CSL3-5, CSL3-24

Short instructions	Version 1.0.0
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Introduction

The *CSL3* is a controller for the *closed loop* operation of BLDC motors. *CSL3* supports the velocity and position mode, as well as homing on block.

The operation mode and the target values can be controlled via the four digital inputs, the analog input or the power supply voltage.

There are two variants available, *CSL3-5* and *CSL3-24*, with 5 or 24 V inputs respectively. In addition, the controller is equipped with two digital outputs.

Three Hall sensor inputs are used for recording the motor rotor position feedback and velocity measurement.

The configuration can be done using Modbus RTU with the software *Plug & Drive Studio 3*, via a UART interface with a 3.3 V signal level.

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Intended use

The *CSL3* serves to control BLDC motors and is used as a component in drive systems in a wide range of industrial applications.

Use the product as intended within the limits defined in the technical data (in particular, see **Permissible operating voltage**) and the approved **Environmental conditions**.

Under no circumstances may this Nanotec product be integrated as a safety component in a product or system. All products containing a component 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.

Target group and qualification

The product and this documentation are directed towards technically trained specialists staff such as:

- Development engineers
- Plant engineers
- Installers/service personnel
- Application engineers

Only specialists may install, program and commission the product. Specialist staff are persons who

- have appropriate training and experience in working with motors and their control,
- are familiar with and understand the content of this technical manual,
- know the applicable regulations.

Warranty and disclaimer

Nanotec assumes no liability for damages and malfunctions resulting from installation errors, failure to observe this manual or improper repairs. The selection and use of Nanotec products is the responsibility of the plant engineer or end user. Nanotec accepts no responsibility for the integration of the product in the end system.

Our general terms and conditions at www.nanotec.com apply.

> **NOTICE**
>
> Changes or modifications to the product are not permitted.

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

> **NOTICE**
>
> - 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.

> **NOTICE**
>
> **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.

> **NOTICE**
>
> **Damage to the electronics through improper handling of ESD-sensitive components!**
>
> 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.

> **NOTICE**
>
> - 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.

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

Overtemperature protection

Above a temperature of approx. 90°C on the power board, the power part of the controller switches off and the error bit is set in the **1001h Error Register**. After cooling down to approx. 75°C and resetting the error via bit 8 in **6040h Control Word** or powering on/off, the controller functions again normally.

Electrical properties and technical data

| Property	Description / value
Operating voltage	10 … 30 V DC
Rated current	3 A$_{rms}$
Peak current	9 A$_{rms}$ for max. 5 seconds
Commutation	BLDC motor closed-loop with Hall sensor
Operating modes	*Velocity Mode*, *Position Mode*, *Homing on Block*
Set value setting	Via the *supply voltage*, the *digital inputs* or the *analog input*
Interfaces	UART 3.3 V

Inputs	- 4 digital inputs:
	   - 5 V for the *CSL3-5* variant
	   - 24 V for the *CSL3-24* variant
	 - 1 analog input, 12-bit resolution, 0-10 V

Property	Description / value
Outputs	2 digital outputs, high-side switch (output voltage corresponds to the supply voltage)
Protection circuit	Overvoltage and undervoltage protection
	Overtemperature protection (> 90° Celsius on the power board)
	Polarity reversal protection: no polarity reversal protection, a line protection device (fuse) is therefore necessary in the supply line. The values of the fuse are dependent on the application and must be dimensioned
	• greater than the maximum current consumption of the controller
	• less than the maximum current of the voltage supply.
	If the fuse value is very close to the maximum current consumption of the controller, a medium / slow tripping characteristics should be used.

Dimensioned drawing

All dimensions are in millimeters.
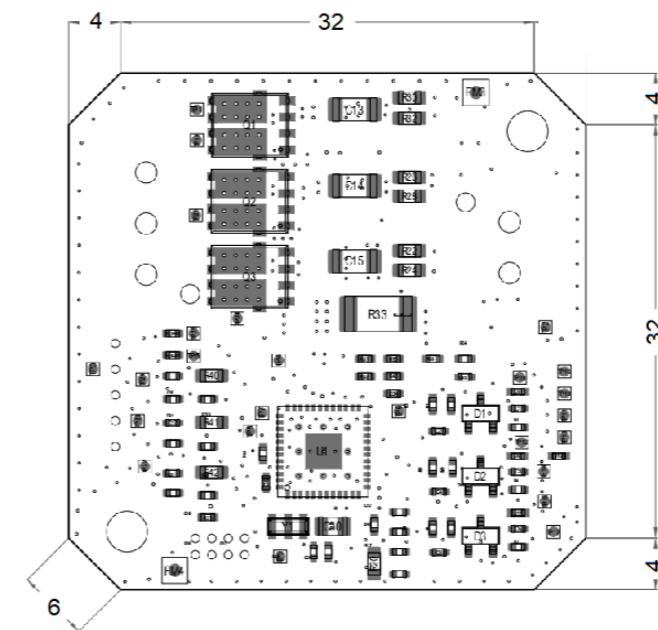
Pin assignment
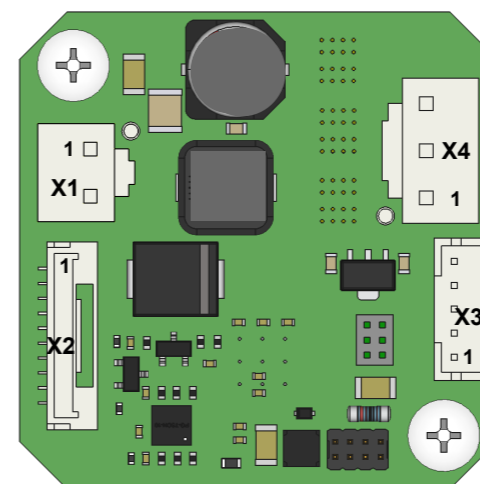
X1 — voltage supply

Connection for the main supply

Type: JST B2P-VH

Suitable Nanotec cable: ZK-VHR-2-500 (not included in the scope of delivery)

Voltage source

The operating or supply voltage supplies a battery, a transformer with rectification and filtering, or a switching power supply.

> **NOTICE**
>
> **EMC: For a DC power supply line longer than 30 m or when using the motor on a DC bus, additional interference-suppression and protection measures are necessary.**
>
> ► An EMI filter is to be inserted in the DC supply line as close as possible to the controller/motor.
>
> ► Long data or supply lines are to be routed through ferrites.
>
> ► A capacitor of at least 4700 µF is to be connected to the supply voltage (parallel) as close to the controller as possible.

Pin assignment

Pin	Function	Note
1	+Ub	10 … 30 V DC
2	GND	

Permissible operating voltage

The maximum operating voltage is 30 V DC. If the input voltage of the controller exceeds the threshold value set in **2034**$_h$, the motor is switched off and an error triggered.

The minimum operating voltage is 10 V DC. If the input voltage of the controller falls below 8 V, the motor is switched off and an error triggered.

A charging capacitor of at least 4700 µF / 50 V (approx. 1000 µF per ampere rated current) must be connected in parallel to the supply voltage to avoid exceeding the permissible operating voltage (e.g., during braking).

X2 – inputs and outputs, communication

Type: JST BM10B-GHS-TBT

Suitable Nanotec cable: ZK-GHR10-500-S-COM (not included in the scope of delivery), for the converter ZK-RS232-USB-1.

Pin	Function	Note
1	Digital input 1	Max. 1 KHz
2	Digital input 2	Max. 1 KHz
3	Digital input 3	Max. 1 KHz
4	Digital input 4	Max. 1 KHz
5	Digital output 1	Positive switching (*High-Side-Switch*), the output voltage corresponds to the supply voltage Max. 50 mA / 1 KHz
6	Digital output 2	Positive switching (*High-Side-Switch*), the output voltage corresponds to the supply voltage Max. 50 mA / 1 KHz
7	Analog input 1	12 bit, 0-10 V
8	UART Tx	3.3 V UART
9	UART Rx	3.3 V UART
10	GND	

For the digital inputs of the variant *CSL3-5*, the following switching thresholds apply:

Max. Voltage	Switching thresholds	
	On	Off
5 V	> 2 V	< 0.8 V

For the digital inputs of the variant *CSL3-24*, the following switching thresholds apply:

Max. Voltage	Switching thresholds	
	On	Off
30 V	> 9 V	< 3.7 V

X3 – Hall sensor

Type: JST B5B-PH

Suitable Nanotec cable: ZK-PHR-5-500 (not included in the scope of delivery)

Pin	Function	Note
1	H1	5 V signal
2	H2	5 V signal

Pin	Function	Note
3	H3	5 V signal
4	+5 V DC	Supply voltage for hall sensors
5	GND	

X4 – motor connection

Type: JST B3P-VH

Suitable Nanotec cable: ZK-VHR-3-500 (not included in the scope of delivery)

Pin	BLDC function
1	U
2	V
3	W

Commissioning

The *Plug & Drive Studio 3* software offers you an option for performing the configuration and adapting the controller to the connected motor. A project template is included.
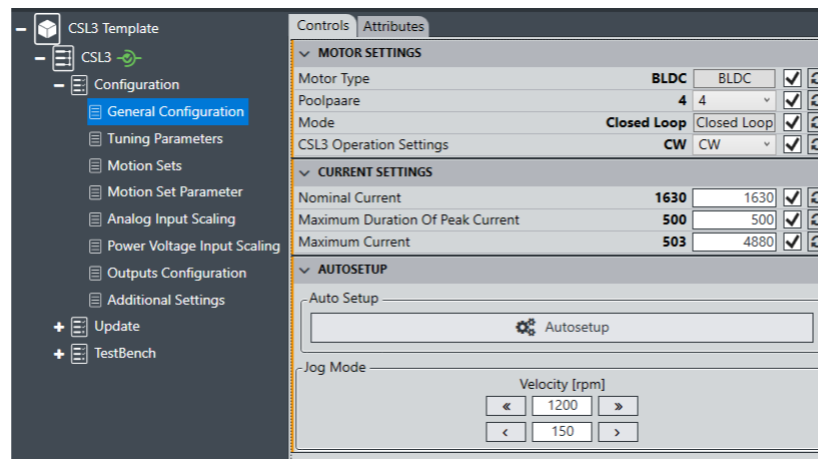
Observe the following note:

NOTICE
EMC: Current-carrying cables – particularly around supply and motor cables – produce electromagnetic alternating fields. These can interfere with the motor and other devices.

Suitable measures may be:

► Use shielded cables and earth the cable shielding on both ends over a short distance.
► Keep power supply and motor cables as short as possible.
► Use cables with cores in twisted pairs.
► Earth motor housing with large contact area over a short distance.
► Lay supply, motor and control cables separately.

Configuration via UART

Configure the controller via the UART interface with a 3.3 V signal level and the following settings:

- Baud rate 256000
- 8 data bits
- Parity: even
- 1 stop bit
- No data flow control

For communication between controller and PC, you need a USB-UART converter with 3.3 V signal level (e.g., *ZK-RS232-USB-1* from Nanotec).

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 BLDC motors, the number of pole pairs is specified directly in the motor data sheet.
- Maximum motor speed: Object $2032_h{:}00_h$ (Maximum Speed) The maximum motor speed (see motor data sheet) is to be entered here.
- Object $2031_h{:}00_h$: Maximum permissible motor current (rms value) in mA (see motor data sheet)
- Object $203B_h{:}01_h$: Rated current of the motor (rms value) in mA (see motor data sheet), limited by 2031_h
- Object $203B_h{:}02_h$ Maximum duration of the maximum current in ms (for initial commissioning, Nanotec recommends a value of 100 ms; this value is to be adapted later to the specific application).

NOTICE
When using the **control modes**, note that the value of the rate current is set via the digital inputs, to one of the pre-set values in object **2463h Pre-set Current**.

The module *General Configuration* of the project template in *Plug & Drive Studio 3* bundles up all relevant paramters:

Auto setup

To determine a number of parameters related to the motor and the connected Hall sensors, you must perform an auto setup.

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

NOTICE
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.

Execution

The module *General Configuration* of the project template in *Plug & Drive Studio 3* offers a special control to execute the *auto setup.*

Setting control mode

You can use one of the pre-programmed control modes to operate the motor in **Profile Velocity** or **Profile Position** mode. The mode selection takes place via the digital inputs.

The controller offers the following control modes:

- **Profile Velocity** with target speed via digital inputs
- **Profile Velocity** with Target speed via analog input
- **Profile Velocity** with Target speed via supply voltage
- **Profile Position** with target position via digital inputs
- **Homing on Block**

To activate the use of the control modes, set bit 0 in **2481h CSL3 Operation Settings** to "1".

In the object **2472h Digital Inputs Mapping**, you define which function the four digital inputs have. Via the inputs you can select the mode and the corresponding sources for the target values.

Each subindex corresponds to one of the combinations of the four inputs, from 0000_b (no input high to 1111_b (all inputs high). The 16 bits in each subindex have the following meaning:

15	14	13	12	11	10	9
Pos Source			Dec Source		Acc Source	

8	7	6	5	4	3	2	1	0
Curr Source			Vel Source			Op Mode		

Op Mode: operation mode

To select the mode, set following bits in the corresponding subindex accordingly:

Bits 0...2 in $2472_h{:}0x_h$	Operation Mode
000	No operation (to introduce a break between two relative positionings for example)
001	OFF / Clear Error
010	STOP
011	Velocity Mode, positive direction
100	Velocity Mode, negative direction
101	Homing on Block
110	Position, relative
111	Position, absolute

Vel Source: source of velocity

To select the source, set following bits in the corresponding subindex accordingly:

Bits 3..5 in $2472_h{:}0x_h$	Velocity Source
000	$2462_h{:}01_h$
001	$2462_h{:}02_h$
010	$2462_h{:}03_h$
011	$2462_h{:}04_h$
100	$2462_h{:}05_h$
101	Velocity is controlled by analog input, see object **2454**$_h$
110	Velocity is controlled by supply voltaget, see object **2454**$_h$
111	Last velocity is hold (eg. when analog input should also be used for current setting)

Curr Source: source of motor current

To select the source, set following bits in the corresponding subindex accordingly:

Bits 6..8 in $2472_h{:}0x_h$	Current Source
000	$2463_h{:}01_h$
001	$2463_h{:}02_h$
010	$2463_h{:}03_h$
011	$2463_h{:}04_h$
100	$2463_h{:}05_h$
101	Current is controlled by analog input, see object **2454**$_h$
110	Current is controlled by supply voltaget, see object **2454**$_h$
111	Last current is hold (eg. when analog input should also be used for velocity setting)

Acc Source: source of acceleration ramp

To select the source, set following bits in the corresponding subindex accordingly:

Bits 9 and 10 n $2472_h{:}0x_h$	Acceleration Source
00	$2464_h{:}01_h$
01	$2464_h{:}02_h$
10	$2464_h{:}03_h$
11	$2464_h{:}04_h$

Dec Source: source of deceleration ramp

To select the source, set following bits in the corresponding subindex accordingly:

Bits 11 and 12 in $2472_h{:}0x_h$	Deceleration Source
00	$2465_h{:}01_h$
01	$2465_h{:}02_h$
10	$2465_h{:}03_h$
11	$2465_h{:}04_h$

Pos Source: source of target position

To select the source, set following bits in the corresponding subindex accordingly:

Bits 13...15 in $2472_h{:}0x_h$	Position Source
000	$2466_h{:}01_h$
001	$2466_h{:}02_h$
010	$2466_h{:}03_h$
011	$2466_h{:}04_h$
100	$2466_h{:}05_h$
101	$2466_h{:}06_h$
110	$2466_h{:}07_h$
111	$2466_h{:}08_h$

Configuration example

In this example, the motor is controlled in the mode *Profile Velocity* via inputs 1 and 2.
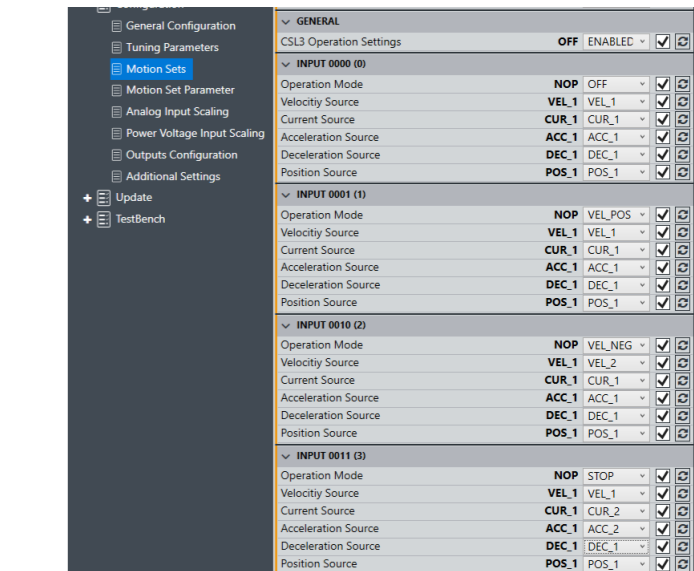

- If both inputs are low, the motor is powered off (OFF). If possible, all occurred errors are reset.
- If only input 1 is high, the motor runs in the positive direction with velocity Vel1 ($2462_h{:}01_h$).
- If only input 2 is high, the motor runs in the negative direction with velocity Vel2 ($2462_h{:}02_h$).
- If both inputs are high, the motor decelerates with Dec2 ($2465_h{:}02_h$) and stays powered on with the holding current Curr2 (($2463_h{:}02_h$).

Inputs		Subindex of 2472_h	Value in Subindex	Mode
DIn2	DIn1			
0	0	01_h	1	OFF
0	1	02_h	3	*Velocity Mode* CW,Vel1,Curr1,Dec1,Acc1
1	0	03_h	12	*Velocity Mode* CCW, Vel2,Curr1,Dec1,Acc1
1	1	04_h	2114	STOP, Curr2, Dec2

You can save the configuration by writing the value "65766173$_h$" in $1010_h{:}01_h$ or via *Plug & Drive Studio 3.*

In order to carry out this configuration in *Plug & Drive Studio 3* proceed as follows:

1. Open the module *General Configuration* of the project template

2. Chosse the corresponding mode and the parameters for the first four motion sets as follows:

3. Transfer the values to the controller by clicking *Set* (the check next to each parameter needs to be set):

4. Store the values to the controller by clicking *Store* (the check next to each parameter needs to be set):