# NP5-02

Short instructions
Original: de

Version 1.0.0

Nanotec Electronic GmbH & Co. KG
Kapellenstraße 6
85622 Feldkirchen, Germany

Phone: +49 (89) 900 686-0
Fax: +49 (89) 900 686-50
info@nanotec.de

## 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**. The short instructions do not replace the *technical manual of the product*.

### Copyright



CE

### 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/**.

### 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.

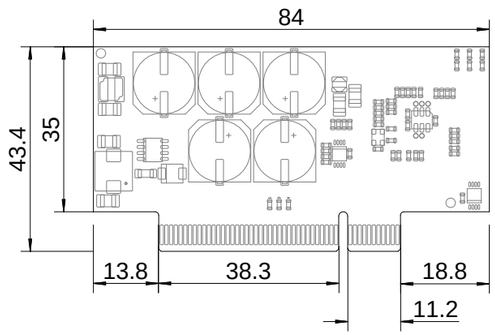
## Technical details and pin assignment

### Environmental conditions

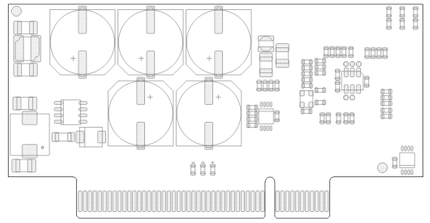
| Environmental condition | Value |
|---|---|
| Protection class | No IP protection |
| Ambient temperature (operation) | -10 … +40°C |
| Air humidity (non-condensing) | 0 … 95 % |
| Altitude of site above *sea level* (without drop in performance) | 1500 m |
| Ambient temperature (storage) | -25 … +85°C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

### Dimensioned drawings

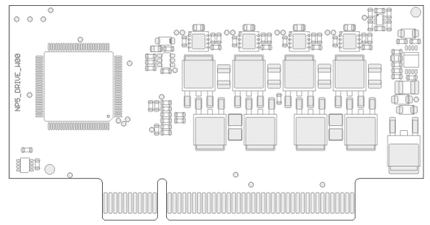
Dimensions are in [mm].




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 $A_{rms}$ |
| Peak current | 10 $A_{rms}$ (for 1 second) |
| Commutation | Stepper motor *open loop*, stepper motor *closed loop* with encoder, BLDC sine commutated via Hall sensor, BLDC sine commutated via encoder<br>**Note:** External wiring is required for encoder and Hall sensor! |
| Operating modes | *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* |
| Set value setting / programming | *Clock-direction*, *analog*, *NanoJ program* |
| Interfaces | 2x SPI, 1x $I^2C$ |
| Encoder/Hall | 2x encoder 1x Hall sensor<br>**Note:** 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, 2×49 contacts |
| Overtemperature | Protection circuit at temperature > 75°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: | $I_{max}$ (controller) < I (tripping current for fuse) < $I_{max}$ (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. 75 °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.

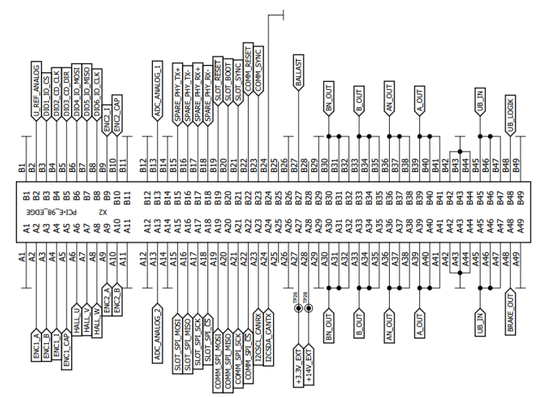
| Flash rate | Error |
|---|---|
| 1 | General |
| 2 | Voltage |
| 3 | Temperature |
| 4 | Overcurrent |
| 5 | Controller |
| 6 | Watchdog-Reset |

**Note**

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

### Pin assignment

PIN assignment of the PCI connector strip



**Note**

- For digital inputs 1 to 6, the switch-on threshold is 1.86 V, the switch-off threshold is 0.91 V DC. The maximum sampling frequency is 1 MHz. If the I/O pins are used as output, 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 1.86 V, the switch-off threshold is 0.91 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<br>Slave address, see **Setting slave address and baud rate** |
| A14 | GND | |
| A15 | SLOT_SPI_MOSI | |
| A16 | SLOT_SPI_MISO | *Modbus RX Data* |
| A17 | SLOT_SPI_SCK | *Modbus TX Data* |
| A18 | SLOT_SPI_$\overline{CS}$ | |
| A19 | COMM_SPI_MOSI | *Receiver Enable* |

| Pin | Name | Description/function |
|---|---|---|
| A20 | COMM_SPI_MISO | |
| A21 | COMM_SPI_SCK | |
| A22 | COMM_SPI_$\overline{CS}$ | |
| 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<br>Slave address, see **Setting slave address and baud rate** |
| 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_$\overline{RESET}$ | System function, reserved |
| B20 | SLOT_BOOT | System function, reserved |
| B21 | SLOT_SYNC | System function, reserved |
| B22 | COMM_RESET | *Driver Enable* |
| B23 | COMM_SYNC | |
| B24 | GND | |
| B25 | n.c. | reserved |
| B26 | GND | |
| B27 | BALLAST | For controlling the external ballast circuit |

| Pin | Name | Description/function |
|---|---|---|
| B28 | n.c. | reserved |
| 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-NP5-4A* . 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 separately.

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 an RS485 transceiver (see also **Connecting Modbus RTU**) is sufficient.
2. Plug the *NP5* into the *PCI* plug connection.

### Connecting Modbus RTU

In the *technical manual* of the controller you can find a reference circuit for connecting the NP5-02 Modbus RTU via RS485.

PCI-specific pin assignment for Modbus RTU:

| Pin | Name | Description |
|---|---|---|
| A13 | ADC_ANALOG_2 | The slave address is defined via the applied voltage, see **Setting slave address and baud rate** in the technical manual |
| A16 | SLOT_SPI_MISO | *Modbus RX Data* |
| A17 | SLOT_SPI_SCK | *Modbus TX Data* |
| A19 | COMM_SPI_MOSI | *Receiver Enable* |
| B2 | U_REF_ANALOG | Is used as a reference voltage of 3.3 V DC to define the slave address, see **Setting slave address and baud rate** in the technical manual |
| B22 | COMM_RESET | *Driver Enable* |

**Tip**

If you do not use the analog input ADC_ANALOG_2 to set the address and baud rate, connect pin A13 to GND.

## 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**.

### Establishing communication via Modbus

1. Connect the *Modbus master* to the controller via the RS-485+ and RS-485- cables.
2. Supply the controller with voltage.
3. Change the configuration values if necessary.

   The controller is set to slave address 5 ex works, baud rate 19200 baud, even parity, 1 stop bit.
4. To test the interface, send bytes `05 65 55 00 2F A7` to the controller (you can find a detailed description of the Modbus function codes in chapter **Modbus RTU** of the *technical manual*).
   The object dictionary is read out.

### 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**$_h$:00$_h$ (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**$_h$:00$_h$: Rated current (bipolar) in mA (see motor data sheet)
    - Object **2031**$_h$:00$_h$: Rated current (bipolar) in mA (see motor data sheet)
    - Object **3202**$_h$:00$_h$ (Motor Drive Submode Select): Defines motor type stepper motor, activates current reduction on motor standstill: 0000008h.
    - Object **2037**$_h$ (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**$_h$:00$_h$ Peak current in mA (see motor data sheet)
    - Object **203B**$_h$:01$_h$ Rated current in mA (see motor data sheet)
    - Object **203B**$_h$:02$_h$ Maximum duration of the peak current in ms (for initial commissioning, Nanotec recommends a value of 100 ms; this value is to be adapted later to the specific application).
    - Object **3202**$_h$:00$_h$ (Motor Drive Submode Select): Defines motor type BLDC: 00000041h
- Motor with encoder: Object **2059**$_h$:00$_h$ (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**$_h$:00$_h$ (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**) 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$_h$:00$_h$ bit 0 = "0", see **2300h NanoJ Control**).

**Tip**

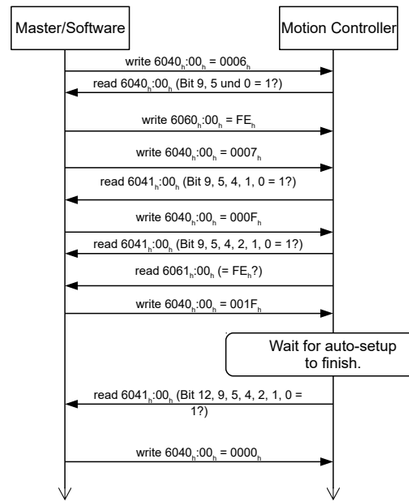
As long as the motor connected to the controller or the sensors for feedback (encoders/Hall sensors) are not changed, auto setup is only to be performed once during initial commissioning.

### Execution

1. To preselect the *auto setup* operating mode, enter the value "-2" (="FE$_h$") in object 6060$_h$:00$_h$.
   The *power state machine* must now switch to the *Operation enabled* state.
2. Start *auto setup* by setting bit 4 *OMS* in object 6040$_h$:00$_h$ (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$_h$:00$_h$ (statusword) indicates that the auto setup was completely executed and ended. In addition, bit 10 *TARG* in object 6041$_h$:00$_h$ can be used to query whether (= "1") or not (= "0") an encoder index was found.




**CAUTION**

**Uncontrolled motor movements!**

After the auto setup, the internal coordinate system is no longer valid. Unforeseen reactions can result.

► Restart the device after an auto setup. Homing alone does not suffice.