NP5-20

Short instructions
Original: de

Version 1.0.0

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

Copyright

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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/**.

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.

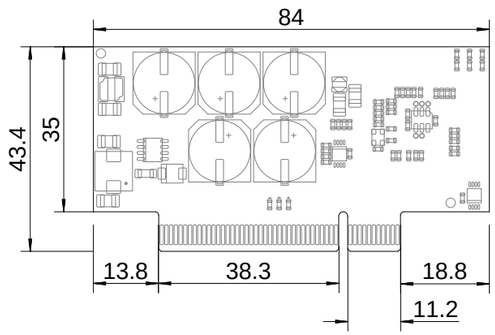
Technical details and pin assignment

Environmental conditions

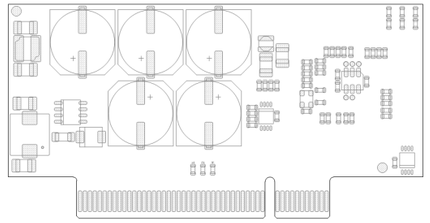
Environmental condition	Value
Protection class	No IP protection
Ambient temperature (operation)	-10 … +40°C
Air humidity (non-condensing)	0 … 95 %
Altitude of site above *sea level* (without drop in performance)	1500 m
Ambient temperature (storage)	-25 … +85°C

Dimensioned drawings

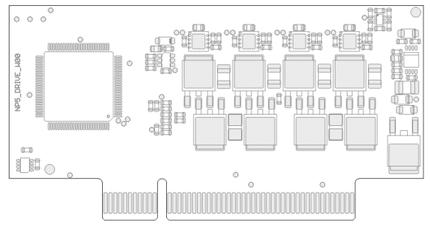
Dimensions are in [mm].



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 **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 **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.

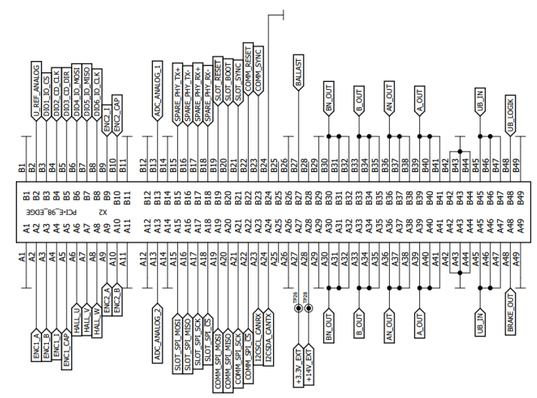
Flash rate	Error
1	General
2	Voltage
3	Temperature
4	Overcurrent
5	Controller
6	Watchdog-Reset

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
A14	GND	
A15	SLOT_SPI_MOSI	
A16	SLOT_SPI_MISO	
A17	SLOT_SPI_SCK	*PDI[6]/EEPROM_Loaded* , see **EtherCAT connection**
A18	SLOT_SPI_$\overline{CS}$	
A19	COMM_SPI_MOSI	*PDI[2]* , see **EtherCAT connection**
A20	COMM_SPI_MISO	*PDI[3]* , see **EtherCAT connection**

Pin	Name	Description/function
A21	COMM_SPI_SCK	*PDI[0]* , see **EtherCAT connection**
A22	COMM_SPI_$\overline{CS}$	*PDI[1]* , see **EtherCAT connection**
A23	I2CSCL_CANRX	*EPROM_CLK* , see **EtherCAT connection**
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_$\overline{RESET}$	System function, reserved
B20	SLOT_BOOT	System function, reserved
B21	SLOT_SYNC	System function, reserved
B22	COMM_RESET	*ETHERCAT_RESET* , see **EtherCAT connection**
B23	COMM_SYNC	*PDI[4]/SPI_IRQ* , see **EtherCAT connection**
B24	GND	
B25	n.c.	reserved
B26	GND	

PDI: Process Data Interface

Pin	Name	Description/function
B27	BALLAST	For controlling the external ballast circuit
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-NP5-68*. 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 suitable EtherCAT wiring (see also **EtherCAT connection**) is sufficient.
2. Plug the *NP5* into the *PCI* plug connection.

EtherCAT connection

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

PCI-specific pin assignment for EtherCAT:

Pin	Name	Description/function
A17	SLOT_SPI_SCK	*ROM_Loaded*
A19	COMM_SPI_MOSI	*PDI[2]* [1]
A20	COMM_SPI_MISO	*PDI[3]*
A21	COMM_SPI_SCK	*PDI[0]*
A22	COMM_SPI_$\overline{CS}$	*PDI[1]*
A23	I2CSCL_CANRX	*EPROM_CLK* input I^2 clock
A24	I2CSDA_CANTX	*EPROM_DATA* Input I^2 data
22	COMM_RESET	*ETHERCAT_RESET*
B23	COMM_SYNC	*PDI[4]/SPI_IRQ*

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**.

Software connection

The following description assumes that an EtherCAT master from Beckhoff with the *TwinCAT* software is used.

1. Supply the controller with voltage.
2. Obtain the *ESI file* that corresponds exactly to the used firmware version from the following sources:
   a. From the Nanotec website **us.nanotec.com**. The current version of the firmware and the *ESI file* can be found in the *Plug & Drive Studio* download folder.
   b. From Nanotec support.
3. Close the *TwinCAT* system manager if it is open.
4. Then copy the *ESI file* to the *TwinCAT* subfolder `Io`.
5. Open the *ESI file* with an editor. Find the *AddInfo* parameter. Enter the value "2" (*Box*) or "0" (*NC-Axis*). Save and close the file.
6. Now restart the *TwinCAT* system manager. The *ESI files* are read in again following a restart.

Note

The cycle time of the sync signal must always be set to 1 ms. You can set the bus cycle time (and, consequently, the interpolation time in **60C2**$_h$) to integer multiples of 1 ms.

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

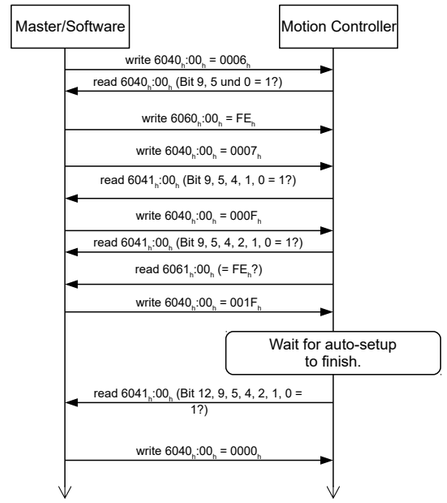
As long as the motor connected to the controller or the sensors for feedback (encoders/Hall sensors) are not changed, auto setup is only to be performed once during initial commissioning.

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.