



Short instructions Version 1.0.0  
Original: de

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**Introduction**

The NP5 is a controller for BLDC and stepper motors in plug-in module format (PCI-format connector strip) for integration in your own developments.

**Note**

The PCI-format connector strip is not electrically compatible with PCI Express. Under no circumstances is it to be plugged into the PC mainboard.

This document describes the installation and commissioning of the controller. You can find the detailed documentation for the product on the Nanotec website [us.nanotec.com](http://us.nanotec.com). The short instructions do not replace the technical manual of the product.

**Copyright, marking and contact**

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**Intended use**

The NP5 is used to control stepper and BLDC motors and is designed for use under the approved **Environmental conditions**. The controller must be connected to motors via a PCI-format connector strip and a suitable motherboard. The system boundary of the controller ends at the PCI connector strip. Any other use is considered unintended use.

**Note**

Changes or modification to the controller are not permitted.

**Warranty and disclaimer**

Nanotec produces component parts that are used in a wide range of industrial applications. The selection and use of Nanotec products is the responsibility of the system engineer and end user. Nanotec accepts no responsibility for the integration of the products in the end system. Under no circumstances may a Nanotec product be integrated as a safety controller in a product or construction. All products containing a component part manufactured by Nanotec must, upon delivery to the end user, be provided with corresponding warning notices and instructions for safe use and safe operation. All warning notices provided by Nanotec must be passed on directly to the end user. Our general terms and conditions apply: [en.nanotec.com/service/general-terms-and-conditions/](http://en.nanotec.com/service/general-terms-and-conditions/).

**Specialist staff**

- Only specialists may install, program and commission the device:
- Persons who have appropriate training and experience in work with motors and their control.
- Persons who are familiar with and understand the content of this technical manual.
- Persons who know the applicable regulations.

**EU directives for product safety**

- The following EU directives were observed:
- RoHS directive (2011/65/EU, 2015/863/EU)

**Other applicable regulations**

In addition to this technical manual, the following regulations are to be observed:

- Accident-prevention regulations
- Local regulations on occupational safety

**Safety and warning notices**

**Note**

- Damage to the controller.
- Changing the wiring during operation may damage the controller.
- Only change the wiring in a de-energized state. After switching off, wait until the capacitors have discharged.

**Note**

- Fault of the controller due to excitation voltage of the motor.
- Voltage peaks during operation may damage the controller.
- Install suitable circuits (e.g., charging capacitor) that reduce voltage peaks.

**Note**

- There is no polarity reversal protection.
- Polarity reversal results in a short-circuit between supply voltage and GND (earth) via the power diode.
- Install a line protection device (fuse) in the supply line.

**Note**

- The device contains components that are sensitive to electrostatic discharge.
- Improper handling can damage the device.
- Observe the basic principles of ESD protection when handling the device.

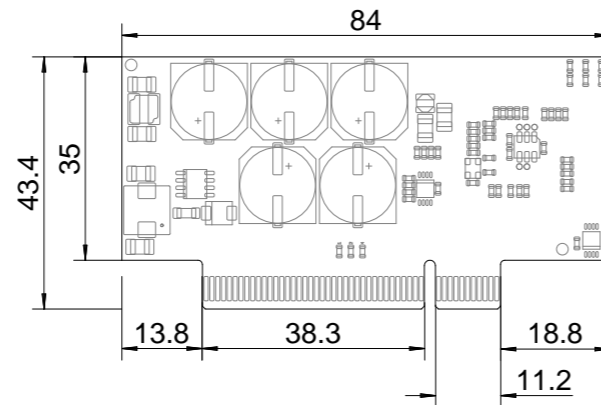
**Technical details and pin assignment**

**Environmental conditions**

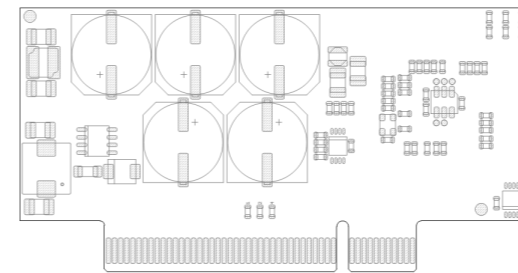
Environmental condition	Value
Protection class	No IP protection
Ambient temperature (operation)	-10 ... +40°C
Air humidity (non-condensing)	0 ... 95 %
Altitude of site above sea level (without drop in performance)	1500 m
Ambient temperature (storage)	-25 ... +85°C

**Dimensioned drawings**

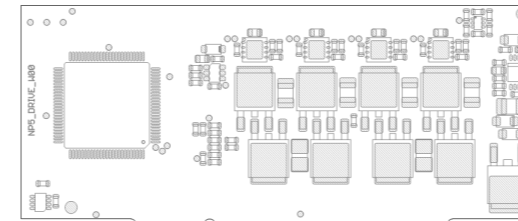
Dimensions are in [mm].



The following figures show the board layout.



Side A



Side B

**Electrical properties and technical data**

Property	Description / value
Operating voltage	12 - 48 V DC ±4%
Rated current	6 A <sub>rms</sub>
Peak current	10 A <sub>rms</sub> (for 1 second)
Commutation	Stepper motor <i>open loop</i> , stepper motor <i>closed loop</i> with encoder, BLDC sine commutated via Hall sensor, BLDC sine commutated via encoder <b>Note:</b> External wiring is required for encoder and Hall sensor!
Operating modes	<i>Profile Position Mode, Profile Velocity Mode, Profile Torque Mode, Velocity Mode, Homing Mode, Interpolated Position Mode, Cyclic Sync Position Mode, Cyclic Sync Velocity Mode, Cyclic Synchronous Torque Mode, Clock-Direction Mode</i>
Set value setting / programming	<i>Clock-direction, analog, NanoJ program</i>
Interfaces	2x SPI, 1x I <sup>2</sup> C or CANopen <b>Note:</b> External wiring is required for CANopen!
Encoder/Hall	2x encoder 1x Hall sensor <b>Note:</b> External wiring is required for encoder and Hall sensor!
I/O	6x general I/O, 2x analog input, 1x output for the external brake (open drain), 1x output for the external ballast circuit
Connector	PCI Express 8x, 1.0 mm RM, 2x49 contacts
Overtemperature	Protection circuit at temperature > 70°C
Polarity reversal protection	Polarity reversal protection by power diode (short-circuit between +UB and GND, fuse necessary in supply line)
Fuse size for polarity reversal protection:	I <sub>max</sub> (controller) < I (tripping current for fuse) < I <sub>max</sub> (voltage supply)
Charging capacitor	For each ampere of rated current on the motor, Nanotec recommends a capacitance of approx. 1000 µF.

**Overtemperature protection**

Above a temperature of approx. 70 °C on the power board the power part of the controller switches off and the error bit is set. After cooling down and confirming the error, the controller again functions normally.

**LED signaling**

**Power LED**

**Normal operation**

In normal operation, the green power LED flashes briefly once per second.

**Case of an error**

If an error has occurred, the LED turns red and signals an error number. The following table shows the meaning of the error numbers.

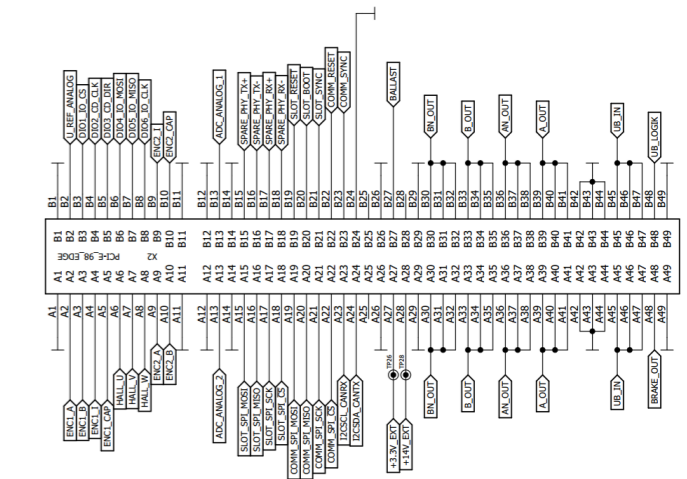
Flash rate	Error
1	General
2	Voltage
3	Temperature
4	Overcurrent
5	Controller
6	Watchdog-Reset

**Note**

For each error that occurs, a more precise error code is stored in object **1003**.

**Pin assignment**

PIN assignment of the PCI connector strip



**Note**

- For digital inputs 1 to 6, the switch-on threshold is 1.8 V, the switch-off threshold is 1.2 V DC. The maximum sampling frequency is 1 MHz. If the I/O pins are used as output (see **Defining input and output assignments**), the maximum admissible current is approx. 10 mA at 3.3 V DC.
- The range of the analog inputs is 0 ... 3.3 V DC.
- The encoder signal is single-ended, the switch-on threshold is 1.8 V, the switch-off threshold is 1.2 V DC. The maximum sampling frequency is 1 MHz.
- The current consumption of the UB\_LOGIC logic supply is approx. 30 mA at 24 V DC.

PCI pin assignment:

Pin	Name	Description/function
A1	GND	
A2	ENC1_A	Encoder 1, A
A3	ENC1_B	Encoder 1, B
A4	ENC1_I	Encoder 1, Index
A5	ENC1_CAP	Not used
A6	HALL_U (H1)	Hall sensor 1 (U)
A7	HALL_V (H2)	Hall sensor 2 (V)
A8	HALL_W (H3)	Hall sensor 3 (W)
A9	ENC2_A	Encoder 2, A
A10	ENC2_B	Encoder 2, B
A11	GND	
A12	GND	
A13	ADC_ANALOG_2	Analog input 2: 0 ... 3.3 V
A14	GND	
A15	SLOT_SPI_MOSI	SLOT_SPI, see <b>Connection SPI</b>
A16	SLOT_SPI_MISO	SLOT_SPI, see <b>Connection SPI</b>
A17	SLOT_SPI_SCK	SLOT_SPI, see <b>Connection SPI</b>
A18	SLOT_SPI_CS	SLOT_SPI_CS, see <b>Connection SPI</b>
A19	COMM_SPI_MOSI	COMM_SPI, see <b>Connection SPI</b>

Pin	Name	Description/function
A20	COMM_SPI_MISO	COMM_SPI, see <b>Connection SPI</b>
A21	COMM_SPI_SCK	COMM_SPI, see <b>Connection SPI</b>
A22	COMM_SPI_CS	COMM_SPI, see <b>Connection SPI</b>
A23	I2CSCL_CANRX	
A24	I2CSDA_CANTX	
A25	n.c.	reserved
A26	GND	
A27	+3.3V_EXT	Not used
A28	+14V_EXT	Not used
A29	GND	
A30	BN_OUT	B\ (stepper motor)
A31		
A32		
A33	B_OUT	B\ (stepper motor) or W (BLDC)
A34		
A35		
A36	AN_OUT	A\ (stepper motor) or V (BLDC)
A37		
A38		
A39	A_OUT	A (stepper motor) or U (BLDC)
A40		
A41		
A42	GND	
A43		
A44		
A45	UB_IN	12 ... 48 V DC ±4%
A46		
A47		
A48	BRAKE_OUT	Control of the external brake, open-drain output, max. 1 A
A49	GND	
B1	GND	
B2	U_REF_ANALOG	3.3 V DC, reference voltage for analog inputs
B3	DIO1_IO_CS	General I/O
B4	DIO2_CD_CLK	General I/O (clock input in clock-direction mode)
B5	DIO3_CD_DIR	General I/O (direction input in clock-direction mode)
B6	DIO4_IO_MOSI	General I/O
B7	DIO5_IO_MISO	General I/O
B8	DIO6_IO_CLK	General I/O
B9	ENC2_I	Encoder 2, Index
B10	ENC2_CAP	Not used
B11	GND	
B12	GND	
B13	ADC_ANALOG_1	Analog input 1: 0 ... 3.3 V
B14	GND	
B15	SPARE_PHY_TX+	reserved
B16	SPARE_PHY_TX-	reserved
B17	SPARE_PHY_RX+	reserved
B18	SPARE_PHY_RX-	reserved
B19	SLOT_RESET	System function, reserved
B20	SLOT_BOOT	System function, reserved
B21	SLOT_SYNC	System function, reserved
B22	COMM_RESET	
B23	COMM_SYNC	
B24	GND	
B25	n.c.	reserved
B26	GND	
B27	BALLAST	For controlling the external ballast circuit
B28	n.c.	reserved

Pin	Name	Description/function
B29	GND	
B30	BN_OUT	B\ (stepper motor)
B31		
B32		
B33	B_OUT	B (stepper motor) or W (BLDC)
B34		
B35		
B36	AN_OUT	A\ (stepper motor) or V (BLDC)
B37		
B38		
B39	A_OUT	A (stepper motor) or U (BLDC)
B40		
B41		
B42	GND	
B43		
B44		
B45	UB_IN	12 ... 48 V DC ±4%
B46		
B47		
B48	UB_LOGIK	External logic supply, 24 V DC
B49	GND	

### Hardware installation



#### Note

Make certain that all components are de-energized.

#### Note

- The device contains components that are sensitive to electrostatic discharge.
- Improper handling can damage the device.
- Observe the basic principles of ESD protection when handling the device.

### Connecting the controller

For easy connection, Nanotec recommends the *Discovery Board DK-NP5-48*. If you operate your controller using this *Discovery Board*, read the *technical manual* of the device.

### Integrating the NP5

#### Note

- EMC: Current-carrying cables – particularly around supply and motor cables – produce electromagnetic alternating fields.
- These can interfere with the motor and other devices. Nanotec recommends the following measures:
  - Use shielded cables and earth the cable shielding on both ends over a short distance.
  - Use cables with cores in twisted pairs.
  - Keep power supply and motor cables as short as possible.
  - Earth motor housing with large contact area over a short distance.
  - Lay supply, motor and control cables physically separate from one another.

You can find the circuit diagram of the *NP5 Discovery Board* in the technical manual of the controller, which can serve as a reference for the development of your own motherboard.

#### 1. Prepare your motherboard.

The minimum wiring varies depending on motor type and any present feedback (stepper or BLDC motor, Hall sensors/encoders). For commissioning, the connection of the voltage supply (*POWER*) of the motor and of the SPI cables (see also **Connection SPI**) is sufficient.

#### 2. Plug the NP5 into the PCI plug connection.

### Connection SPI

In the technical manual of the controller you can find a reference circuit for connecting the *NP5 SPI*.

PCI-specific pin assignment for SPI:

Pin	Name	Description/function
A15	SLOT_SPI_MOSI	SLOT_SPI
A16	SLOT_SPI_MISO	SLOT_SPI
A17	SLOT_SPI_SCK	SLOT_SPI
A18	SLOT_SPI_CS	SLOT_SPI
A19	COMM_SPI_MOSI	COMM_SPI
A20	COMM_SPI_MISO	COMM_SPI
A21	COMM_SPI_SCK	COMM_SPI
A22	COMM_SPI_CS	COMM_SPI

### Commissioning

The *Plug & Drive Studio* software offers a convenient option for performing the configuration and adapting the controller to the connected motor. You can find further information in document *Plug & Drive Studio: Quick Start Guide* at [us.nanotec.com](http://us.nanotec.com).

### Establishing communication via SPI

- Connect the SPI master to the controller via the *SCK* (source clock), *MOSI* (master out, slave in), *MISO* (master in, slave out) and *CS* (chip select) cables. Check that the earth (GND) of the master is connected to the earth of the controller.
- Supply the controller with voltage.
- Change the configuration values if necessary, see **SPI** configuration in the technical manual of the controller.
- To test the interface, send bytes 01 40 41 60 00 00 00 00 00 00 D4 to the controller and, after receipt of the first response (02 00 00 00 00 00 00 00 00 51), bytes 02 00 00 00 00 00 00 00 00 51. (You can find a detailed description of the messages in chapter **SPI message** of the technical manual). Status word (6041<sub>h</sub>) was read; you receive this response: 01 4B 41 60 00 XX XX 00 00 0A

### Setting the motor data

Prior to commissioning, the motor controller requires a number of values from the motor data sheet.

- Number of pole pairs: Object 2030<sub>h</sub>:00<sub>h</sub> (pole pair count) The number of motor pole pairs is to be entered here. With a stepper motor, the number of pole pairs is calculated using the step angle, e.g., 1.8° = 50 pole pairs, 0.9° = 100 pole pairs (see step angle in motor data sheet). With BLDC motors, the number of pole pairs is specified directly in the motor data sheet.
- Setting the motor current / motor type:
  - Stepper motor only: Object 2031<sub>h</sub>:00<sub>h</sub>: Rated current (bipolar) in mA (see motor data sheet)
    - Object 2031<sub>h</sub>:00<sub>h</sub>: Rated current (bipolar) in mA (see motor data sheet)
    - Object 3202<sub>h</sub>:00<sub>h</sub> (Motor Drive Submode Select): Defines motor type stepper motor, activates current reduction on motor standstill: 0000008h.
    - Object 2037<sub>h</sub> (Open Loop Current Reduction Value/factor): the root mean square is specified to which the rated current is to be reduced if current reduction is activated in *Open Loop*.
  - BLDC motor only:
    - Object 2031<sub>h</sub>:00<sub>h</sub> Peak current in mA (see motor data sheet)
    - Object 203B<sub>h</sub>:01<sub>h</sub> Rated current in mA (see motor data sheet)
    - Object 203B<sub>h</sub>:02<sub>h</sub> Maximum duration of the peak current in ms (for initial commissioning, a value of 100 ms is recommended; this value is to be adapted later to the specific application).
    - Object 3202<sub>h</sub>:00<sub>h</sub> (Motor Drive Submode Select): Defines motor type BLDC: 00000041h
- Motor with encoder: Object 20592059<sub>h</sub>:00<sub>h</sub> (Encoder Configuration): Depending on the encoder version, one of the following values is to be entered (see motor data sheet):
  - Supply voltage 5V, differential: 00000000h
  - Supply voltage 5V, single-ended: 00000002h
- Motor with brake: Object 3202<sub>h</sub>:00<sub>h</sub> (Motor Drive Submode Select): The brake control is activated for the initial commissioning. Depending on the specific application, this configuration can be deactivated later if necessary. One of the following values is to be entered depending on the motor type:
  - Stepper motor, brake control (and **current reduction** while at standstill) activated: 0000000Ch
  - BLDC motor, brake control activated: 00000044h

### Auto setup

To determine a number of parameters related to the motor and the connected sensors (encoders/Hall sensors), an auto setup is performed. **Closed Loop** operation requires a successfully completed auto setup.

#### Note



- Note the following prerequisites for performing the auto setup:
  - The motor must be load-free.
  - The motor must not be touched.
  - The motor must be able to turn freely in any direction.
  - No NanoJ programs may be running (object 2300<sub>h</sub>:00<sub>h</sub> bit 0 = "0", see **2300h NanoJ Control**).

#### Tip



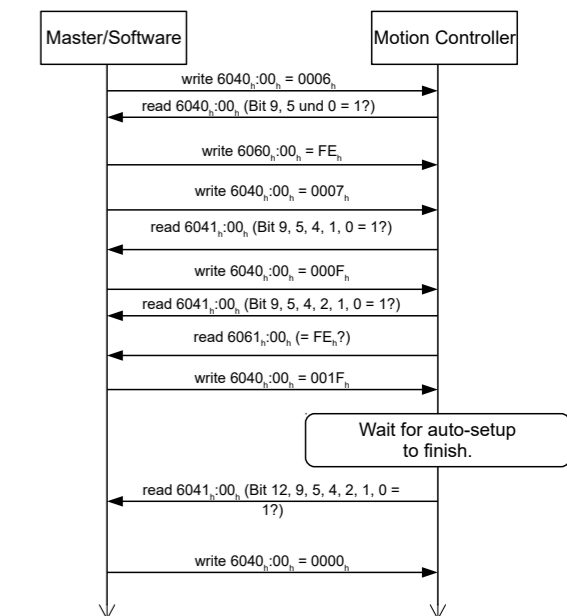
As long as the motor connected to the controller or the sensors for feedback (encoders/Hall sensors) are not changed, auto setup is only to be performed once during initial commissioning.

### Execution

- To preselect the *auto setup* operating mode, enter the value "-2" (= "FE<sub>h</sub>") in object 6060<sub>h</sub>:00<sub>h</sub>. The *power state machine* must now switch to the *Operation enabled state*.
- Start *auto setup* by setting bit 4 *OMS* in object 6040<sub>h</sub>:00<sub>h</sub> (controlword). While the auto setup is running, the following tests and measurements are performed in succession:

To determine the values, the direction of the measurement method is reversed and edge detection re-evaluated.

Value 1 in bit 12 *OMS* in object 6041<sub>h</sub>:00<sub>h</sub> (statusword) indicates that the auto setup was completely executed and ended. In addition, bit 10 *TARG* in object 6041<sub>h</sub>:00<sub>h</sub> can be used to query whether (= "1") or not (= "0") an encoder index was found.



#### CAUTION



- After executing auto setup mode, the internal coordinate system is no longer valid.
- Homing* alone does not suffice! If the controller is not restarted, unexpected reactions may result.
- Restart the device after an auto setup!