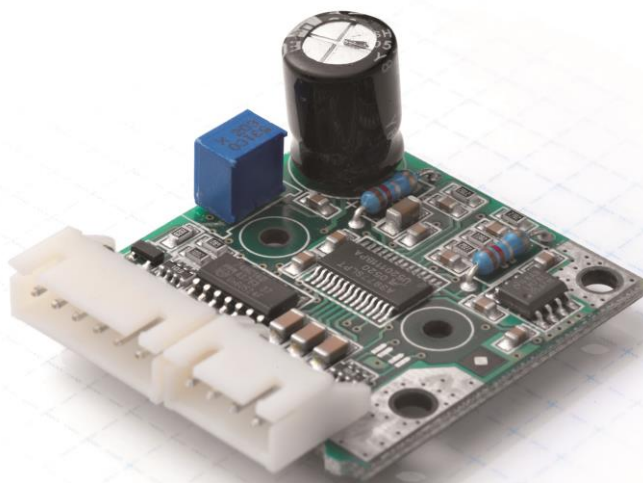


# Technical manual



## Microstep driver **SMC11**

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## Editorial / About this manual

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Thank you for choosing a Nanotec microstep driver!

### Target group

This technical manual is aimed at designers and developers who need to operate a Nanotec<sup>®</sup> stepper motor without much experience in stepper motor technology.

### About this manual

This technical manual must be carefully read before installation and commissioning of the driver.

Nanotec<sup>®</sup> reserves the right to make technical alterations and further develop hardware and software in the interests of its customers to improve the function of this product without prior notice.

This manual has been written with due care. It is exclusively intended as a technical description of the product and as commissioning instructions. The warranty is exclusively for repair or replacement of defective equipment, according to our general terms and conditions; liability for subsequent damage or errors is excluded. Applicable standards and regulations must be complied with during installation of the device.

For criticisms, proposals and suggestions for improvement, please contact the above address or send an email to: [info@nanotec.com](mailto:info@nanotec.com)

### Version/Change overview

Version	Date	Changes
0.7	27.02.2007	New
1.0	08.08.2008	Revision
1.1	01.12.2008	Revision
1.2	30.09.2009	Revision
1.3	25.11.2009	Revision
1.4	20.01.2010	Revision
1.5	10.02.2010	Connection diagram
1.6	06.03.2014	Revision

## Contents

<b>Editorial / About this manual</b> .....	<b>2</b>
<b>Contents</b> .....	<b>3</b>
<b>1 Overview</b> .....	<b>4</b>
<b>2 Commissioning</b> .....	<b>6</b>
<b>3 Connections</b> .....	<b>7</b>
3.1 Connection diagram .....	7
3.2 Inputs: connector X2 .....	8
3.2.1 Pin assignment.....	8
3.2.2 Voltage supply.....	8
3.2.3 Input circuits .....	10
3.2.4 "Clock" input (CLK) .....	11
3.2.5 "Direction" input (DIR) .....	11
3.2.6 "Enable" input (EN) .....	12
3.2.7 "Automatic current reduction" input.....	13
3.2.8 Time behaviour of input signals .....	15
3.3 Outputs for motor connection: connector X1 .....	16
<b>4 Settings</b> .....	<b>18</b>
4.1 Setting the phase current .....	18
4.2 Setting the step mode .....	20
<b>5 Technical data</b> .....	<b>21</b>
5.1 Specific values .....	21
5.2 Dimensions .....	22
5.3 Compliance with EMC standards.....	22
<b>Index</b> .....	<b>23</b>

# 1 Overview

## Purpose and application

The SMC11 is an extremely compact bipolar constant-current microstep driver for controlling 4, 6 and 8-conductor stepper motors. Its small housing dimensions permit the use of several step motor output stages in confined spaces.

The SMC11 was developed for stepper motor sizes 20 (Nema 8), 28 (Nema 13) and 40 (Nema 17). Depending on the phase current, it can also be used with larger stepper motors of size 56 (Nema 23) and 86 (Nema 34).

## SMC 11 functions

The SMC11 offers the following functions:

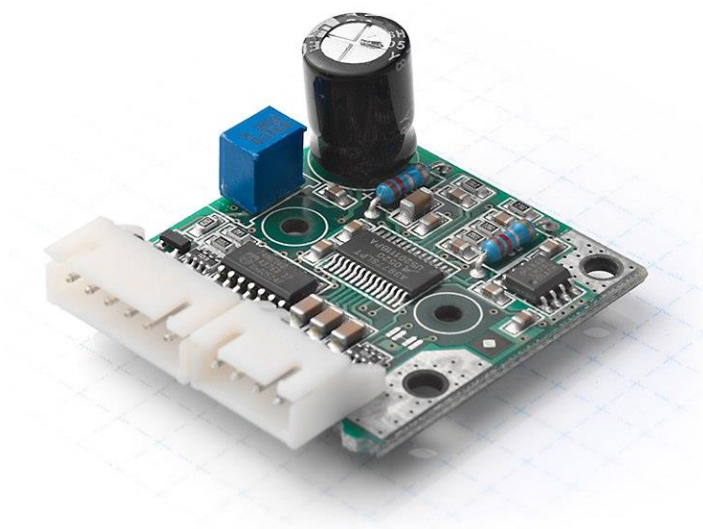
- Step resolution is adjustable via solder bridges.
- Phase current is continuously adjustable from 0.3 A to 2.5 A via a potentiometer.
- Control of "Clock", "Direction", "Enable" and "Current reduction" inputs via 3.5 V low voltage processors or via a 3.5 V or 5 V TTL signal.
- Integrated overload and temperature protection
- Transient overvoltage protection
- Automatic current reduction (SMC11-2 only): To reduce the thermal load of the motor and the output stage when at a standstill, the phase current is automatically reduced to < 50% of the set value after a clock pause of max. 1.5 s.

## Model

The driver is available in the following model:

- Open model: SMC11
  - Variable current setting for different bipolar motors
  - Attachment via screws (with simple wiring also suitable for mounting on the back of the motor)

## Picture



## Variants

The SMC11 is available in the variants SMC11-1 and SMC11-2. The variants differ with respect to the following features:

- Range of step mode settings
  - SMC11-1: 1/1, 1/2, 1/4, 1/8
  - SMC11-2: 1/1, 1/2, 1/4, 1/16
- Automatic current reduction only available in SMC11-2

## Advantages


The SMC11 is based on the SMD power driver (A3979SLP-T). Building on many years of experience with stepper motors and with the optimal design of stepper motor controls, Nanotec has developed a small printed circuit board that enables designers and developers to quickly and easily test the entire functional scope of this component. In addition to the power driver, the SMC11 also includes useful functions and protective circuits, as well as an EMC-compatible layout. Thus, the SMC11 is not only suitable as an evaluation board but is also ideal for numerous small and medium-sized applications as a standard stepper motor control due to its robust design and functional capabilities, and especially due to its attractive price.


In light of the large quantities, Nanotec offers the IMT 903 at distributor prices so that customers with up to 2000 units benefit from its fair price, support and high availability.

Apart from the advantages of the SMC11, other customized circuits and boards have already been developed on the basis of IMT 903 for specific installation sizes and functions, and these are already in use in many specific application – maybe even in yours.

## 2 Commissioning

### Safety warnings

	<p><b>CAUTION!</b> <b>Danger of destruction of output stage!</b></p> <ul style="list-style-type: none"> <li>• Check the connections carefully.</li> <li>• Never unplug the motor connections while they are live.</li> </ul>
---	--

	<p><b>CAUTION!</b> <b>Alternating electromagnetic fields!</b></p> <p>Alternating electromagnetic fields around current-carrying cables, especially around the supply and motor cables, can cause interference in the output stage and other devices.</p> <ul style="list-style-type: none"> <li>• Shield the cables. Run the shield connection on one side or both sides to a short earth.</li> <li>• Use twisted pair cables.</li> <li>• Keep power supply and motor cables as short as possible.</li> <li>• Run large areas of the output stage housing and motor to a short earth.</li> <li>• Run supply, motor and control cables separately.</li> </ul>
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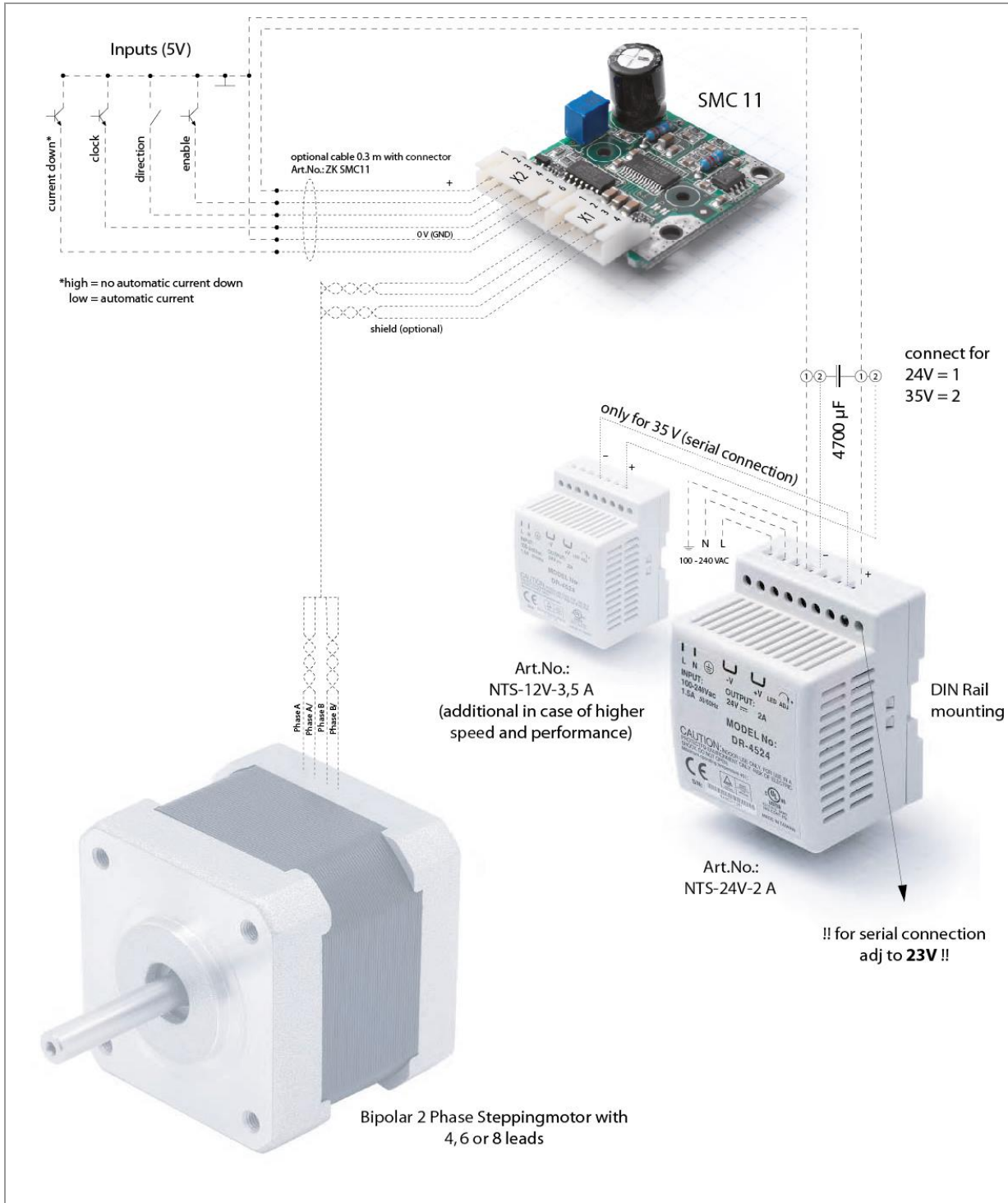
### Procedure

Proceed as follows to take the output stage into service safely:

Step	Action	See also
1	Set the desired step mode via the corresponding solder bridges or DIP switch.	Section 4.2
2	Connect the motor at the outputs.	Section 3.3
3	Connect the power supply. Connect a charging capacitor of at least 4700µF in parallel to the power supply (terminal x ), depending on the motor size.	Section 3.2.2
4	Set the required motor phase current on the potentiometer, if necessary.	Section 4.1
5	Enable the current reduction, if necessary.	Section 3.2.7
6	Change the step mode, if necessary.	Section 4.2
7	Switch on the power supply. The motor moves slightly and goes into the stable phase position. The holding torque acts in the motor. The output stage is ready for operation and can be moved in the corresponding direction via the "Clock" input, depending on the direction signal.	

## 3 Connections

### 3.1 Connection diagram



## 3.2 Inputs: connector X2

### 3.2.1 Pin assignment

The pins on connector X2 are assigned as follows:

Pin no.	Name	Comment
1	V <sub>BB</sub>	Operating voltage +9 V DC ... +35 V DC
2	EN	"Enable" input: <ul style="list-style-type: none"><li>• Low (&lt; 0.8 V) = active</li><li>• High (3.15 – 5.5 V) or open = disable</li></ul>
3	DIR	"Direction" input: <ul style="list-style-type: none"><li>• Low (&lt; 0.8 V) = active</li><li>• High (3.15 – 5.5 V) or open = disable</li></ul>
4	CLK	"Clock" input: <ul style="list-style-type: none"><li>• Low (&lt; 0.8 V) = active</li><li>• High (3.15 – 5.5 V) = disable</li><li>• Pulse width &gt; 2 μs</li><li>• Pulse pause &gt; 2 μs</li></ul>
5	GND	Earth (0 V)
6	–	Automatic current reduction to approx. 50%: <ul style="list-style-type: none"><li>• Low (&lt; 0.8 V) = active</li><li>• High (3.15 – 5.5 V) or open = disable</li></ul>

### 3.2.2 Voltage supply

#### Voltage source

The operating or supply voltage is supplied by a battery (low voltage 12 – 24 V), a transformer with rectification and screening or, preferably, a switched-mode power supply (NANOTEC NTS24) with 24 V or higher (max. 35 V for maximum speed and power utilization).

#### Permissible operating voltage

The permissible operating voltage ranges from +9 to +35 V DC.

A charging capacitor of at least 4700 μF/ 50 V must be connected at the supply voltage to ensure that the permissible operating voltage is not exceeded (e.g. during braking).



#### **CAUTION!**

#### **Danger of electrical surges**

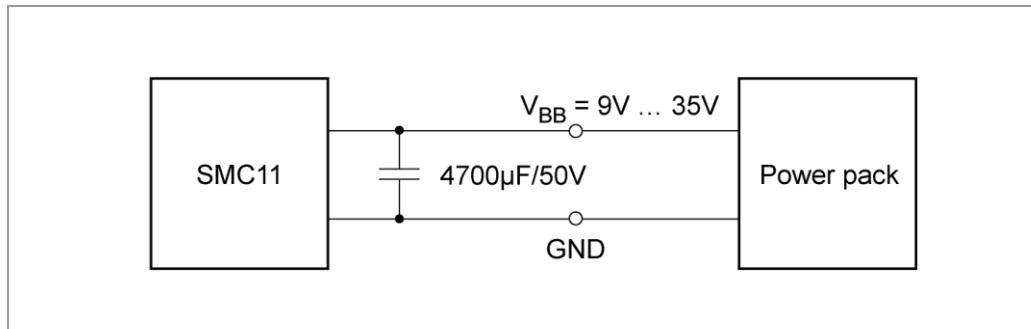
Connect charging capacitor with minimum 4700 μF!

An operating voltage > 50 V will destroy the output stage! Mixing up the connections can destroy the output stage!

- Never disconnect the link when operating voltage is applied!
- **Never** disconnect lines when live!



Install the charging capacitor as close as possible to the SMC11:



The external moments of inertia  $J_{ex}$  in motor sizes ST59 and ST89 should not exceed  $E_{ex} = J_{motor} * 5 / 2$ .

### Accessories for voltage supply


Power packs and charging capacitors are available as accessories:

Designation	Order number
Power pack	NTS24 (24 V)
Power pack	NTS12 (12 V) Add an additional power supply at 35V supply for greater speeds.
Charging capacitor	Z-K4700/50

**Note:**

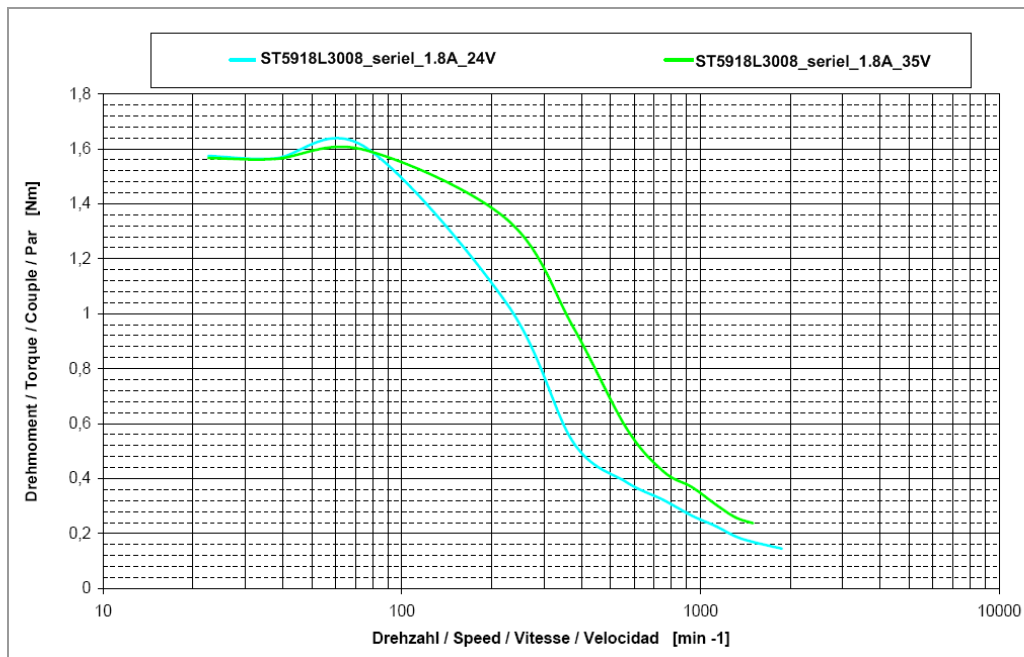
Additional information on the accessories is available on the Nanotec website:  
[www.nanotec.com](http://www.nanotec.com)

### Series connection of power supplies

	<p><b>CAUTION!</b> <b>Danger of destruction of output stage!</b></p> <ul style="list-style-type: none"> <li>Adjust the maximum voltage via the potentiometers of the power supplies (Voltage Adj. Range): NTS24: 23V; NTS12: 11V.</li> </ul>
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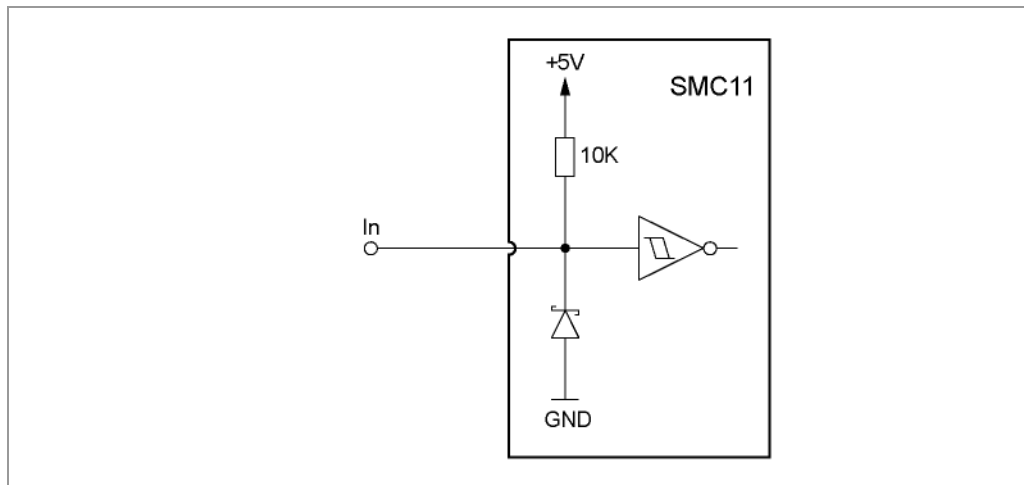
In applications in which the maximum power of the stepper motor absolutely must be obtained in combination with the end stage SMC 11, and a 35V power supply is not available, the NTS24 and NTS12 power supplies can be connected in series (see connection diagram).

The characteristic lines in the following figure show the power increase from 24V to 35V:

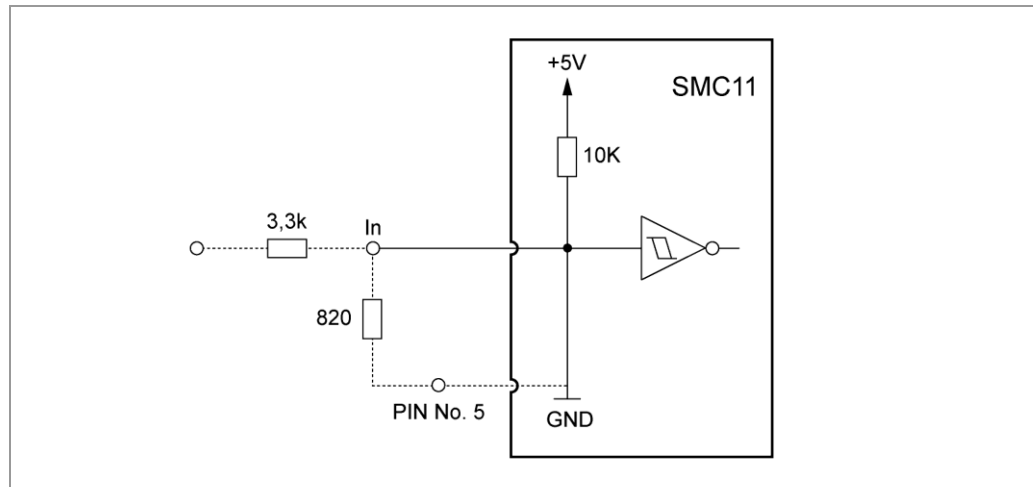


### 3.2.3 Input circuits

#### Input circuit 5 V / 15 mA



### Input circuit 24 V / 15 mA



### Overvoltage protection

All inputs are protected against overvoltage by protection diodes.

The integrated Schmitt trigger ensures reliable switching of the input signals independent of the edge steepness.

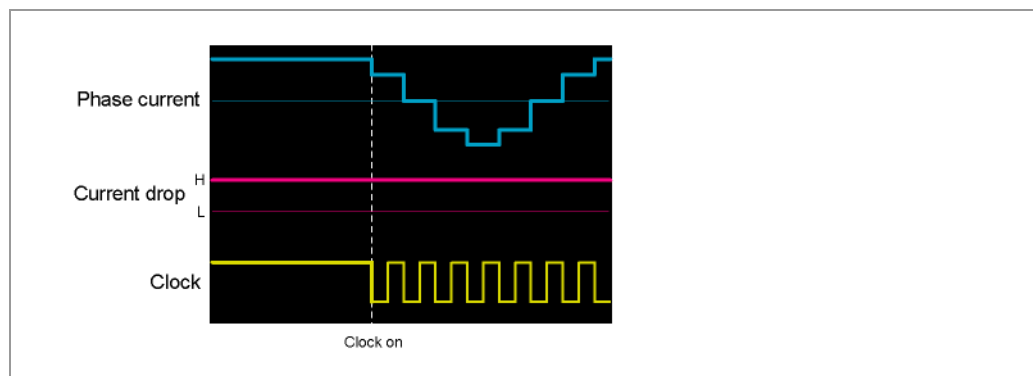
### 3.2.4 "Clock" input (CLK)

#### Function

The step is triggered by a negative edge at the "Clock" input.

#### Phase current

The following figure shows the phase current as a function of the input signal.



### 3.2.5 "Direction" input (DIR)

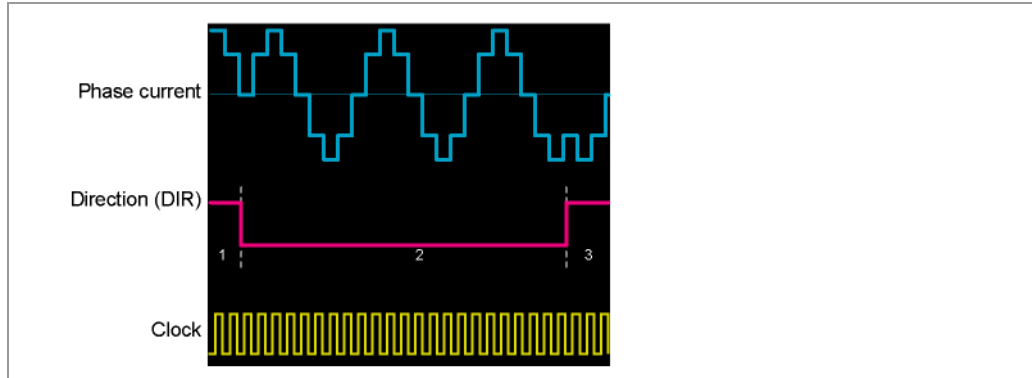
#### Function

The "Direction" input specifies the rotation direction of the motor. There must be a pause of  $>120 \mu\text{s}$  between switching the rotation direction and activation of the input.

"Direction" input level	State	Motor rotation direction
High or open	Disable	Motor turns in the direction set when operation started.
Low	Enable	Motor turns in the opposite direction.

## Phase current

The following figure shows the phase current as a function of the input signal.



1 and 3: The motor turns to the right

2: The motor turns to the left

### 3.2.6 "Enable" input (EN)

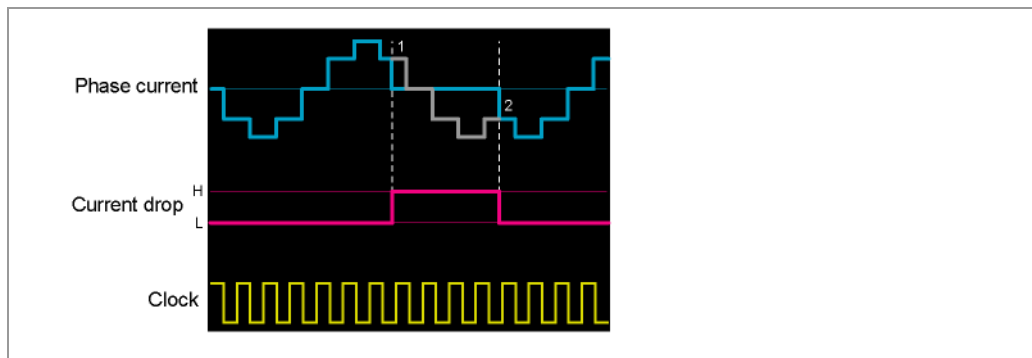
#### Function

After the signal is set to "High" (positive edge), the output stage switches off the phase currents and the motor is not supplied with current. The "Low" signal supplies the motor with current again.

If the enable signal is disabled during the running clock signal (level on "High"), the output stage switches to no current. The internal ring counter continues running with the external clock signal.

## Phase current

The following figure shows the phase current as a function of the input signal.



The grey lines in the figure show that the output stage has internally moved the motor four additional steps from position 1 to position 2. When the enable signal is reactivated (level on "Low"), motor operation continues from position 2 (only if the supply voltage  $V_{BB}$  remains in tact and the clock frequency is constant).

### 3.2.7 "Automatic current reduction" input

**Note:**

This function is only available in SMC11-2.

**Function**

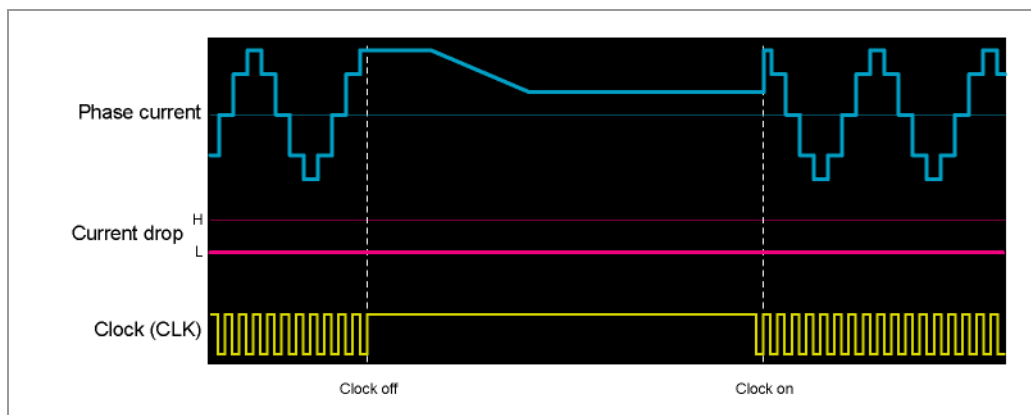
To reduce the thermal load on the motor and output stage during a motor standstill, the current reduction can be enabled via a "Low" signal (disable) on pin 6.

When current reduction is enabled, the phase current is automatically reduced to < 50% of the set current value after a clock pause of max. 1.5 s:

Step mode	Phase current in A (pin 6 = enable)	Phase current in A (pin 6 = disable)	Current reduction in %
Full step	0.5	0.2	40
	1.5	0.48	32
	2.4	0.68	28
Half step	0.5	0.23	46
	1.5	0.46	31
	2.5	0.72	29
Microstep	0.5	0.24	48
	1.5	0.56	37
	2.5	0.8	32

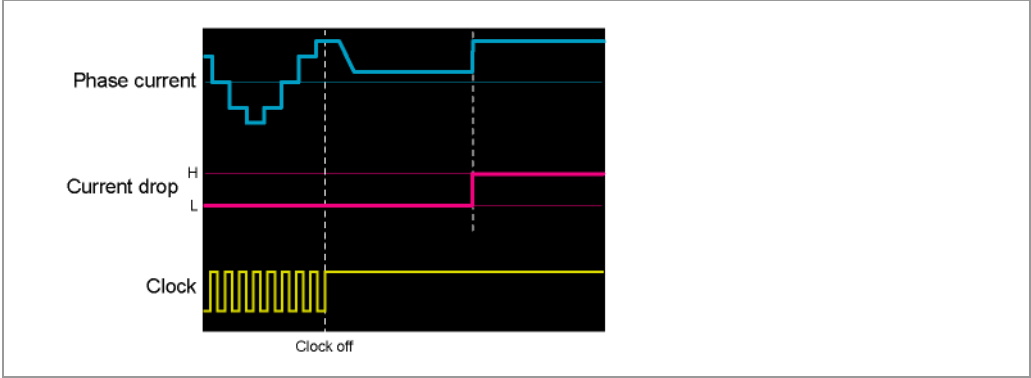
**Phase current with enabled current reduction**

The following figure shows the phase current when current reduction is enabled.



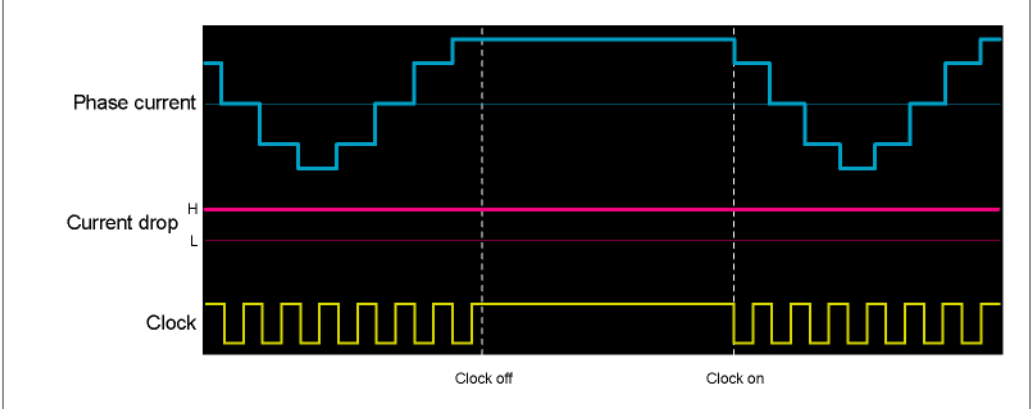
**Phase current when current reduction is begin disabled**

When the automatic current reduction is disabled, the phase current returns to the original phase current value without a significant time delay.



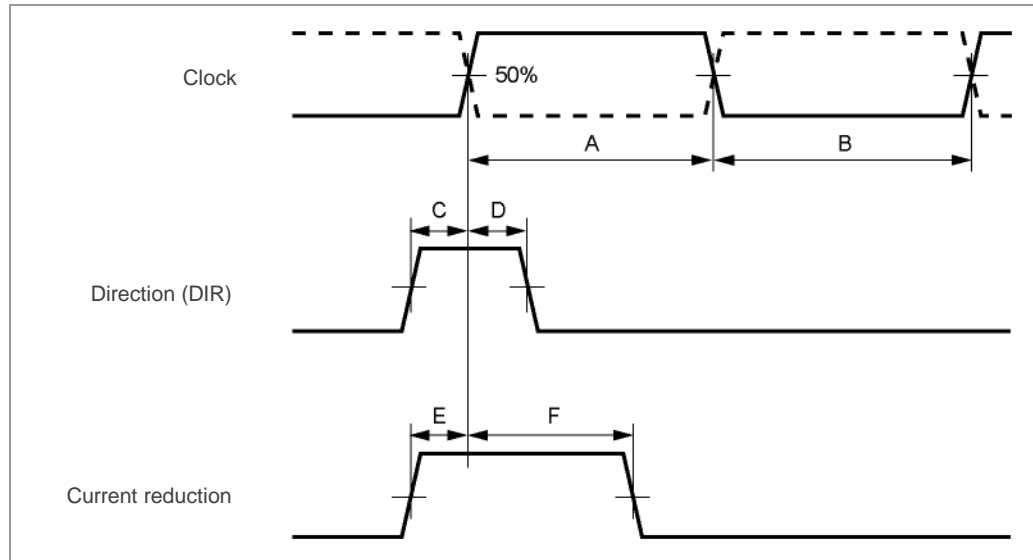
**Phase current with disabled current reduction**

The following figure shows the phase current when current reduction is disabled.



### 3.2.8 Time behaviour of input signals

The following figure shows a schematic diagram of the time behaviour of the "Clock", "Direction" and "Automatic current reduction" input signals.



A	> 2 $\mu$ s	Pulse width
B	> 2 $\mu$ s	Pulse pause
C	> 2 $\mu$ s	DIR enable time before pulse
D	> 2 $\mu$ s	DIR enable time after pulse
E	> 2 $\mu$ s	Current reduction disabled after pulse on
F	< 1,5 s	Current reduction enabled after pulse off

### 3.3 Outputs for motor connection: connector X1

**Notes**


The following information should be noted:

- The SMC11 is used exclusively to control 2-phase stepper motors with 4, 6 or 8 connecting wires in bipolar mode.
- Swapping the connecting cables within a phase (A with A/ or B with B/) changes the direction of rotation.
- When using a motor with 6 or 8 connections, the windings must be connected.
- Motor cables that are not needed should be galvanically isolated (see connection diagrams).
- Using twisted pair and shielded motor cables can reduce interference on or from other devices.
- The labelling of the motor connections can be found from the data sheet of the respective stepper motor.

**Pin assignment**

The following table shows the pin assignment for the X1 connector:

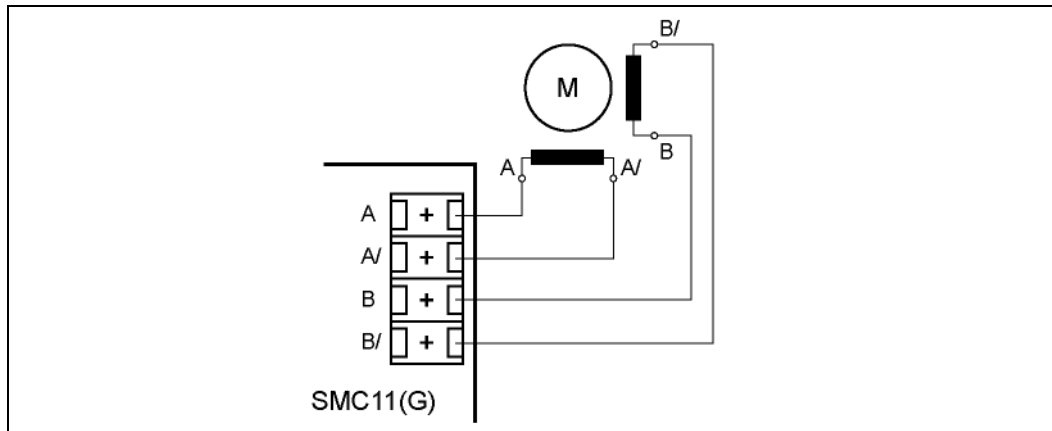
Pin no.	Name	Comment
1	A	See also data sheet of connected stepper motor (colour code of 4 wires).
2	A/	
3	B	
4	B/	

	<p><b>CAUTION!</b>  <b>Danger of electrical surges</b>                      Mixing up the connections can destroy the output stage!</p> <ul style="list-style-type: none"> <li>• Never disconnect the link when operating voltage is applied!</li> <li>• <b>Never</b> disconnect lines when live!</li> </ul>
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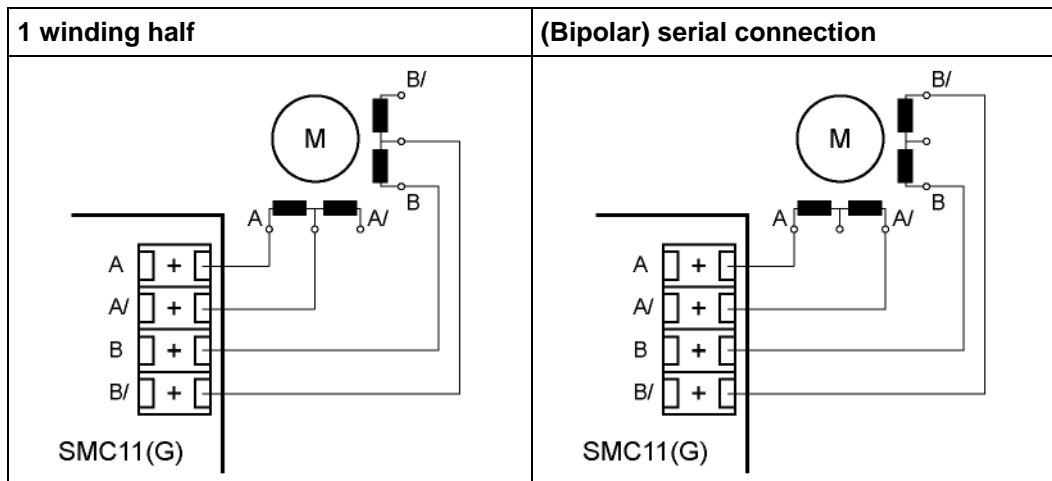


**Connection diagrams**

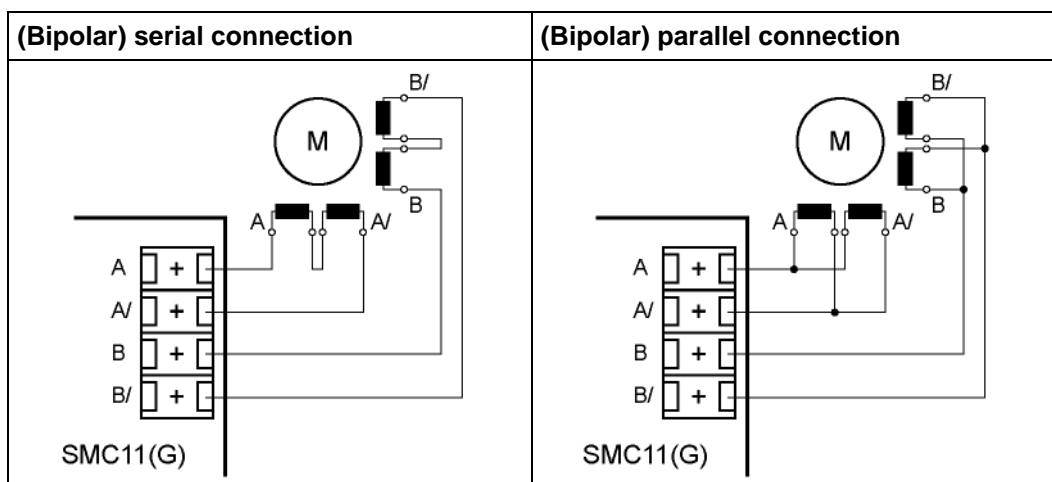
Motor with 4 lines:



Motor with 6 lines:



Motor with 8 lines:



## 4 Settings

### 4.1 Setting the phase current



#### CAUTION!

#### Danger of property damage from overcurrent!

Step loss may occur, and the motor windings may overheat or burn out!

- Do not exceed the maximum permissible current values of the motor and control unit.

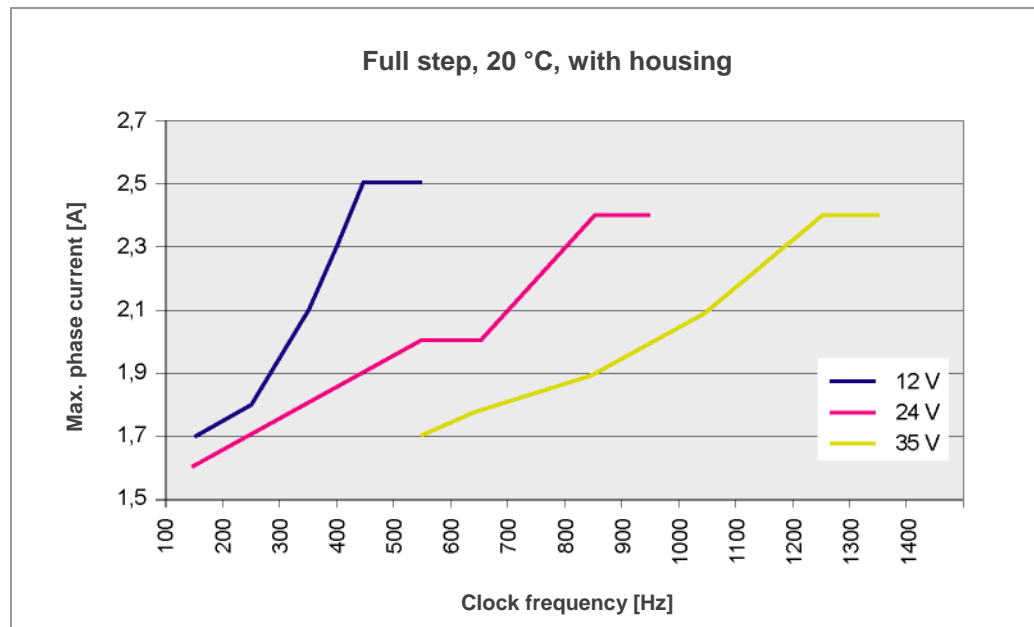
#### Setting at low clock frequency

The natural resonance of stepper motors, which tends to arise in the low speed ranges and frequencies under full step operation, can give rise to current peaks that lie above the set phase current value and can lead to overcurrent step loss in the driver chip.

Avoid operating in the resonance range due to the unstable running behaviour, audible running noise and low torque.

The following information should be noted:

- Avoid full step mode at low speeds or frequencies.
- Reduce the maximum phase current in the low speed range; see the following figure.



#### Guide values

The permissible phase current with which the output stage can drive the motors without step loss depends on operating conditions such as the operating voltage, frequency, step mode, motor being driven, load, ambient temperature and effective cooling of the end stage (via large cooling surfaces or fans).

The values specified here are guide values that may vary depending on the installation conditions.

The following information should be noted:

- Thermal aspects (heat dissipation).
- When using a setting with high phase currents, perform a test of at least two hours. If the temperature value remains stable throughout this time period, and the output stage does not exhibit step loss, the output stage can be used under the same operating conditions. Otherwise, better heat dissipation must be provided for.

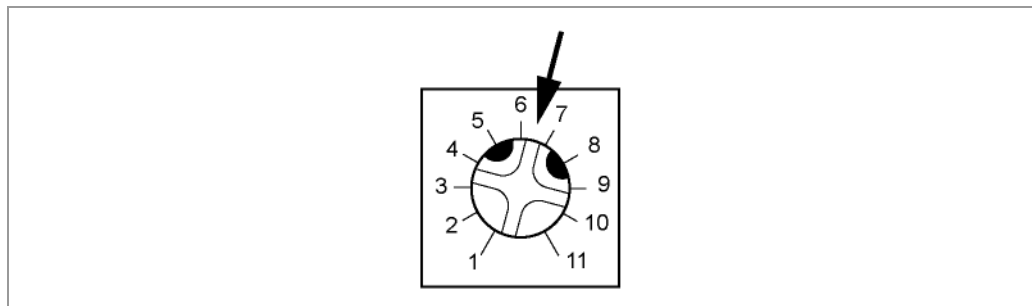
The following table shows the guide values for the maximum phase current setting at an ambient temperature of 40 °C max.:

Step mode	SMC11
Full step	1.0 A
Half step to microstep	1.4 A

### Setting via the potentiometer

The phase current can be set continuously with the integrated potentiometer.

Turning clockwise increases the phase current value. The setting in the following figure corresponds to level 6.5.



The following table shows the assignment of the phase current values to the potentiometer levels:

Level	Phase current (in A)		
	Full step	Half step	Microstep
1			
2		0.1 - 0.3	0.2 - 0.4
3	0.3	0.5	0.5
4	0.6	0.8	0.8
5	0.9	1.2	1.2
6	1.2	1.6	1.6
7	1.5	2.0	2.0
8	1.8	2.4	2.4
9	2.1	2.8	2.8
10	2.4		
11	2.5		

**Note:**

The values in the table have a tolerance of up to 10%.

## Overcurrent protection

The output stage is protected against damage by the integrated overtemperature and overcurrent protection. Depending on the set phase current, heat generation in the chip can be very high, which activates the internal overtemperature protection (barrier layer temperature max. 165 °C, chip surface temperature approx. 85 °C) and automatically deactivates the output stage if necessary or switches off the phase current.

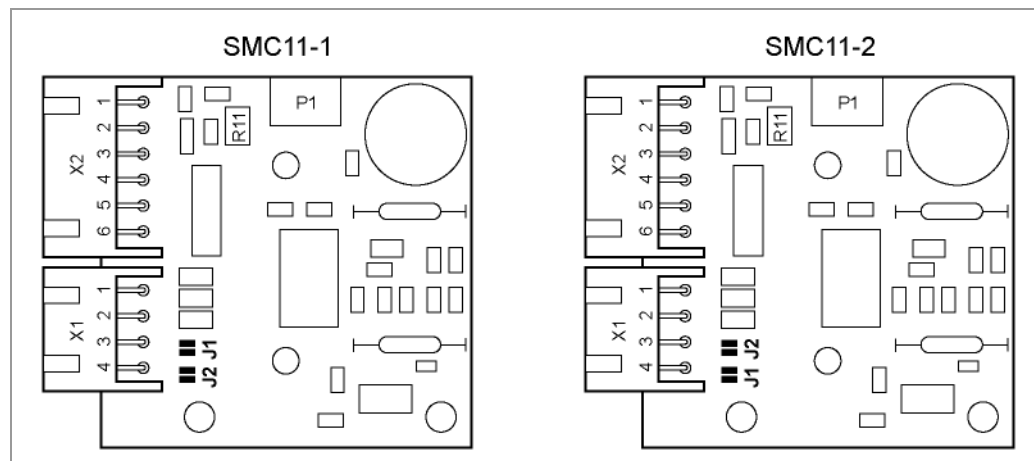
## Checking the phase current

The set current value can be determined using a clamp-on ammeter (e.g. type E3N of Chauvin Arnoux) in the motor supply line of a phase.

## 4.2 Setting the step mode

### SMC11

The step mode is set via the solder bridges J1 and J2 in SMC11. The solder bridges are arranged differently in SMC11-1 and SMC11-2; see the following figure:



Step mode	Solder bridge	
	J2	J1
1/1	x	x
1/2		x
1/4	x	
1/8 (SMC11-1) or 1/16 (SMC11-2)		

## Notes

All SMC11 models are delivered preset to the microstep mode (one-eighth step in SMC11-1 and one-sixteenth step in SMC11-2).

Advantages of the microstep mode:

- High step resolution and a more continuous, smooth running of the motor
- Less resonance at low speeds

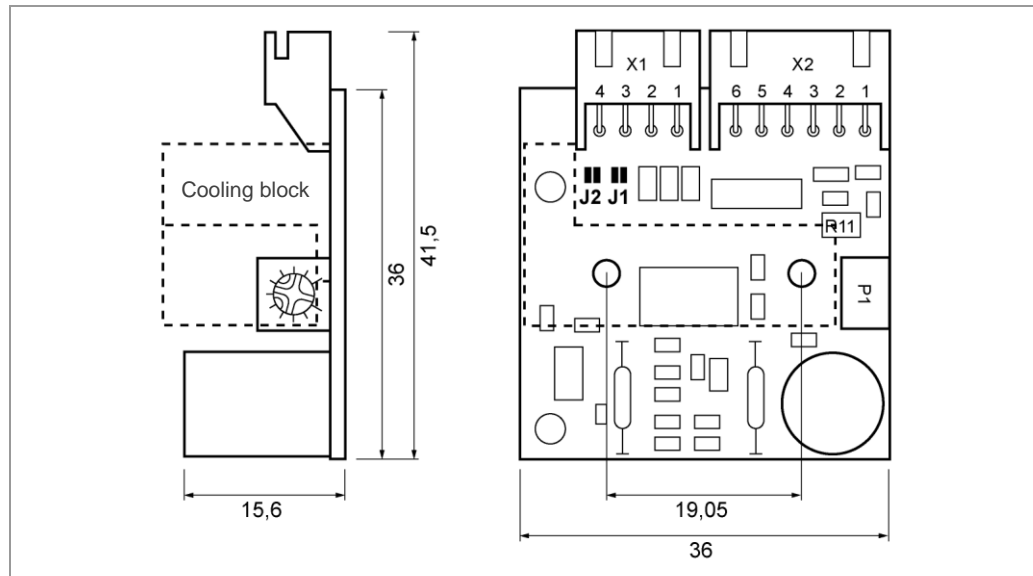
## 5 Technical data

### 5.1 Specific values

Operating voltage $V_{BB}$	DC +9 V to +35 V
Max. phase current	1.4 A/phase
Current reduction	< 50% of phase current Clock pause < 1.5 s Settling time < 1.5 s
Interfaces	Plug-in terminals JST-XHP
Step resolution	Full step Half step 1/4 step 1/8 step (in SMC11-1) 1/16 step (in SMC11-2)
Operating mode	Bipolar chopper driver
Step frequency	0 to 200 kHz (with respect to control)
Signal input	5 V / 15 mA Enable: Low (< 0.8 V) Disable: High (3.1 - 5.5 V or open)
Motor output	$V_{OUT} = V_{BB}$ ; to 35 V
Clock	$V_{DD} = 3.0 - 5.5$ V, typically 5 V Low: 0 - 0.8 V High: 3.1 - 5.5 V Pulse width: >2 $\mu$ s Pulse width: >2 $\mu$ s
Ambient temperature	0 to 40 °C
Attachment	<ul style="list-style-type: none"> <li>• 2x M2.5 drilled holes spaced at 19.05 mm</li> <li>• 2x M3 drilled holes</li> </ul>
Dimensions	41.5 x 36 x 15.6 (L x W x H) without cooling block

## 5.2 Dimensions

### SMC11



## 5.3 Compliance with EMC standards

The following tests for electromagnetic compatibility (EMC) were performed on the SMC11 according to EMC directive 89/336/EC:

Standard	Test	Overall result
EN 61000-6-1 (2002)	Electromagnetic compatibility (EMC) generic immunity standard	Device complies with standard.
EN 61000-6-3 (2002)	Electromagnetic compatibility (EMC) generic emission standard	Device complies with standard.
EN61000-4-4	Fast burst transient immunity	Device complies with standard.
EN61000-4-2	Electrostatic discharge immunity	Device complies with standard.
EN61000-4-6	Conducted RF immunity (conducted RF induction, induced by high frequency fields above 9 kHz)	Device complies with standard.
EN61000-4-5	Surge immunity	Device complies with standard.
EN61000-6-3	Conducted emissions	Device complies with standard.

## Index

### A

Attachment .....	21
Automatic current reduction.....	13

### C

Charging capacitor .....	9
CLK (clock input) .....	11
Clock input .....	11
Connections.....	7
Current peaks .....	18
Current reduction.....	13

### D

Dimensions .....	22
DIR (direction input).....	11
Direction input.....	11

### E

EMC .....	22
Emission .....	22
EN (enable input).....	12
Enable input.....	12

### F

Functions .....	4
-----------------	---

### H

Heat dissipation .....	19
------------------------	----

### I

Immunity .....	22
Input circuits .....	10
Inputs .....	8
Time behaviour .....	15
Interfaces .....	7

### J

Jumper.....	20
-------------	----

### M

Models .....	4
--------------	---

Motor connection .....	16
------------------------	----

Motor connection diagram .....	17
--------------------------------	----

### N

Natural resonance.....	18
------------------------	----

### O

Operating conditions .....	18
Operating voltage.....	8
Outputs .....	16
Overcurrent protection .....	20
Overcurrent step loss.....	18
Overtemperature .....	19, 20
Overvoltage protection.....	11

### P

Phase current.....	18
Pin assignment	
Connector X1 .....	16
Connector X2 .....	8
Potentiometer.....	19
Power pack .....	9
Protection diodes .....	11

### S

Solder bridges.....	20
Standards.....	22
Step mode.....	20

### T

Technical data.....	21
---------------------	----

### V

Variants .....	5
Voltage source .....	8
Voltage supply .....	8

### X

X1 connector .....	16
X2 connector .....	8

