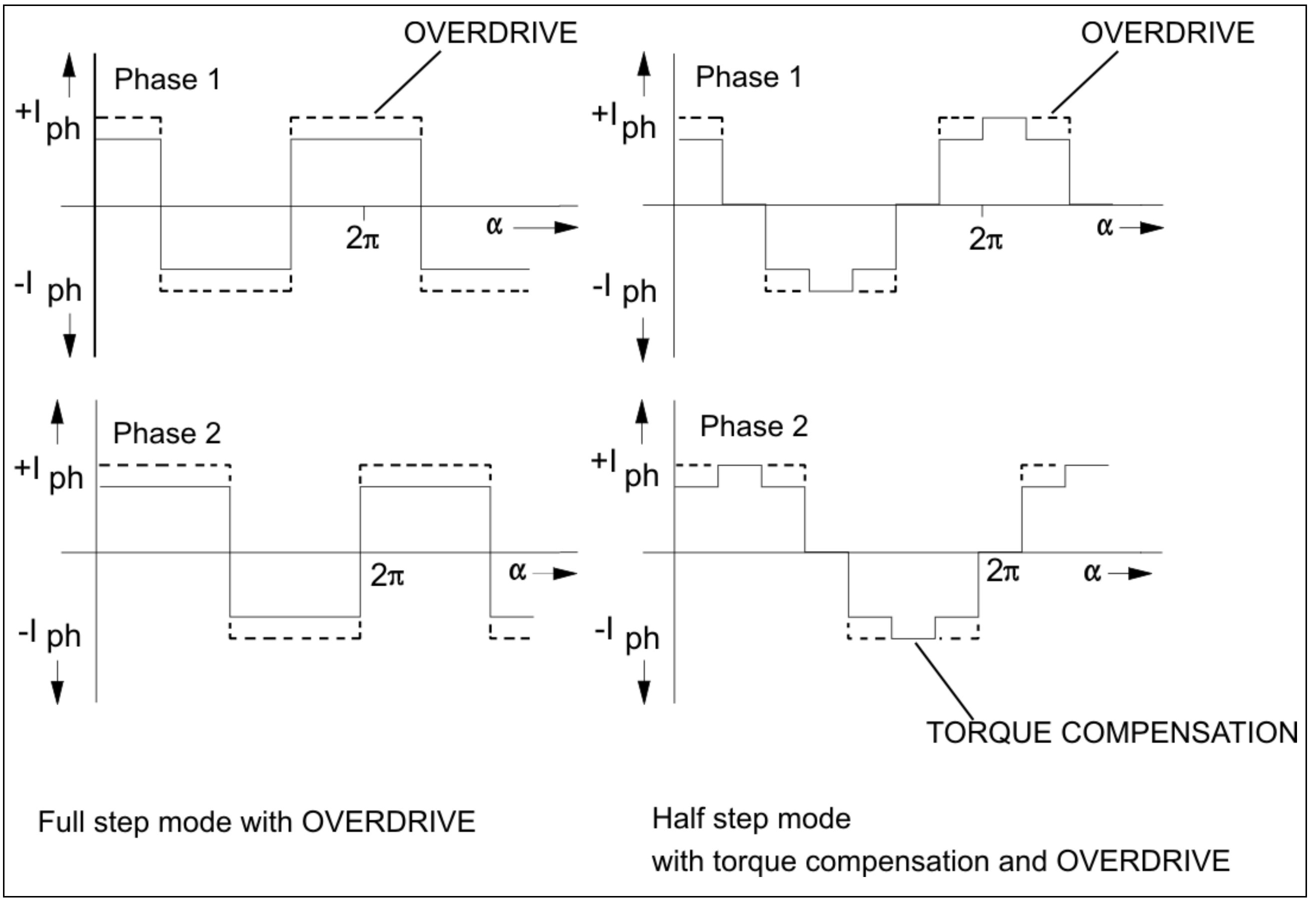


Fig. 22: Phase currents with Overdrive

The Overdrive function increases the r.m.s. phase current automatically by a factor of $\sqrt{2}$,
for all frequencies > 1 kHz (=300 rpm for a 200-step motor)
In the 1/n ministep mode, this function becomes active at the n x 1 kHz frequency.

Factory settings: OVERDRIVE activated (DIP switch: ON)

The stepper motor phase current decreases with increasing step frequency caused by the counter-electromotive force of the motor. The overdrive function compensates the decrease of current and torque. The phase current is increased by about 40 %. The table below shows the frequency values for switching on and off the overdrive function with different step resolutions:

Step resolution	**Input control pulse frequency**	
	Overdrive **on** at >	Overdrive **off** at <
1/1	1 kHz	0.9 kHz
1/2	2 kHz	1.8 kHz
1/4	4 kHz	3.6 kHz
1/5	5 kHz	4.5 kHz
1/10	10 kHz	9.0 kHz
1/20	20 kHz	18.0 kHz

A higher torque in the middle and high frequency ranges is effected.

Fig. 23 shows a phase current diagram below and above the Overdrive activation frequency in Full step- and 1/10-step modes.

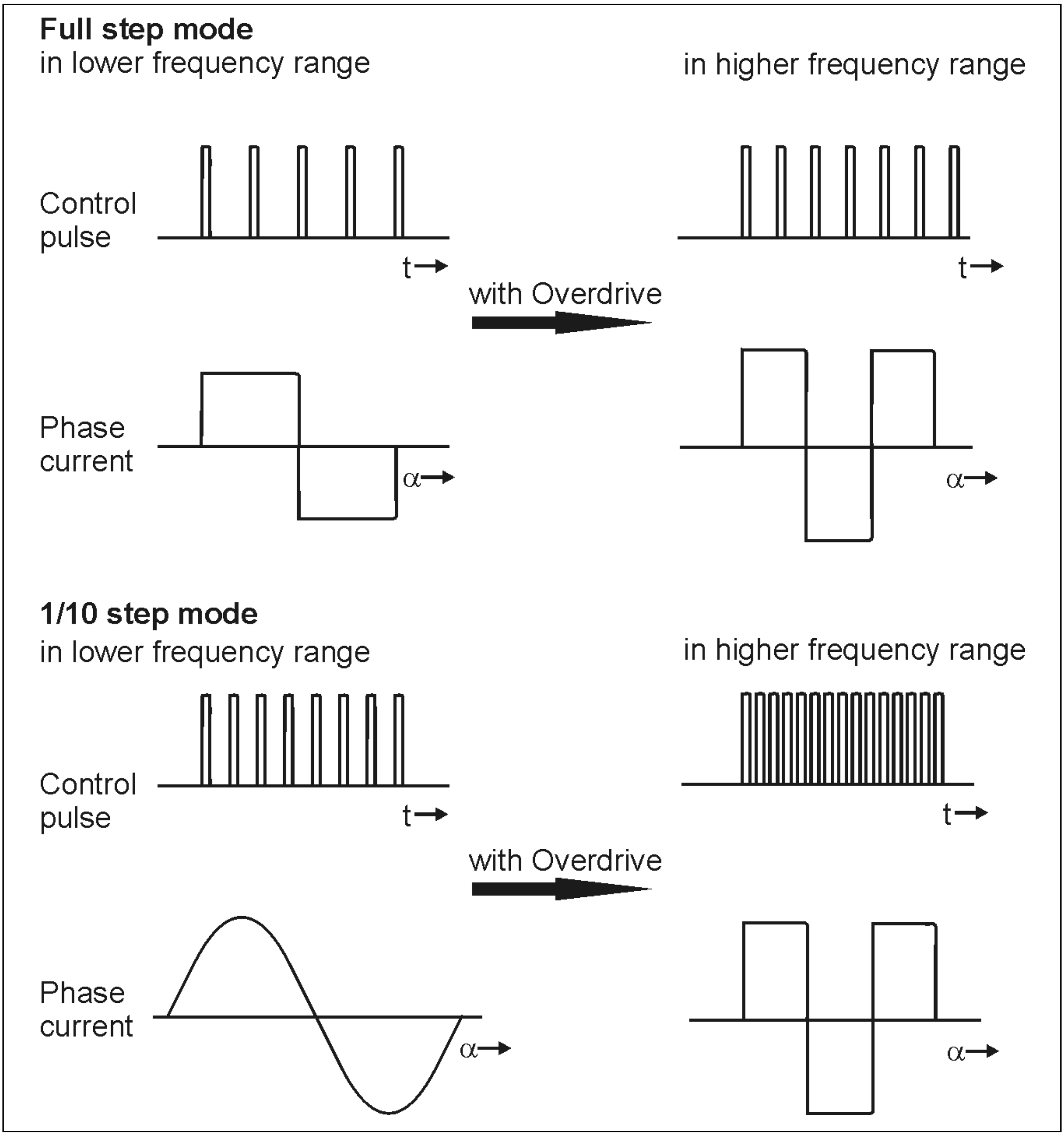


Fig. 23: Phase current diagram of one phase in with or without Overdrive in full step and 1/10-step mode

Remark:
The current shape in the Ministep mode with Overdrive is similar to that of the full step mode, however, in the 1/n-Ministep mode the number of pulses necessary to attain the same speed is n times higher than in the full step mode.

Example:
2000 pulses must be generated in the 1/10-Ministep mode with or without Overdrive.

A4 Current Shaping CS

Current Shaping (CS) is a circuitry method for delivering a true phase current which corresponds for a wide range of frequencies to a selected current shape (CS= 4 quadrant current regulation).

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

The 1/20 sine wave mode results in a current deviation as shown in fig. 23, for average speed:

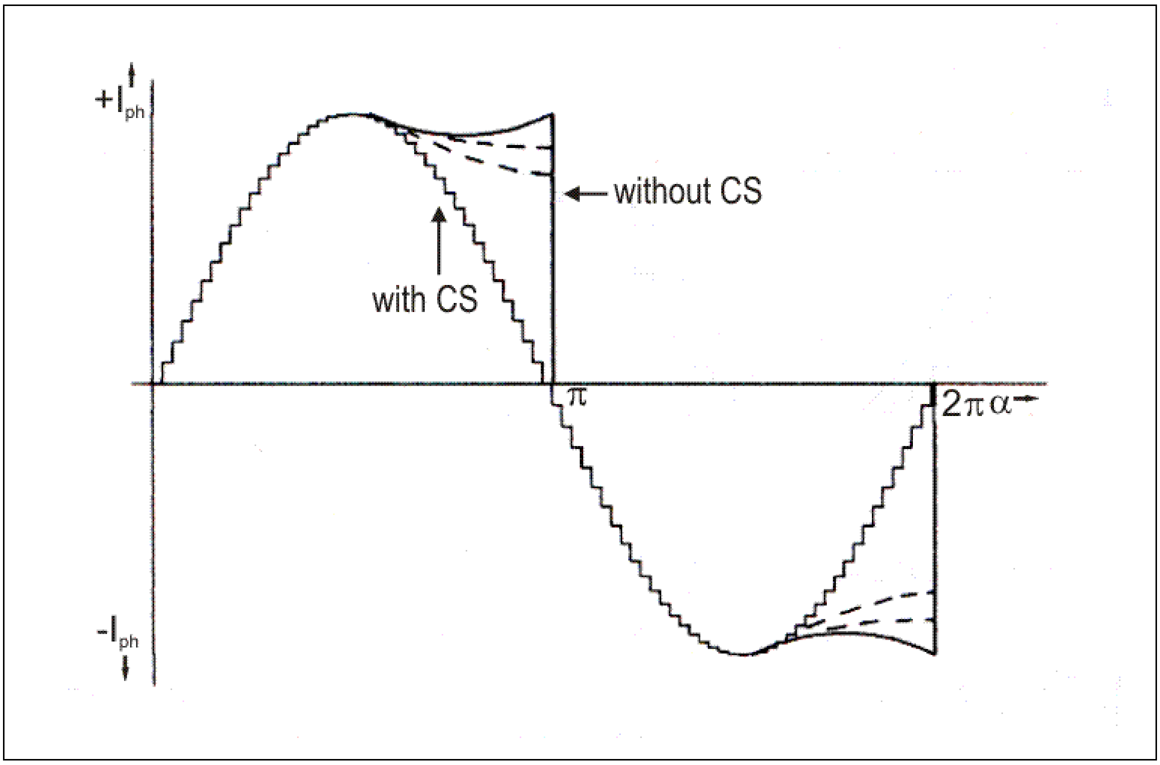


Fig. 24: Current Shaping CS

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

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

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

A5 Optimization of the Current Shape - BLOW UP

For an ideal stepper motor the holding torque is a true sine wave. In practice, the torque curve more or less differs from this ideal shape.

Therefore the MSX offers the possibility to select a current shape as shown in figure 24. In function of the motor used, it is possible to increase the motor performance during run and acceleration.

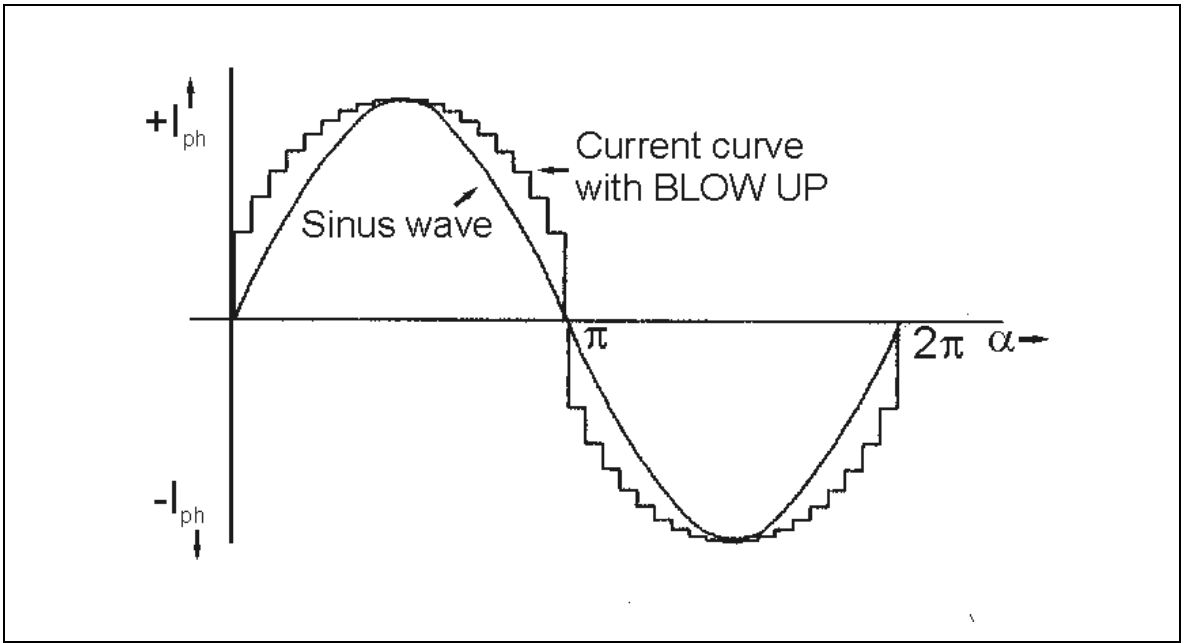


Fig. 25: Optimization of the current shape BLOW UP

The optimum current shape must be determined by a test of the complete system: control unit, motor, load.

A6 Current Delay Time

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

We recommend tospecify t_{Delay} so that the motor's oscillations are dying out after the last motor step and mispositioning is avoided.
The current delay time is set to 40 ms.

Automatic change from run to stop current:

The ratio between both phase currents remains equal in the respective current feed pattern. Changing from run to stop current is synchronously for both motor phases.
In the following figure the next motor step follows after every **falling** control pulse edge:

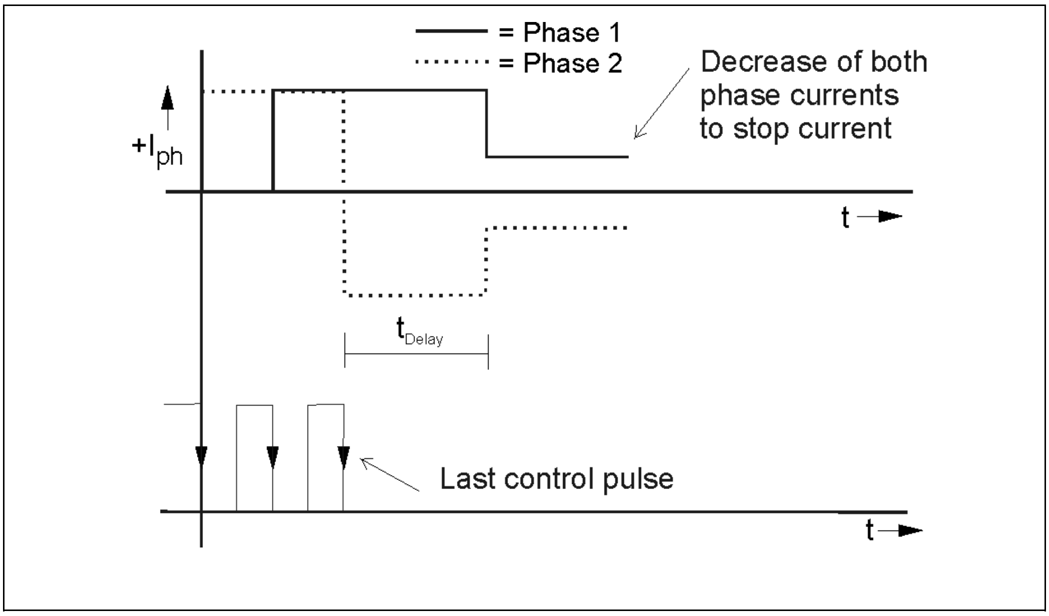


Fig. 26: Decrease to stop current after the last control pulse (full step)

Decreasing to stop current takes the following advantages:

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

Appendix B: G-MSX Adaptor Board

Type MSX power stages can be directly plugged on the G-MSX adaptor board. The adaptor board includes connectors for motor cable (ST4 to ST7), signal lines (ST2) and supply voltage (ST8 and ST9).

The control signals for Open-Collector controlling are connected to the ST2. It is possible to change to ‘Basic position’ or ‘Auxiliary voltage for control unit IXEα' by J1 jumper.

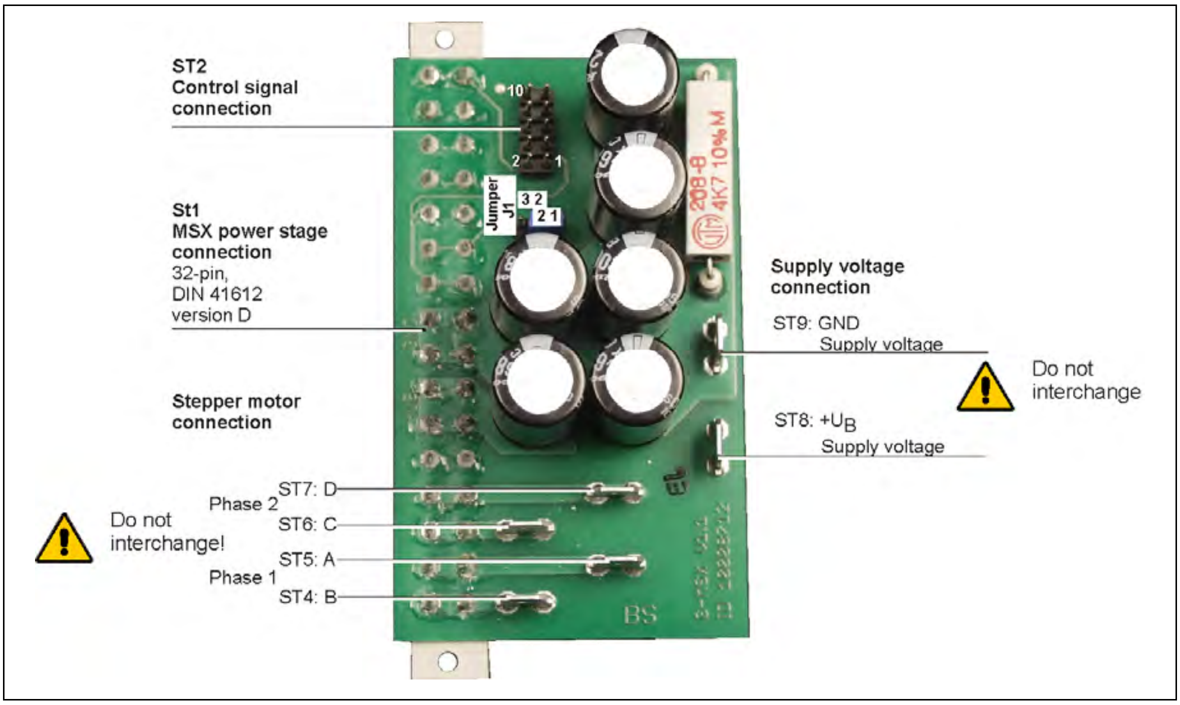


Fig. 27: Connections G-MSX

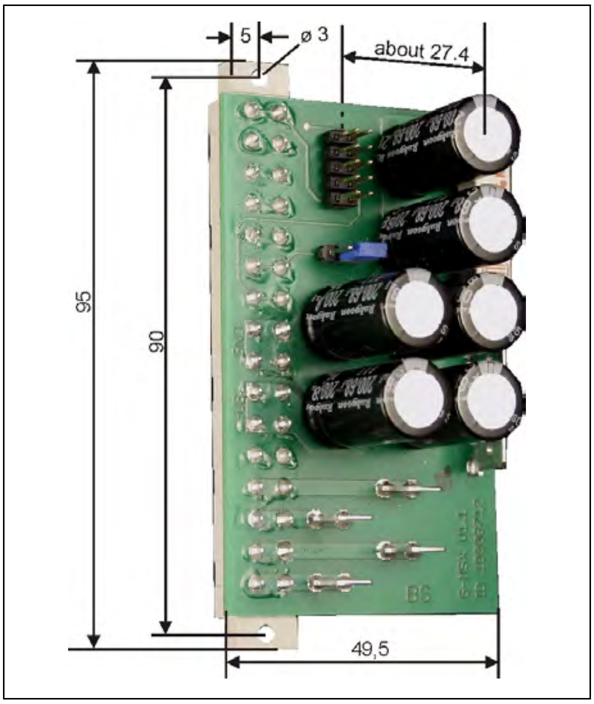


Fig. 28: Dimensions G-MSX (in mm)

Jumper positions

J1 Jumper position	Open-Collector controlling SLS-A
1 – 2	Auxiliary voltage for IXEα
2 – 3	Basic position

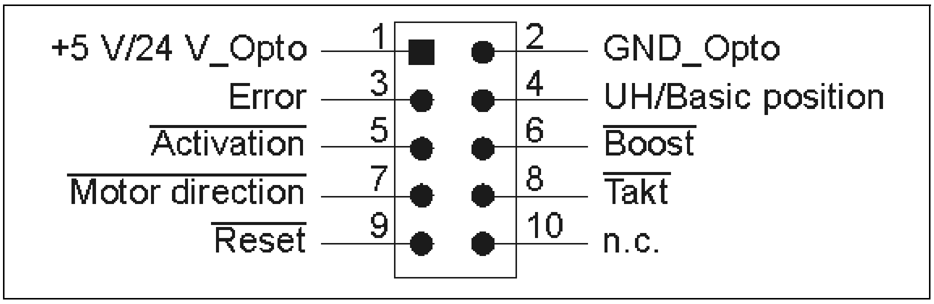


Fig. 29: ST2 10-pin connector

Safety Instructions:

- The G-MSX adaptor board must only be connected and put into service by qualified and trained personnel.
- Switch off the supply voltage before connecting or disconnecting the power stage.

  Danger of damage by electric arcing.
- All connectors must only be plugged in or out when the supply voltage is switched off.
- The G-MSX adaptor board has to be mounted in a closed housing, protected against accidental contact.

  Danger of electric shock when touching non-isolated powered components.
- When mounting the board, 6 mm minimum space between board (welding and component side) and other components or the housing is recommended. The minimum space at the left, right, upper and lower side of the board is 1.6 mm.

Appendix C

In this chapter warranty and ESD protective measures are described.

C1 Warranty

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

C2 ESD Protective Measures

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

Warning:

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

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

Appendix D: Declarations of Conformity

Phytron-Elektronik GmbH

EG-Konformitätserklärung

Declaration of Conformity

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

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

Produktbezeichnung *Part name*	**Identnummer** *ID-No.*	**Ab Seriennr.** From *Serial No*
MSX 52-152 MINI	10004902, 10004903, 10004904, 10008751, 10008752, 10008753, 10008754, 10008755, 10008756	Alle/all

Angewendete EG-Richtlinie / *EU Directive Applied*:
73/23/EWG vom 19. Februar 1973 (Niederspannungsrichtlinie) *73/23/EEC of February 19th 1973 (Low Voltage Directive)*
89/336/EWG vom 3. Mai 1989 (EMV-Richtlinie) *89/336/EEC of May 3rd, 1989 (EMC Directive)*

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

Anmerkung/*Comment:*

Gröbenzell, den 04. Juli 2007 / Gröbenzell, July 04th, 2007

Heribert Schmid
Technischer Geschäftsführer/ Managing Director

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customized solutions in motion

Phytron-Elektronik GmbH

EG-Herstellererklärung

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

Declaration of Conformity

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

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

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

Produktbezeichnung ***Part name***	**Identnummer** ***ID-No.***	**Ab Seriennr.** **From *Serial No***
MSX 52-152 MINI	10004902, 10004903, 10004904, 10008751, 10008752, 10008753, 10008754, 10008755, 10008756	Alle/all

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

Anmerkung/*Comment:*

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

This declaration loses its validity as a result of structural alterations and/or use other than defined, unless the express written approval of the manufacturer is present.

Gröbenzell, den 04.Juli 2007 / Gröbenzell, July 4th, 2007

Heribert Schmid
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customized solutions in motion

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