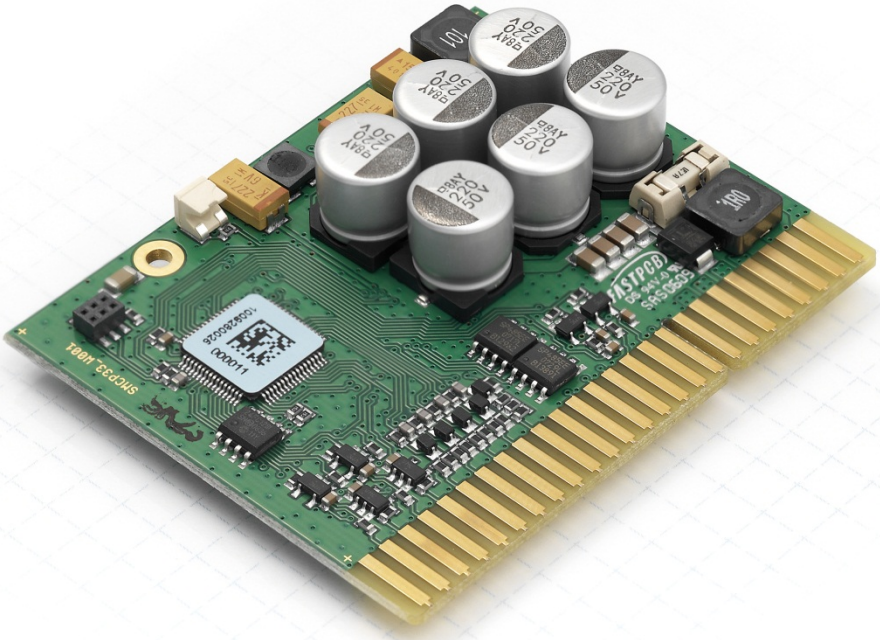
Technical Manual



Stepper controller
SMCP33

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Editorial

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Translation of original handbook

Version/Change overview

Version	Date	Changes
1.0	23.11.2009	New issue
1.1	01.02.2010	Technical data/inputs
1.2	10.02.2010	Pin assignment
1.3	03.11.2010	BLDC use
1.4	03.11.2011	Output circuits
1.5	25.06.2013	Signal states at the outputs

About this manual

Target group

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

Important information

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

Nanotec® 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 was created 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.de

Additional manuals

Please also note the following manuals from Nanotec:

NanoPro User Manual	Configuration of controllers with the NanoPro software	
Programming manual	Controller programming • Command reference • NanoJ • COM interface	

The manuals are available for download at www.nanotec.com.

Contents

1 Overview

Introduction

The SMCP33 stepper motor controller is an extremely compact and cost-effective constant current final output stage with integrated closed loop current control.

Due to the great capacity and functions available, it offers designers and developers a rapid and simple method of resolving numerous drive requirements with less programming effort.

It is used for controlling standard stepper motors (including with attached encoders) or motors with integrated encoders or brakes. BLDC motors are also supported.

The plug-in module can be integrated in complex device controllers with a minimum of additional development effort, especially for the direct and virtually noise-free and resonance-free control of the output stages via the microcontroller by means of the dspDrive® method – both in open loop and closed loop operation.

In conjunction with the integrated NanoJ programming language based on the Java standard, complete sequencing programs can be implemented on the plug-in module that can be run autonomously without a superordinate controller.

Variants

The SMCP33 is available in the following variants:

- SMCP33: 2 A phase current
- SMCP33-K: With a heat sink for 4 A phase current

Functions of the SMCP33

The SMCP33 stepper motor controller contains the following functions:

- Microstep -1/1 – 1/64 final output stage (step resolution of up to 0.014° in motors with a step angle of 0.9° in 1/64 step mode)
- Closed loop current control (sinusoidal commutation via the encoder)
- Powerful DSP microprocessor for flexible I/O
- Sequence programs with NanoJ
- Rotation monitoring for optional encoder
- RS485 port for parameterization and control
- Network capability with up to 254 controllers
- The function of the digital inputs and outputs and the two analog inputs is freely configurable
- Easy programming with the NanoPro Windows software

Closed loop current control (sinusoidal commutation via the encoder):

In contrast to conventional stepper motor controllers where only the motor is actuated or the position adjusted via the encoder, sinusoidal commutation controls the stator magnetic field via the rotary encoder as in a servo motor. The stepper motor acts in this operating mode as nothing more than a high pole servomotor, i.e. the classic stepper motor noises and resonances vanish. As the current is controlled, the motor can no longer lose any steps up to its maximum torque.

If the controller recognizes that the rotor is falling behind the stator field due to overload, adjustments are made with optimal field angle and increased current. In the opposite case, i.e. if the rotor is running forward due to the torque, the current is automatically reduced so that current consumption and heat development in the motor and controller are much lower compared to normal controlled operation.

dspDrive®

With dspDrive®, the motor current is controlled directly by a digital signal processor. Unlike conventional ICs, which resolve the winding current measurement and the target current value with only 6 or 8 bit, the new dspDrive® performs the entire control with a resolution of 12 bit. The parameters of the PI current controller can be adjusted to the motor and by the user as a function of the rpm.

This has the following application advantages:

- Very smooth, low-resonance operation with a sinusoidal current in the windings, even at low speeds.
- Very good step angle precision and synchronicity, even in open loop operation.
- Three-phase stepper motors and BLDC motors can be controlled as well.

NanoJ

The integrated programming language NanoJ, based on the Java standard, means complete application programs can be realized on the drivers that can be executed independently without a higher-order controller.

The programs can be created, compiled directly and written to the controller with the free NanoJEasy editor.

More detailed information can be found in the separate programming manual.

Settings

The operating behavior of the motor can be set and optimized according to individual requirements by setting the motor-related parameters. The parameters can be set using the NanoPro software and significantly reduce commissioning time.

More detailed information on this can be found in the separate NanoPro user manual.

Rotation monitoring

Even if stepper motors do not lose steps during normal operation, the integrated rotation monitoring provides additional security in all operating modes, e.g. against motor stalling or other external sources of error. The monitoring function detects motor blockage or step loss after half a step at the most (for 1.8° stepper motors).

Automatic error correction is possible after the drive profile is ended or between the travel profiles.

2 Commissioning

Requirements

Commissioning of the SMCP33 stepper motor is described below.

You will find the main "First Steps" here to start working rapidly with the SMCP33 if you are using the NanoPro software from a PC.
You will find more detailed information in the separate NanoPro manual.

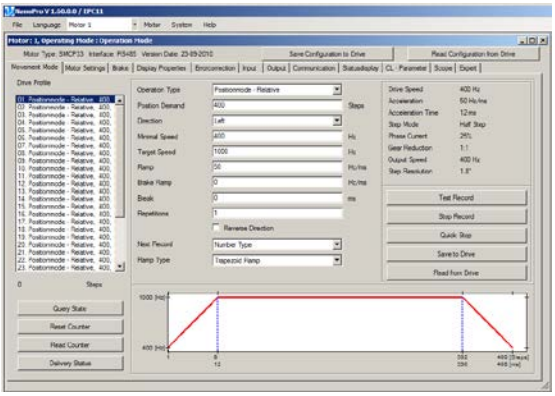
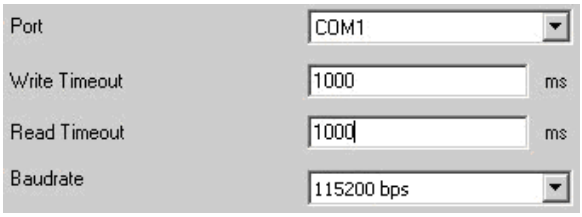
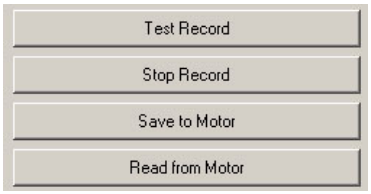
If you want to work at a later time with a PLC or your own program, you will find the necessary information in the separate "Programming manual".

Familiarize yourself with the SMCP33 stepper motor controller and the corresponding NanoPro control software before you configure the controller for your application.

Procedure

Proceed as follows to commission the controller:

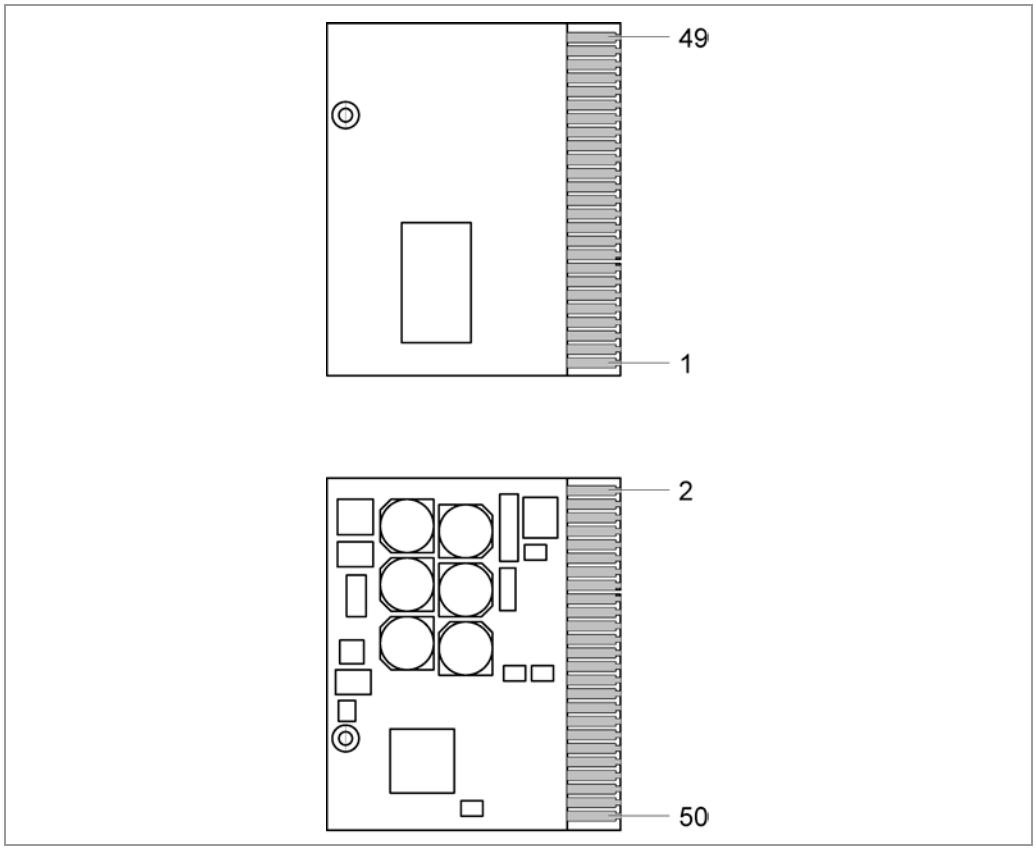
Step	Action	Note
1	Install the NanoPro control software on your PC. See the NanoPro separate manual.	Download from www.nanotec.com
2	Plug the SMCP33 into the motherboard (SMCP33-EVA evaluation board).	Detailed information on the SMCP33-EVA can be found in Section 3.2 SMCP33-EVA evaluation board and under the Accessories/Electronics menu item on www.nanotec.com.
3	Connect the controller to the stepper motor.	Detailed information on connections can be found in Section 3 „Connections and circuits“.
4	Switch on the operating voltage (12 V DC ... 48 V DC).	
5	If necessary, install the converter driver for the converter cable ZK-RS485-RS232 or ZK-RS485-USB.	Download from www.nanotec.de in the Accessories/Converter menu item
6	Connect the controller with your PC via the serial D-Sub 9 or the USB port of the SMCP33-EVA motherboard. Use one of the following converter cables for this purpose: • ZK-RS485-RS232 for connection to the serial port • ZK-RS485-USB for connection to the USB port	Order number: • ZK-RS485-RS232 • ZK-RS485-USB

Step	Action	Note
7	Start the NanoPro software. 	The NanoPro main menu appears.
8	Select the <Communication> tab. 	
9	In the "Port" field, select the COM port to which the SMCP33 is connected. 	The number of the COM port to which the controller is connected can be found in the device manager of your Windows PC (System Control/System/Hardware).
10	Select the "115200 bps" entry in the "Baudrate" selection field.	
11	Check the current setting using the motor data sheet. **Presettings:** • Phase current: 50% (current level) • Phase current during idle: 25% (idle current)	Under no circumstances may the current be set to a value higher than the rated current of the motor.
12	Select the <Movement Mode> tab. 	
13	Click on the <Test Record> button to carry out the pre-set travel profile. 	The connected motor operates with the pre-set travel profile (default travel profile after new installation).
14	You can now enter your required settings. For instance, you can enter a new travel profile.	See the NanoPro separate manual.

3 Connections and circuits

3.1 Pin assignment SMCP33

Pin assignment



Description

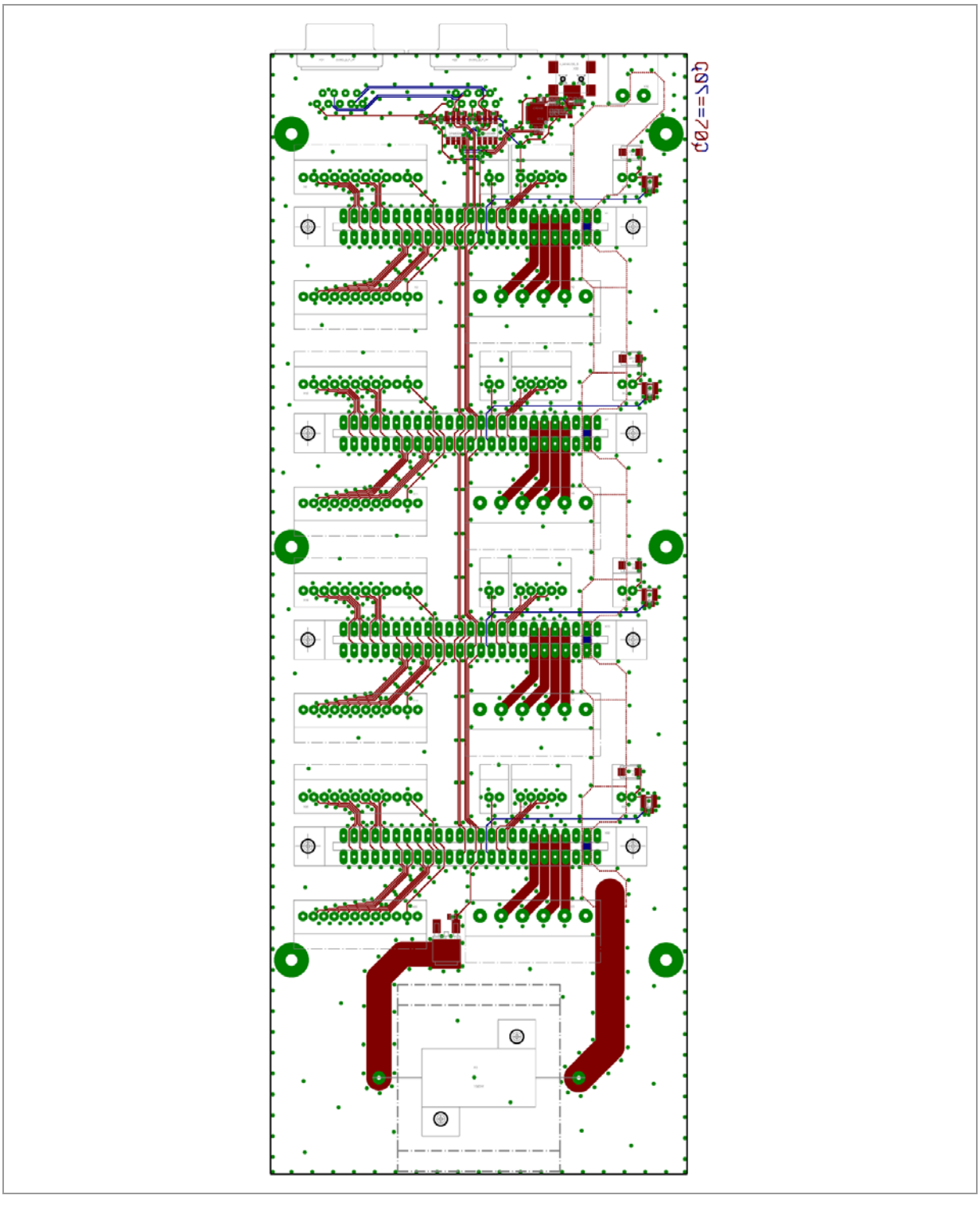
Pin no.	Name	Observations
1/2	GND	Mass (0 V)
3/4	$+V_B$	Operating voltage +12 V DC ... +48 V DC
5/6	GND	Mass (0 V)
7/8	B/	Motor phases; For BLDC motors: • A = V (red) • A/ = U (yellow) • B = W (black) • B/ = not connected
9/10	B	
11/12	A/	
13/14	A	
15/16	GND	Mass (0 V)
17	Index track (I)	Encoder,
18	Track (A)	
19	Track (B)	
20	+5 V	In BLDC motors: supply for hall sensors
21	Temp motor	
22	Brake	Brake output
23/24	Ballast	Ballast output
25	RS-485 Rx–	RS-485 connection
26	RS-485 Rx+	
27	RS-485 Tx–	
28	RS-485 Tx+	
29/30	GND	Mass (0 V)
31	Analogue In 1	Analogue input 1 (–10 V ... +10 V)
32	Analogue In 2	Analogue input 2 (–10 V ... +10 V)
33	Input 1	Digital inputs; For BLDC motors: • Input 2 = Hall sensor H1 (blue) • Input 3 = Hall sensor H2 (white) • Input 4 = Hall sensor H3 (green)
34	Input 2	
35	Input 3	
36	Input 4	
37	Input 5	
38	Input 6	
39	Input 7	
40	Input 8	
41	Output 1	Outputs
42	Output 2	
43	Output 3	
44	Output 4	
45	Output 5	
46	Output 6	
47	Output 7	
48	Output 8	
49/50	GND	Mass (0 V)

3.2 SMCP33-EVA evaluation board

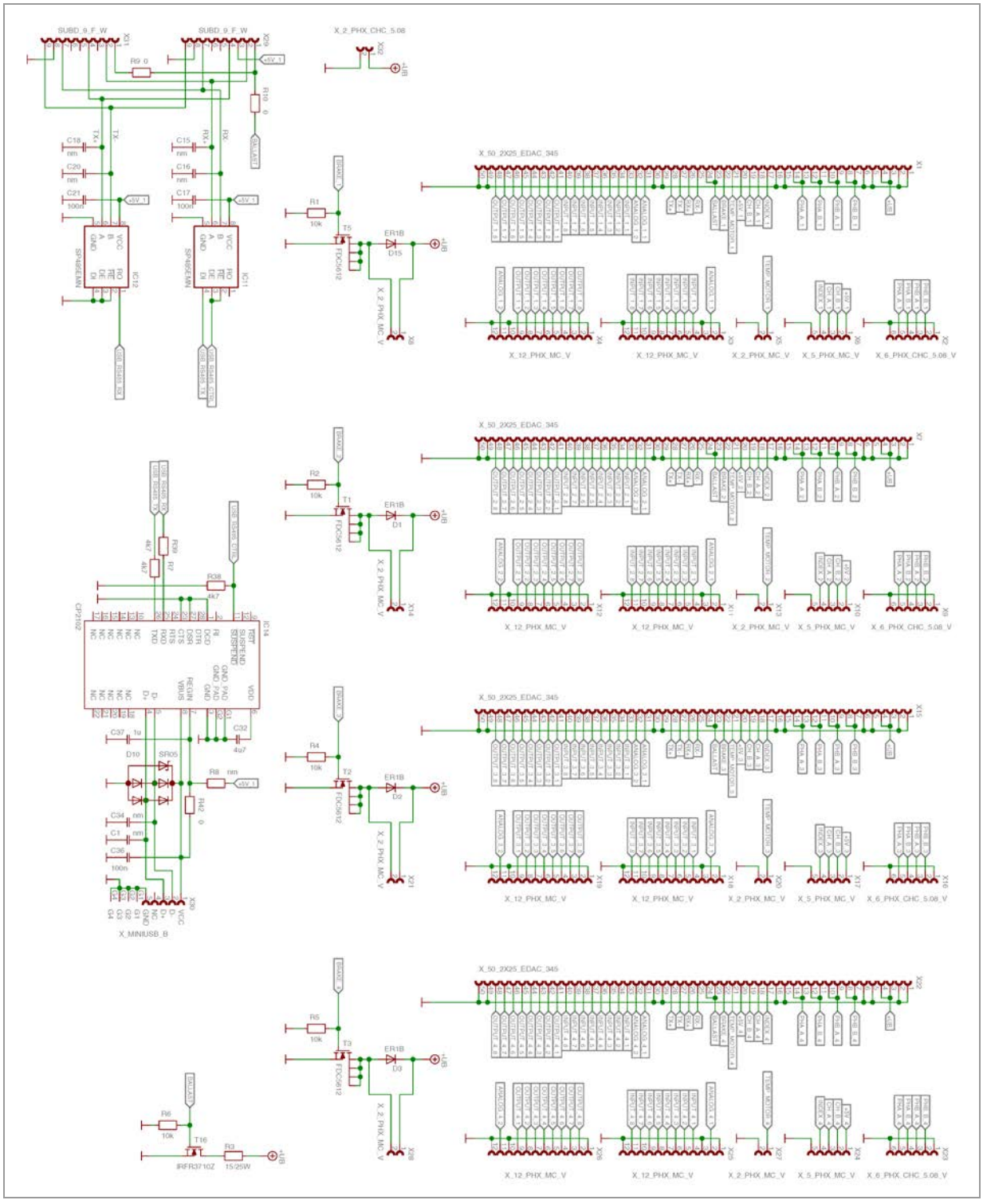
General information

The SMCP33-EVA evaluation board of Nanotec is a motherboard for the SMCP33 plug-in device card. It can be used for the rapid commissioning of four stepper motors via a pre-wired RS485 network and a PC connection. All inputs and outputs available in the SMCP33 are led to the outside via Phoenix Combicon connectors. In addition, an encoder or a brake can be connected.

Board



Connection diagram



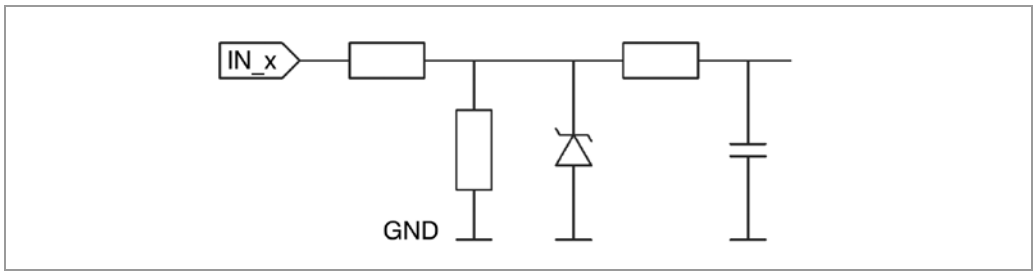
Note:
The connection diagram is available for download on www.nanotec.com.

3.3 Inputs and outputs (I/O)

Input circuits

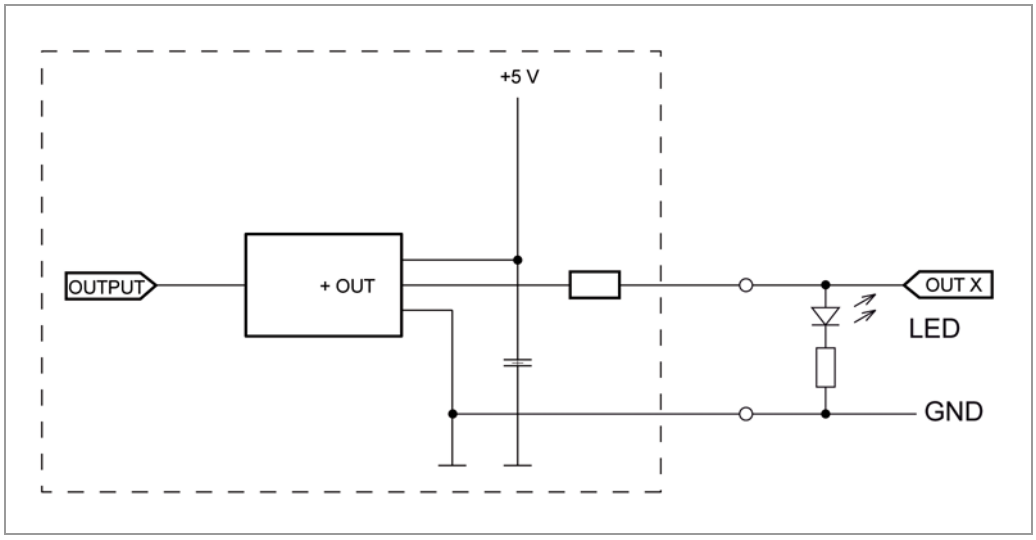
All digital inputs are designed for 5 V input signals.

Note:
The voltage must not exceed 5 V. It should drop below 2 V for safe switching off and be at least 4.5 V for safe switching on.



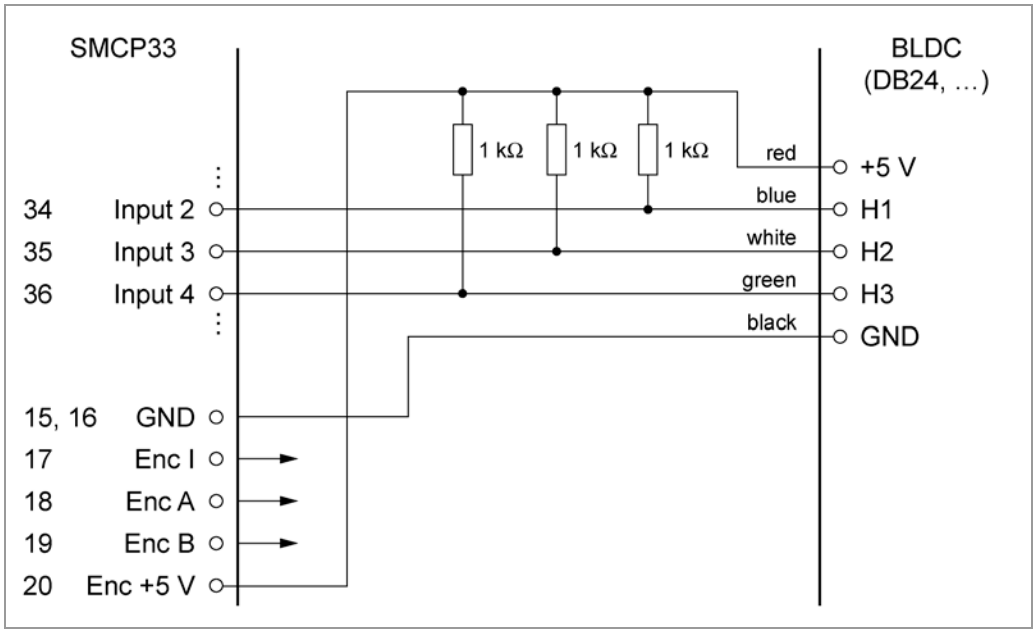
Output circuits

The outputs are a TTL outputs (5 V/max. 20 mA). To be able to test the output, an LED with a series resistance against earth can be integrated. The LED lights up when the output is active.



Circuitry of hall sensors in BLDC mode

The hall sensors of the BLDC motor are connected as shown in the following graphic:



Function of the inputs

All digital inputs – with the exception of the "Clock" input in the clock directional mode – can be freely programmed using the NanoPro software (e.g. as a limit position switch, enable, etc.) and can be used for sequential control with NanoJ.

Note:
In BLDC mode, the inputs 2, 3 and 4 cannot be used for the configuration of the operating mode. A reconfiguration is not possible at this time.

The "Analogue In 2" analog input currently can only be used by the programming language.

All inputs can be configured for “active-high" (PNP) or “active-low" (NPN) with NanoPro.

Signal states at the outputs

The following table shows the possible signal states at the outputs:
(assignment: Output 1 = ready, Output 2 = running, Output 3 = error)

Signal states								Meaning
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1	
						0	0	Rotation monitoring (error) or limit switch
						0	1	Motor idle (waiting for new command)
						1	0	Busy (control processing last command)
						1	1	Reference point or zero point reached
					1			Overtemperature

The outputs can be freely programmed using the NanoPro software.

Note:
Output 3 is also used to display errors and when switching on the controller.

3.4 Brake connection

Function

The brake output is used to control an external safety brake for the motor. This allows the holding torque and therefore the system stiffness to be increased further when necessary.

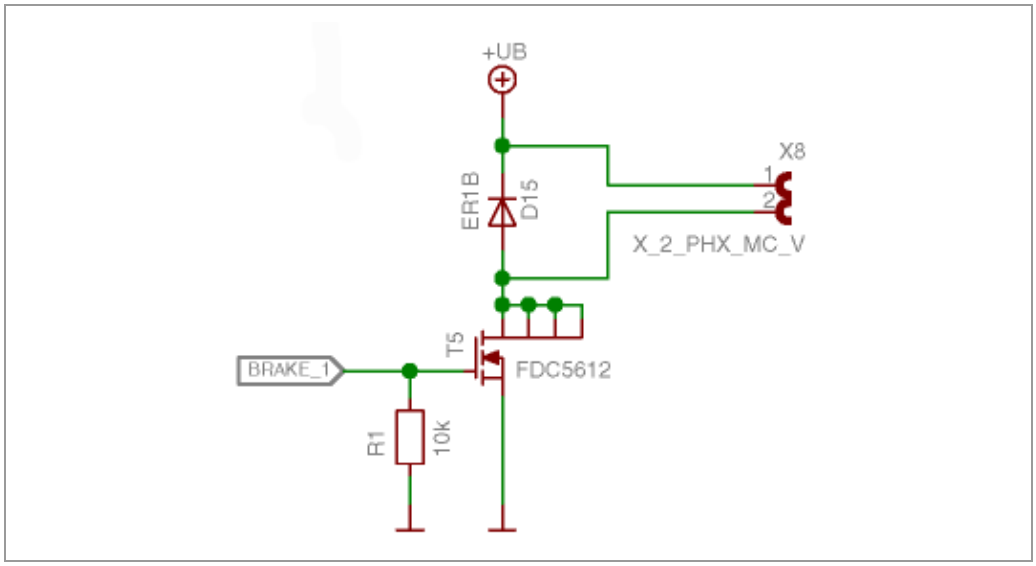
Because the output is a TTL output, an additional controller component is needed.

Parameters

In NanoPro, the brake parameters can be configured in the <Brake> tab; see the separate manual on NanoPro.

Example: Connection to SMCP33-EVA

On the SMCP33-EVA motherboard shown in Section 3.2 SMCP33-EVA evaluation board, the brake connections are located on the interfaces X8/ X14/ X21/ X28.



3.5 Ballast connection

Function

The ballast output is used by the controller to indicate overvoltage at the supply.

Circuit on the motherboard

The motherboard should have a circuit that protects the controller against brief voltage peaks as can occur through the reverse feeding of the motors in the generator mode.

The connection diagram of the evaluation board shows a version of the ballast circuit that conducts the excess voltage/energy to a resistor with the aid of a transistor, where it is converted to heat. This resistor is also referred to as the "Brake resistor" because the energy usually arises from braking of the motor.

This protects the SMCP33 against destruction from brief overvoltage. The rating and cooling of the resistor determines how long it can convert the overvoltage before it becomes too hot and is destroyed.

3.6 Encoder connection

Optional encoder

An optional encoder can be connected to the stepper motor controller.

By default, the closed loop control for a three-channel encoder is set up with 500 pulses/revolution in a 1.8° stepper motor. With an 0.9° stepper motor, you should use an encoder with 1000 pulses/revolution to achieve the same control quality. Depending on the application, it may make sense to use higher encoder resolutions (up to max. 2000 pulses/revolution) to improve control quality or to use a lower resolution (min. 200 pulses/revolution) for low-cost applications or for step monitoring alone.

The following encoder resolutions can normally be processed by the controller: 192, 200, 256, 400, 500, 512, 1000, 1024, 2000, 2048, 4000, 4096.

Recommendation
If possible, use Nanotec encoders with the order identifier WEDS/WEDL-5541 Xxx.

If an encoder is **not** used, the "Disable" mode must be set in the <Error correction> tab in the "Rotation Direction Mode" selection menu. See the NanoPro separate manual.

Using encoders with line drivers

The encoders of the WEDL series with a line driver output an inverted signal in addition to the encoder signal; this leads to better interference immunity and is especially recommended for long lines lengths (> 500 mm) and neighboring interference sources. The differential signal can be evaluated with a line driver/encoder adapter.

The SMCP controllers themselves currently cannot evaluate the differential signal, meaning that only the channels A, B and I need to be connected to perform position monitoring. We recommend shielding and twisting the encoder line to minimize interference with the encoder signal from the outside.

3.7 Stepper motor connection

Connection cable

The motor is connected to the SMCP33 with a 4-wire cable. Twisted wire pair cables with braided shields are recommended.

Danger of electrical surges
Mixing up the connections can destroy the output stage! See the data sheet of the connected stepper motor.
Never disconnect the motor when operating voltage is applied!
Never disconnect lines when live!

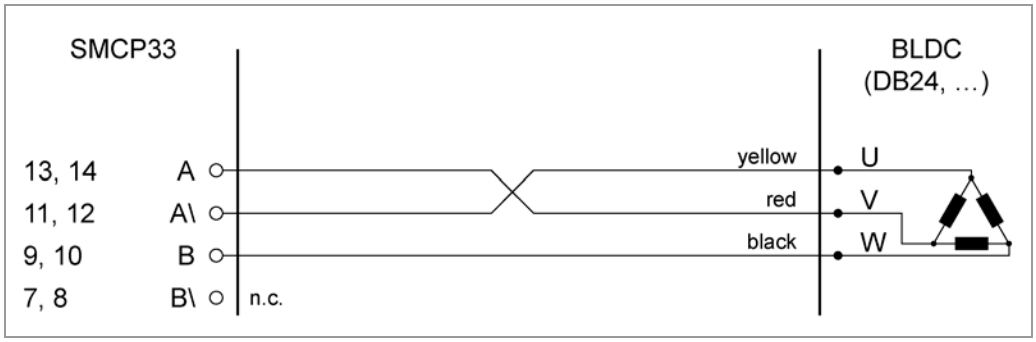
Motor with 6 or 8 connections

If you are using a motor with 6 or 8 connections, you need to connect the windings.

The pin configuration for the motor can be found on the motor data sheet, which can be downloaded from www.nanotec.com.

3.8 BLDC motor connection

A BLDC motor is connected to the controller as shown in the following graphic. To connect the hall sensors, see Section 3.3 "inputs and outputs (I/O)".



3.9 Power supply connection

Permissible operating voltage

The permissible operating voltage of the SMCP33 stepper motor controller lies within the range +12 to +48 V DC and must not exceed 50 V or undershoot 10 V.

A charging condenser with minimum 4700 µF (10000 µF) must be provided for the operating voltage to prevent exceeding the permissible operating voltage (e.g. during braking).

Danger of electrical surges

Connect charging condensor with minimum 4700 µF!

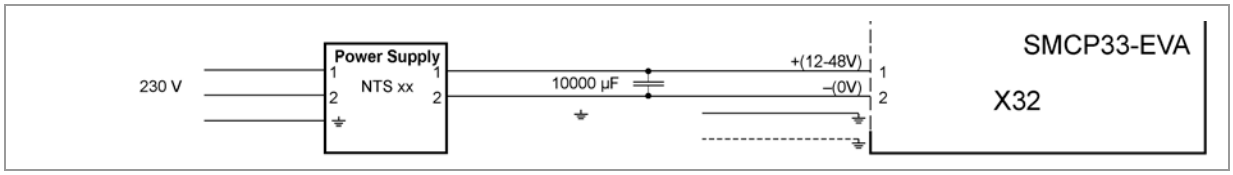
Connect a condenser with 10000 µF for motors with flange size 86x86 (series ST8918) or greater!

An operating voltage > 50 V will destroy the output stage!

Mixing up the connections can destroy the output stage! See the data sheet of the connected stepper motor.

Never disconnect the motor when operating voltage is applied!

Never disconnect lines when live!



Accessories

Appropriate power packs and charging condensers are available as accessories:

Name	Order identifier
Power pack	NTS-xxV-yA (xx=voltage: 12, 24 or 48 V, y=current: 2.5, 5 or 10 A) Information on the selection of the required power supply unit can be found in our FAQ on www.nanotec.com.
Charging condenser	Z-K4700 or Z-K10000

Note: Further information about accessories can be found on the Nanotec website www.nanotec.com.

3.10 RS485 communication

SMCP33 in a network

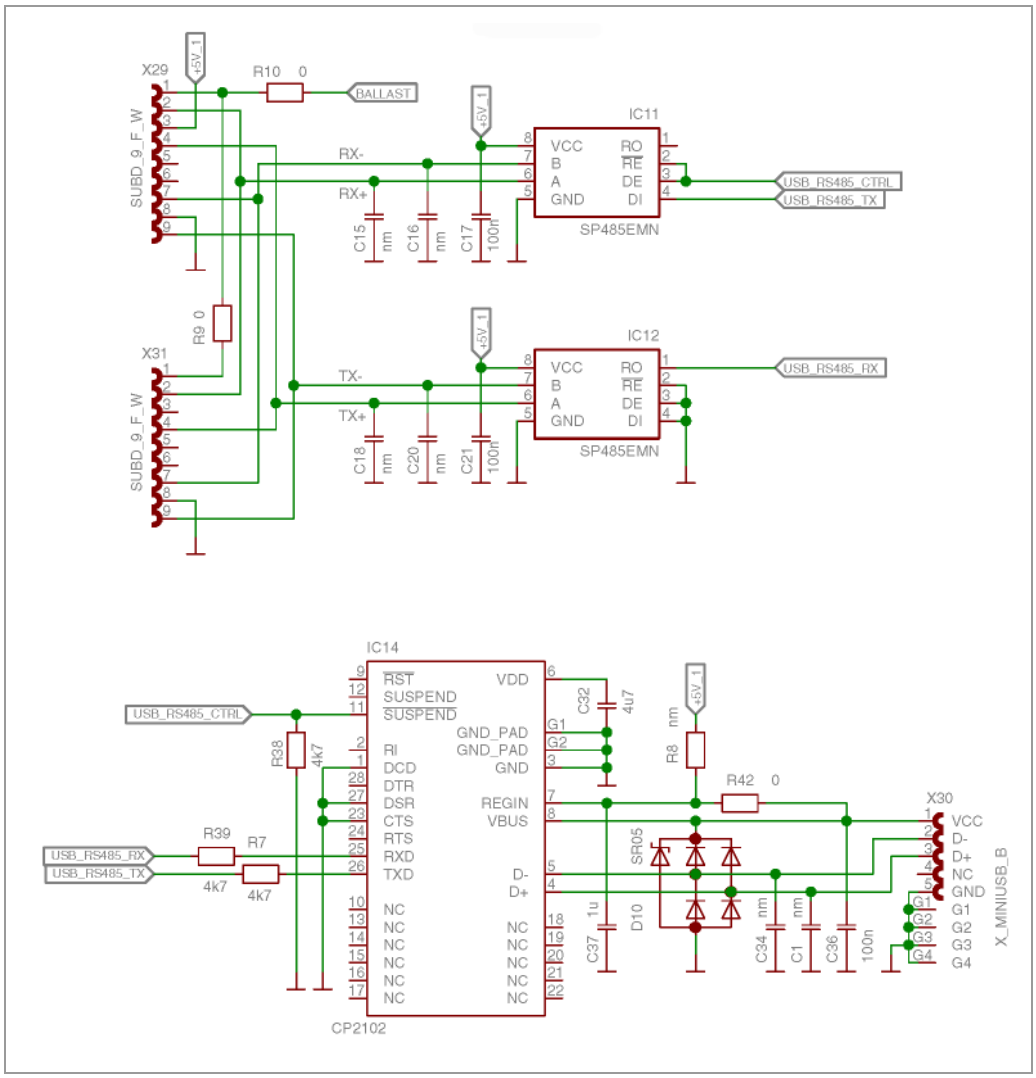
Up to 254 stepper motor controllers can be controlled in a network from a PC or PLC.

This network connection is set up via the RS485 port.

Example: Connection to SMCP33-EVA

On the SMCP33-EVA motherboard shown in Section 3.2 "SMCP33-EVA evaluation board", four stepper motors can be rapidly commissioned via a pre-wired RS485 network and a PC connection.

For the PC connection, either a serial D-Sub 9 port (X29) or the USB port (X30) of the SMCP33-EVA motherboard can be used.



Use the following converter cable:

- ZK-RS485-RS232 for connection to the serial port
- ZK-RS485-USB for connection to the USB port

4 Operating modes

Introduction

Depending on the travel profile, the motor can be operated using different operating modes. Due to the great capacity and functions available, it offers designers and developers a rapid and simple method of resolving numerous drive requirements with less programming effort.

Select the required operating mode for each drive profile and configure the controller according to your requirements.

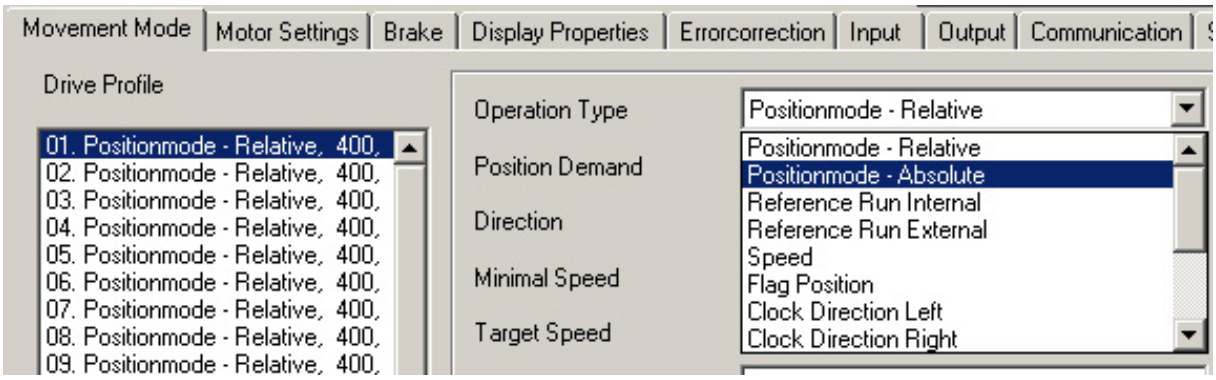
More detailed information can be found in the separate NanoPro manual.

Overview of operating modes and their areas of application

Operation mode	Application
Relative positioning	Use this mode when you wish to travel to a specific position. The motor travels according to a specified drive profile from a Position A to a Position B.
Absolute positioning	
Internal reference run	During the internal reference run, the motor travels to an internal reference point (the index mark of the encoder) at the set minimum speed.
External reference run	During an external reference run, the motor travels to a switch connected to the reference input.
Speed mode	Use this mode when you wish to travel with a specific speed (e.g. a conveyor belt or pump speed). In the speed mode, the motor accelerates with a specified ramp from the starting speed (start frequency "V Start") to the specified maximum speed (maximum frequency "V Normal"). Several inputs enable the speed to be changed on-the-fly to different speeds.
Flag positioning mode	The flag positioning mode offers a combination of the speed and positioning modes. The motor is initially operated in speed mode; when a trigger point is reached, it changes to the positioning mode and the specified setpoint position (relative to the trigger position) is approached. This operating mode is used for labeling, for example: the motor first travels with the set ramp to the synchronous speed of the conveyed goods. When the labels are detected, the preset distance (position) is traveled to apply the labels.

Operation mode	Application
Clock direction mode, left	Use this mode when you wish to operate the motor with a superordinate controller (e.g. CNC controller). In the clock direction mode, the motor is operated via two inputs with a clock and a direction signal from a superordinate positioning control (indexer). Depending on the mode selected (Int. Ref./Ext. Ref.), the internal and external reference runs are supported.
Clock direction mode, right	
Clock direction mode Int. Ref.	
Clock direction mode Ext. Ref.	
Analog and joystick mode	The motor is controlled in this operating mode simply with a potentiometer or a joystick (–10 V to +10 V). Use this mode if you want to use the motor in a simple application: • Setting a specific speed, e.g. via an external potentiometer, • Traveling synchronously with a superordinate controller with analog output (–10 V to +10 V).
Analogue positioning mode	Use this mode when you wish to travel to a specific position. The voltage level at the analog input is proportionate to the desired position, thus enabling servo performance.
Torque mode	Use this mode when you require a specific output torque independent of the speed as is the case in typical winding and unwinding applications. The maximum torque is specified via the analog input.

Selecting the operating mode in NanoPro



5 Troubleshooting

Troubleshooting procedure

Proceed with care during troubleshooting and error rectification to avoid damaging the controller.

Danger of electrical surges
An operating voltage > 50 V and incorrect connections can destroy the end stage.
Never disconnect the motor when operating voltage is applied!
Never disconnect lines when live!

Possible error

Error	Possible cause	Rectification
Controller is not ready	Data transmission to SMCP33 is not possible (communication error): Incorrect COM port selected.	In the <Communication> tab, select the PC port to which you connected the SMCP33 (e.g. "COM-1"). The port used can be found in the device manager of your PC.
	Communication cable not connected or interrupted (incorrect converter used).	Use the recommended RS232-RS485 converter from Nanotec: • Order identifier: ZK-RS485-RS232
	A non-existent motor number (module number) is set.	Set the correct module address. See the separate manual on NanoPro.
	The power supply of the SMCP33 is interrupted.	Check voltage supply, switch on if necessary.
	Another open program is blocking the COM port to which the SMCP33 is connected.	Close down other programs on your PC.
	Inadmissible data was sent to the controller during the output of a travel profile.	Click on the <Yes> button to stop the travel profile. The SMCP33 switches back to the "Ready" state. The data can then be resent to the controller.
	Multiple controllers with the same address are installed in the evaluation board.	Install the controllers one after the other and assign a unique motor address to each.
Transmission error	Data transmission to the SMCP33 is disturbed (sender or receiver are disturbed).	Check the possible causes for the transmission error and rectify the cause of the error.
Position error	A button was clicked while the controller was in error mode (position error or limit switch in normal operation).	Click the <Yes> button in the error message; the error is reset.

Error	Possible cause	Rectification
Red LED on the SMCP33 lights up.	Overtemperature of power electronics > 75 °C	Switch off controller and allow to cool. The error is reset when the SMCP33 is disconnected from the power supply unit.
	Undervoltage	Check voltage supply.

6 Technical data

Electrical connections

Operating voltage V_b	DC 12 V to 48V ±4%
Max. phase current	SMCP33: nominal current 2 A, adjustable up to max. 3 A/phase SMCP33-K (with heat sink): nominal current 4 A
Current drop	Adjustable 0 to 100% of phase current
RS-485 interface	• 115200 Baud (adjustable) • 1 start bit, 8 data bits, 1 stop bit • No parity

Controller parameters

Step modes	Full Step Half Step Quarter Step Fifth Step Eighth Step Tenth Step 32nd Step 64th Step Feed rate Adaptive microstep (1/128)
Step frequency	16 kHz with a full step, corresponding multiples with a microstep (e.g. 1 MHz with 1/64) Max. input frequency, clock direction mode: 200 kHz
Position monitoring	Automatic error correction to 0.9° only with optical encoder (e.g. WEDS5541 series)

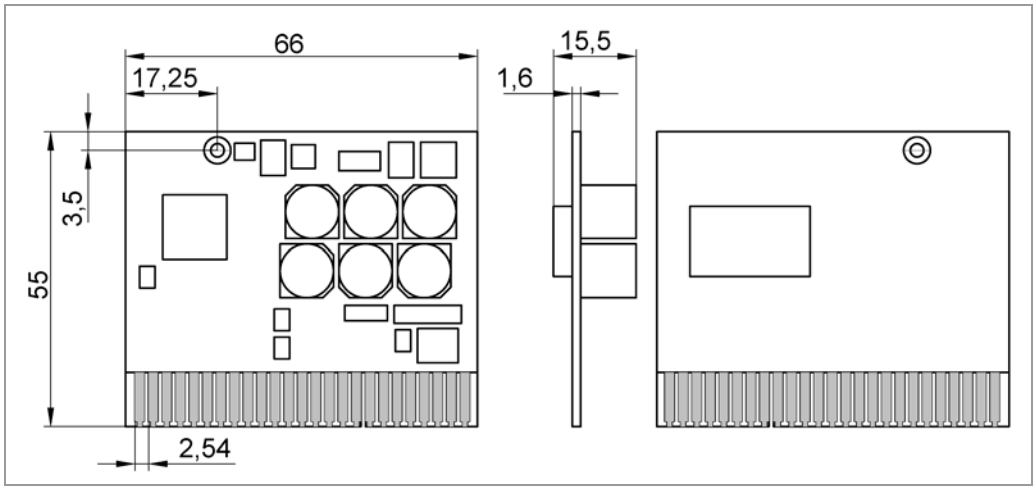
Inputs and outputs

Inputs	8 digital inputs (5 V) • Safe switch off: max. 2 V • Safe switch on: min. 4.5 V 2 analog inputs
Outputs	8 TTL outputs (0 switching, max. 5 V/25 mA) 1 brake output, 1 ballast output

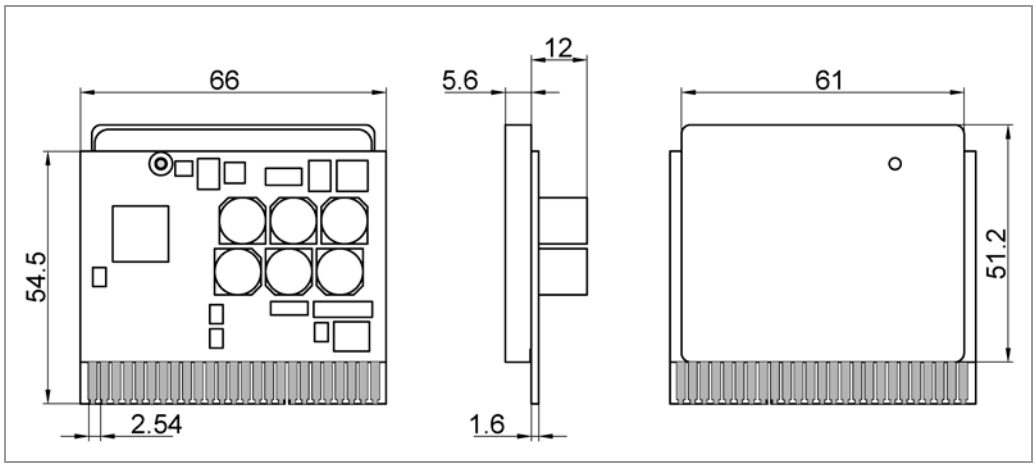
Protective circuits

Overvoltage and undervoltage	Protection circuit for voltage > 50 V or < 10 V
Max. heat sink temperature	Approx. 80 °C
Ambient temperature	0 to 40 °C

SMCP33 dimensions



SMCP33-K dimensions (with heat sink)



A complete set of datasheets is available for downloading at www.nanotec.com.

Mating connector/board holder, EADC types

Mating connector: 345-050-521-202

Inline plug-in unit, short: 345-220-088

Encoding element between contact: 345-240-318

Overtemperature protection

In the SMCP33 with a heat sink, the power drive of the controller is switched off at a temperature of approx. 75 °C and is set to output 3.

In the SMCP33 without a heat sink, the overtemperature protection of the driver component is activated at a temperature of approx. 130 °C. The power drive of the controller is switched off and output 3 is set.

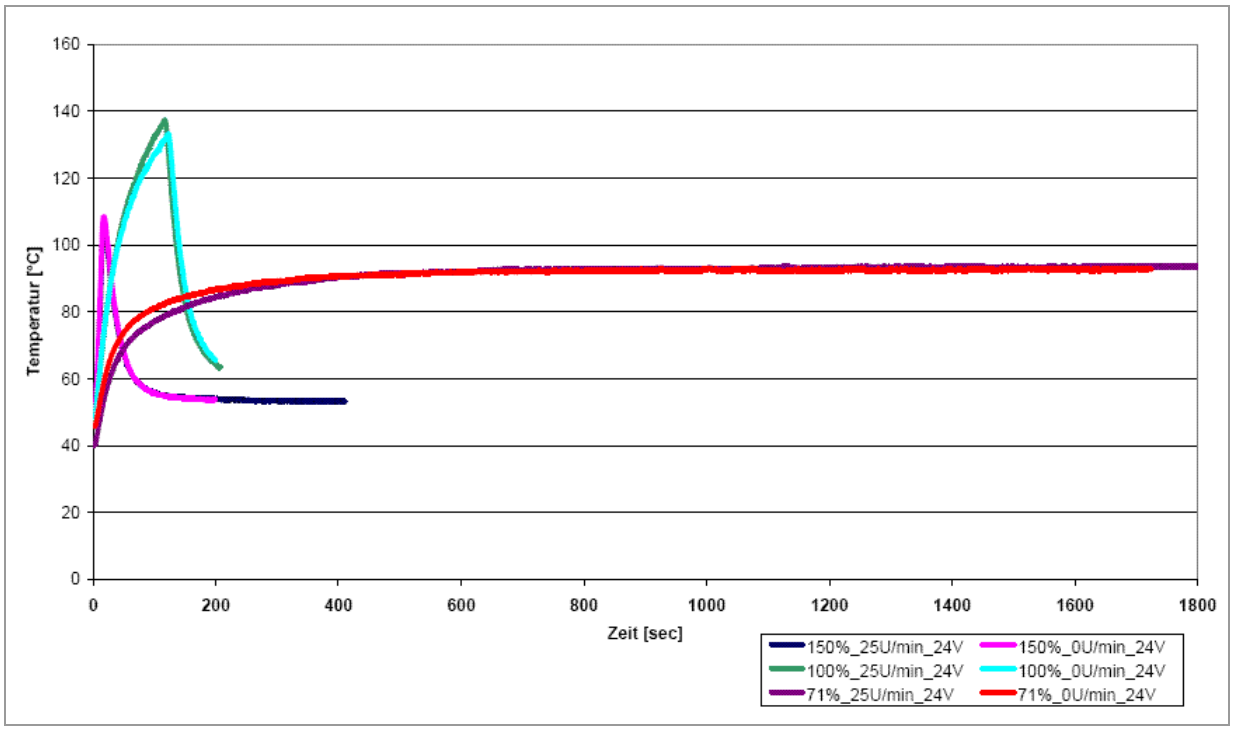
After the controller is cooled and restarted, it becomes functional again.

Temperature tests were performed under the following conditions:

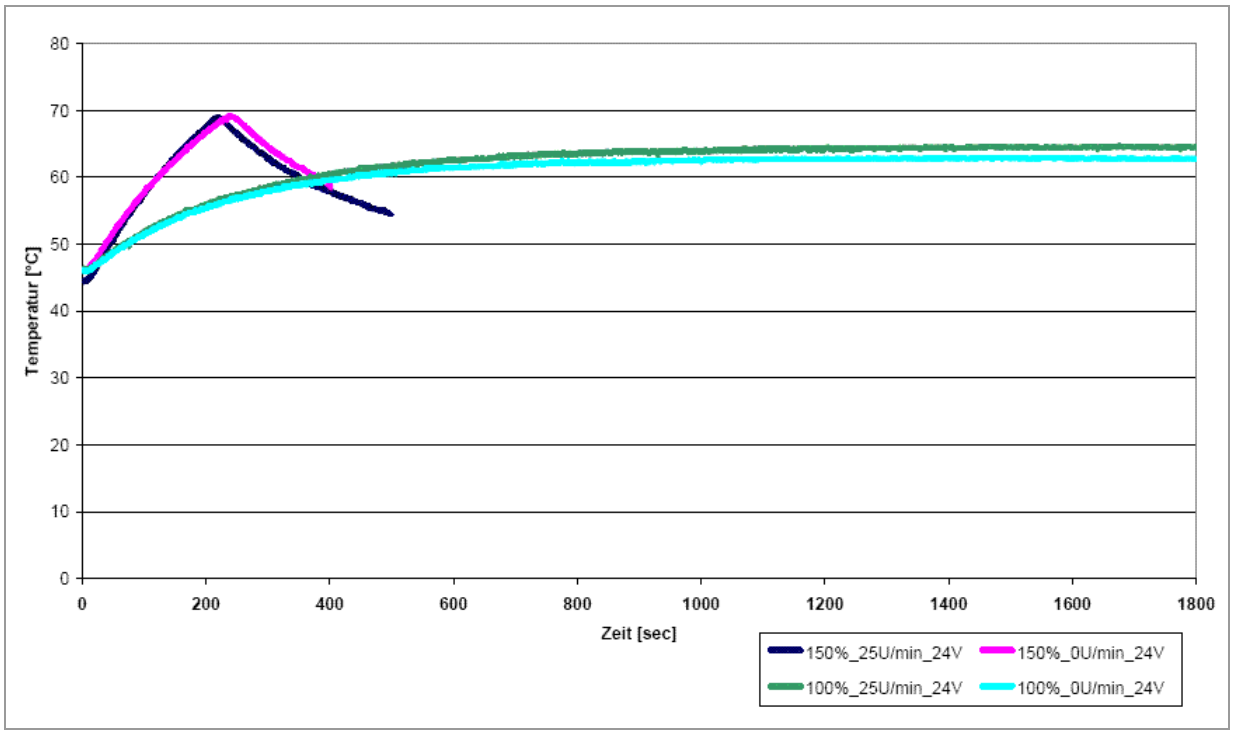
- Operating voltage: 24 V/48 V DC
- Motor current: 71% (2 A), 100% (2.8 A), 150% (4.2 A)
- Operation mode: Full step speed mode, 25 rpm and 0 rpm
- Operating environment: Binder FED 53 temperature cabinet, circulated air at 100% fan speed
- Ambient temperature: 45 °C
- Test motor: ST5918M6404
- Measurement point:
  - SMCP33 without heat sink: chip housing of driver component
  - SMCP33 with heat sink: heat sink above driver component

The following graphics show the temperature test results:

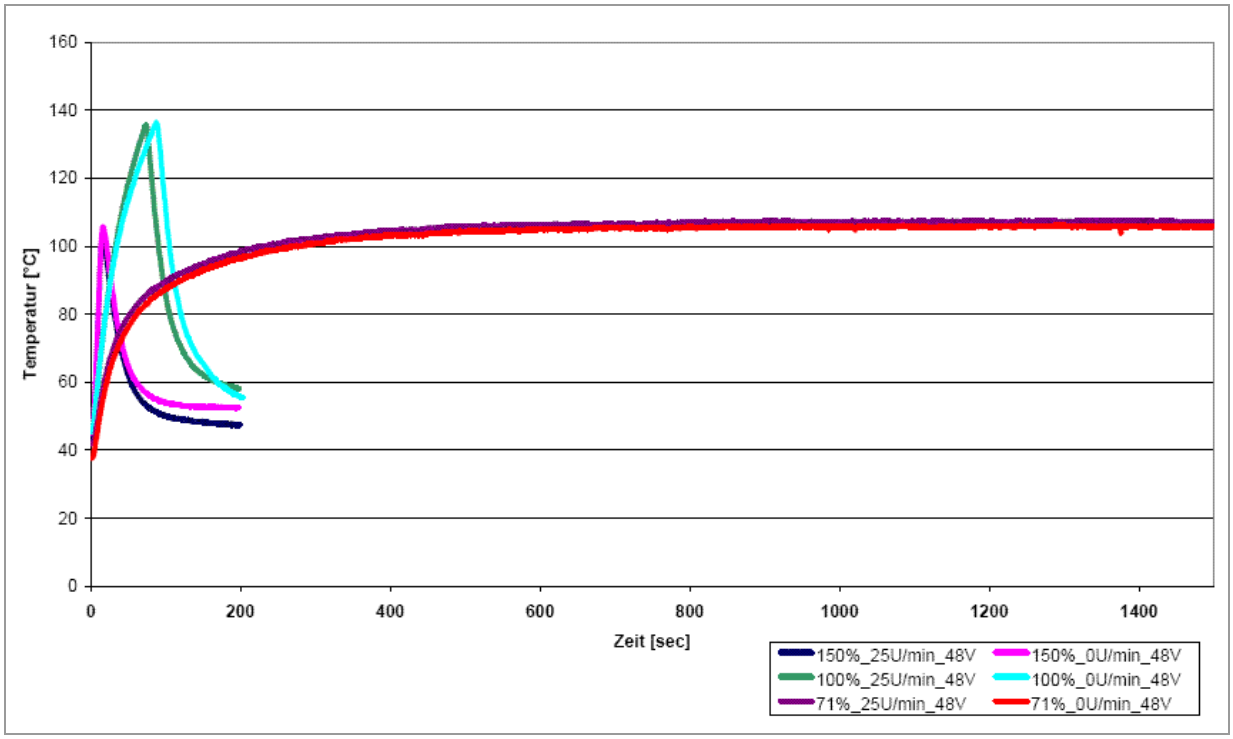
Operating voltage 24 V (without heat sink)



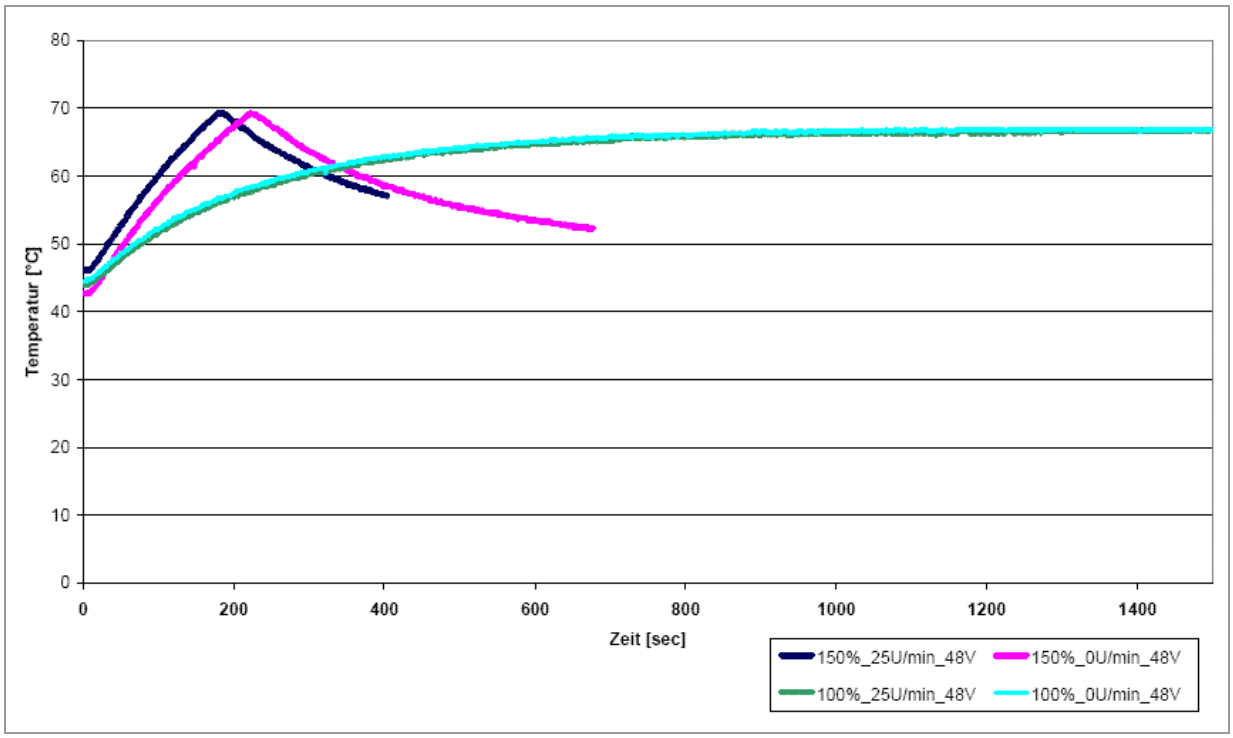
Operating voltage 24 V (with heat sink)



Operating voltage 48 V (without heat sink)



Operating voltage 48 V (with heat sink)



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