North Sea Electronics

Product Specification

Product:

HT 600V BLDC Motor Controller

Doc no.: NSE-500105-001
Rev. K

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REVISION HISTORY

REV	DATE	DESCRIPTION	PREPARED BY	APPROVED BY	COMPANY
01	05.10.2012	Initial system spec	RFY	GLK	NSE
02	18.02.2013	Updated parameters and formatting	RFY	GLK	NSE
03	18.04.2013	Updated specs	RFY	GLK	NSE
04	29.04.2013	Updated specs	EEN	GLK	NSE
05	21.08.2013	Product photo, and minor editing	RFY/BCM	GLK	NSE
06	11.09.2013	Change in wire thickness for Glenair plugs.	AJA	GLK	NSE
07	20.09.2013	Updated sensorless algorithm information	BCM	GLK	NSE
08	10.02.2014	Changed Glenair plugs to HT/Nickel version. Updated max input voltage (logic supply). Added connector pinouts.	AJA	GLK	NSE
I	10.06.2014	Updated with high voltage pulse rating section	RFY	GLK	NSE
J	20.02.2015	Minor specifications changes. Updated mechanical dimensions Added power derating chart Updated description of HW and FW	RFY	GLK	NSE
K	01.07.2016	Updated with RS-485 interface	RFY	EHJ	NSE

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2 Abbreviations

ACIM	AC Induction Motor
BLDC	Brushless Direct Current
bps	Bits Per Second
CAN	Controller Area Network
CRC	Cyclic Redundancy Check
EMC	Electromagnetic Compatibility
emf	Electromotive force
NSE	North Sea Electronics
PWM	Pulse Width Modulation
RPM	Revolutions Per Minute
RS-485	Serial interface standards
RTD	Resistance Temperature Detector

3 Product Photo

Figure 1 Product photo

4 System Specifications

Parameter	Conditions / Comments	Min	Typ	Max	Unit
Supply voltage					
Input High Voltage	*Operational*	50		600	Vdc
Input High Voltage	*Survival*			1000	Vdc
Input Low Voltage		18		36	Vdc
Drive Section					
Motor Type			BLDC PMSM ACIM		
Commutation Mode			Trapezoid Sine		
Speed Range	*4 pole motor*				
	Hall Encoder Feedback	0		12.000	RPM
	*Sensorless**	300		10.000	RPM
Input Current		0		8*	Arms
Hall Encoder					
Hall Excitation Voltage		4.5	5.0	5.5	V
Hall Excitation Current				20	mA
Resolver					
Excitation Voltage			4.0		Vrms
Excitation Frequency		2		20	kHz
Input Voltage		2			Vrms
CAN port					
Baud rate			83.3 / **125** / 250 / 500		kbits/s
RS-485 port					
Baud rate			4.8 / 9.6 / 19.2 / **38.4** / 57.6 / 76.8 / 115.2		kbits/s
Temperature Sensors					
Internal Sensor range		-20		180	°C
Internal Sensor accuracy		5			%
External Sensor Type	**PT1000 is optional*		PT100		
External Sensor range		-20		190	°C
External Sensor accuracy		5			%
Environment					
Op. Temperature Range**		-10		177	°C
Physical board dimension					
Height			29.1		mm
Width			37		mm
Length – Short Base			269.5		mm
Length – Long Base			281.5		mm
Mount holes			6xM4		

** Ref 8 Power Derating for power/current derating chart*
*** Consult NSE for mounting guidance.*

Table 1 System specifications

5 Sensors and interface

5.1 Sensors

On board sensor:	1 internal temperature sensor 1 off – Supply current measurement 1 off – Supply voltage measurement
External Temperature sensor interface:	1 off PT100
External commutation interface	1 off Hall Sensor interface (default) 1 off Resolver interface (with "add on" board mounted) Note that the motor controller can have *either* Hall Sensor interface or Resolver interface.

5.2 Communication interface

The unit can be provided either with:

- CAN bus
  or
- RS-485 bus interface

Refer to the following document for protocol description:

Document Number	Document Name
NSE-500105-060	Register Description
NSE-500105-061	Protocol Description

5.3 Input Connector (Power and Communications)

5.3.1 Connector Types

- Driver input connector: Glenair GMPM2-D113R
- Mating connector (pre-wired) : Glenair GMPM2-D113PT6-20K7-300S-MC273

5.3.2 Input Connector Drawing

Figure 2 Input connector drawing

5.3.3 Input Connector Pin-out – (CAN version)

Pin	Signal	Wire Color	Description
A	HV IN	White	Motor supply positive (Max. 600Vdc)
B	HV GND	White	Motor supply return (0V)
1	GND	Black	Logic supply return (0V)
2	CAN L	Brown	CAN Bus Low
3	N.C	Red	Not Connected
4	VIN	Orange	Logic supply positive
5	CAN H	Yellow	CAN Bus High
6	N.C	Green	Not Connected

Table 2 Input connector pinout

5.3.4 Input Connector Pin-out – (RS-485 version)

Pin	Signal	Wire Color	Description
A	HV IN	White	Motor supply positive (Max. 600Vdc)
B	HV GND	White	Motor supply return (0V)
1	GND	Black	Logic supply return (0V)
2	RS-485 B	Brown	RS-485 B
3	N.C	Red	Not Connected
4	VIN	Orange	Logic supply positive
5	RS-485 A	Yellow	RS-485 A
6	N.C	Green	Not Connected

Table 3 Input connector pinout (RS-485 version)

5.4 Output Connector (Motor)

5.4.1 Connector Types

- Driver output connector: Glenair GMPM2-E113P
- Mating connector (pre-wired): Glenair GMPM2-E113RT6-20K7-300S-MC273

5.4.2 Output Connector Drawing

Figure 3 Output connector drawing

5.4.3 Pin-outs, Hall Feedback

Note that the labeling of hall sensor outputs varies between manufacturers, as can phasing relative to the driven windings. Consult motor datasheet or contact NSE where further information is required.

Pin	Signal	Color	Description
A	PH A	White	Motor Phase A
B	PH B	White	Motor Phase B
C	PH C	White	Motor Phase C
1	5V EXT	Black	Supply for hall sensors. 5Vdc.
2	HALL B	Brown	Hall sensor input B

3	GND EXT	Red	Return for sensor 5V supply
4	RTD+	Orange	RTD temperature sensor (PT100 or PT1000)
5		Yellow	Not used in Hall feedback configuration
6	HALL A	Green	Hall sensor input A
7	HALL C	Blue	Hall sensor input C
8	RTD-	Purple	RTD temperature sensor return

Table 4 Output connector pinout for Hall feedback operation

5.4.4 Motor cable recommendations

NSE recommends using a shielded cable for connection to the motor. High slew rates from a PWM output stage can generate noise that may interfere with other systems.

5.4.5 Pin-outs, Resolver Feedback

Note that the polarity of resolver outputs may vary with resolver model. Consult NSE or resolver vendor where further information is required. Additional setup may be required depending on the phasing of sensor output relative to motor phases.

Pin	Signal	Color	Description
A	PH A	White	Motor Phase A
B	PH B	White	Motor Phase B
C	PH C	White	Motor Phase C
1	RES EXEC+	Black	Resolver excitation winding
2	RES SIN -	Brown	Resolver Sine output (neg.)
3	RES COS +	Red	Resolver Cosine output (pos.)
4	RTD+	Orange	RTD temperature sensor (PT100 or PT1000)
5	RES EXEC-	Yellow	Resolver excitation return
6	RES SIN +	Green	Resolver Sine output (pos.)
7	RES COS -	Blue	Resolver Cosine output (neg.)
8	RTD-	Purple	RTD temperature sensor return

Table 5 Output connector pinout for resolver feedback operation

5.4.6 Hall Sensor Truth Table

This truth-table represents the expected sensor input to the motor driver. Note that the direction of rotation will depend on the motor wiring, and should be checked against the manufacturer's data, or confirmed by testing.

Step	Motor Phases			Sensors		
	A	B	C	Hall A	Hall B	Hall C
1	**+**	**-**		0	1	1
2	**+**		**-**	0	1	0
3		**+**	**-**	1	1	0
4	**-**	**+**		1	0	0
5	**-**		**+**	1	0	1
6		**-**	**+**	0	0	1

Table 6 Hall sensor truth table

6 Hardware Description

6.1 Block Diagram

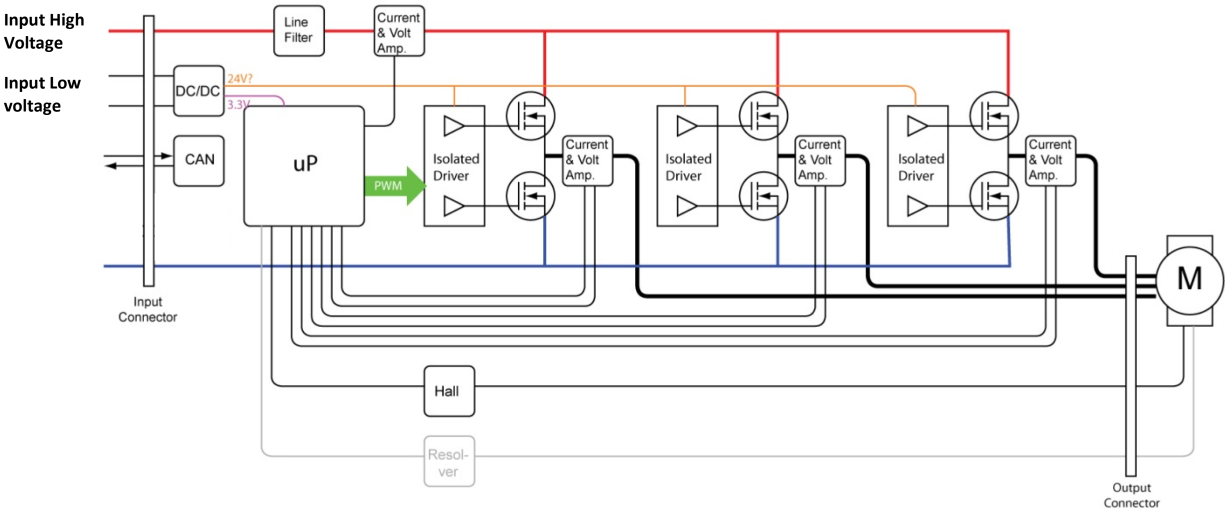


Figure 4 Block Diagram

6.2 Driver Stage

The Motor Controller uses 6 state of the art SiC power transistors to provide 3 phase output voltage to the motor.

Each transistor is driven by a high speed gate driver circuit. Each of the driver circuits are galvanically isolated, allowing for flexibility in connection. Note that in the standard configuration, both the high voltage and low voltage return (0V) are connected internally to the chassis. Contact NSE for alternate connections.

Current and voltage at each phase, and on the input, is read and fed to the Motor Controller DSP.

6.3 Internal DC-DC

An internal DC-DC converter converts the low voltage input (ref. 4 System Specifications for voltage range), to the internal voltages needed to power the logic of the Motor Controller. It is important to note that the Motor Controller needs low voltage power in order to run.

6.4 DSP Microcontroller

A DSP Microcontroller provides processing and interface capability. It has dedicated PWM outputs and ADC interface used for controlling the motor. The DSP Microcontroller reads all feedback parameters such as phase voltage, phase currents, hall sensor or resolver positions and this data is employed in the various available control strategies.

The DSP Microcontroller has a CAN bus / RS-485 bus interface and non-volatile flash registers that are used for storing settings and setup-data.

The CAN bus interface uses a high-temperature industrial CAN transceiver with additional noise and EMC filtering.

The RS-485 interface uses a high-temperature industrial RS-485 transceiver with additional bias and termination resistors at PCB level.

6.5 Hall and resolver feedback

The Motor Controller can be set up to read *either* hall or resolver input. The resolver interface requires an optional board to be mounted inside the motor controller. Both interfaces are filtered with hardware filters internally in the motor controller, providing good noise immunity.

The optional resolver board provides sinusoidal excitation, A/D conversion, and processing in order to provide a digital position to the microcontroller.

6.6 Input Line Filter

An input line filter provides filtering of the high voltage input power to the motor controller. This filter attenuates the PWM switching noise from the motor, but will not remove voltage ripple induced by the motor currents. Noise or ripple sensitive applications may require additional external filtering.

The filter comprises high temperature inductor and capacitor components.

6.7 Internal Temperature sensor

The Motor Controller has a digital internal temperature sensor to provide feedback of the operating environment of the control electronics. The internal temperature is sampled by the DSP Microcontroller and can be read using the CAN bus / RS-485 bus interface.

6.8 External Temperature sensor Interface

The external temperature interface can be used with RTD sensors that are either 2-wire PT100 (default) or PT1000 elements. The RTD interface has onboard signal conditioning and noise filtering. Note however that RTD elements inside motors may be sensitive to motor noise that can reduce the accuracy while the motor is running.

The external temperature is sampled by the DSP Microcontroller and can be read using the CAN bus / RS-485 bus interface.

NSE recommends using twisted cables for the external motor temperature sensor interface. Shielding may be helpful in noisy environments.

7 Firmware Control and Feedback Parameters

7.1 Overview

The motor controller has a CAN bus / RS-485 bus interface for setting control parameters and reading back motor controller status parameters. The BLDC Driver Stage can be set up to run open-loop PWM control (0-100%), and closed-loop current and speed control. The driver will change between modes as required (for example, regulating to a set shaft speed unless a set value of input current is reached, after which the current will be regulated as load continues to increase).

Fault parameters may be set to required levels, or disabled, via the CAN / RS-485 interface.

7.2 Sensorless Algorithm

All NSE HT 600V BLDC drivers include a sensorless control option, either for use as a backup to sensored feedback, or as the principal control strategy. The control system is back-emf sensing, using a phase-locked loop approach.

Each phase voltage is sensed, filtered, and acquired by the on-board controller. A virtual-neutral-point voltage is calculated, and used to determine the phase of the feedback voltage from the non-conducting winding. When operating correctly, the feedback voltage should pass the neutral-point at the halfway point of the commutation interval. The phase error is used as the input to a software phase-locked loop, such that the output frequency is adjusted to bring the phase error to zero. The overall gain of the PLL is set so as to ensure rapid correction in the event of step changes in input voltage or motor torque.

Starting the motor requires applying phase currents at a fixed frequency, such that the motor begins to turn and provide back-emf feedback. The frequency and magnitude of the starting currents may be set via the control interface, to best match a given motor and load. As soon as the motor shaft begins to turn, the phase-feedback quickly brings the output currents into phase with the motor, and the frequency can ramp up rapidly to the desired set-point (determined by fixed PWM level, reference speed, or reference input current level).

7.3 Open-Loop Torque Control

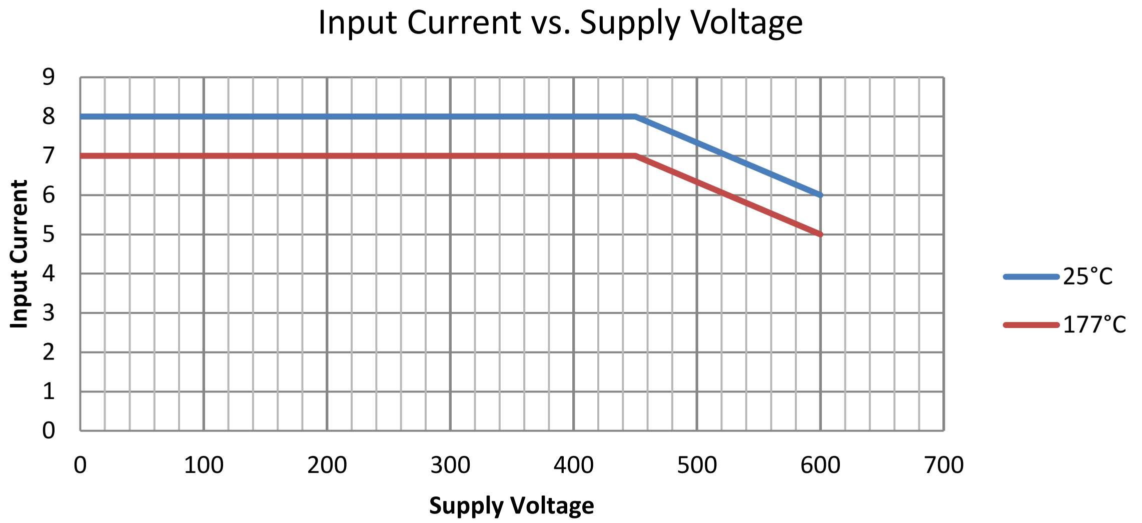
The standard firmware provides speed control and regulation of input current (of use when sharing a current-limited power source). Optional firmware adds control of motor current, hence approximate torque control. Torque control to zero speed is only available when using sensor feedback (hall or resolver).

7.4 ACIM Scalar Control

Firmware is also available for scalar control of ac induction motors. Speed feedback may be added via tachometer input to one of the hall sensor inputs. Contact NSE for further options.

8 Power Derating

The Motor Controller has some de-rating as function of input voltage and temperature, as shown below:



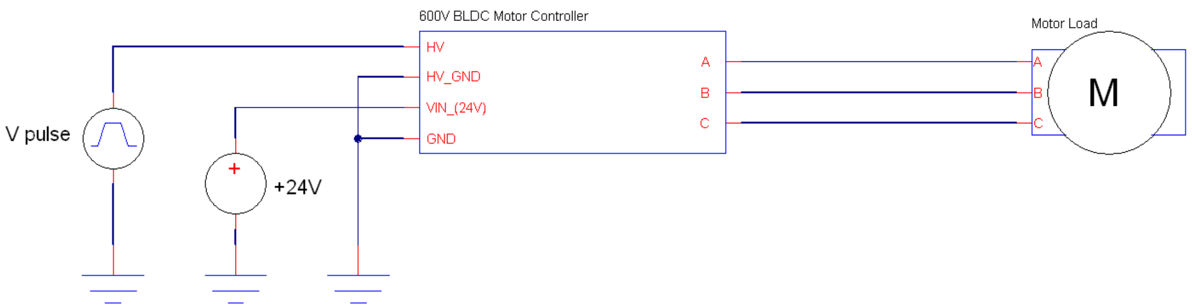
9 High Voltage Pulse Rating

The 600V BLDC controller can withstand short pulses of high input voltage. However – the maximum input voltage of 600V should be respected, and exposure of the motor controller to several repetitions of overvoltage, can damage the unit.

9.1 Test setup for maximum pulse voltage test

The 600V BLDC should not be exposed to pulses that exceed the voltage, slew rating or time given in these specifications.

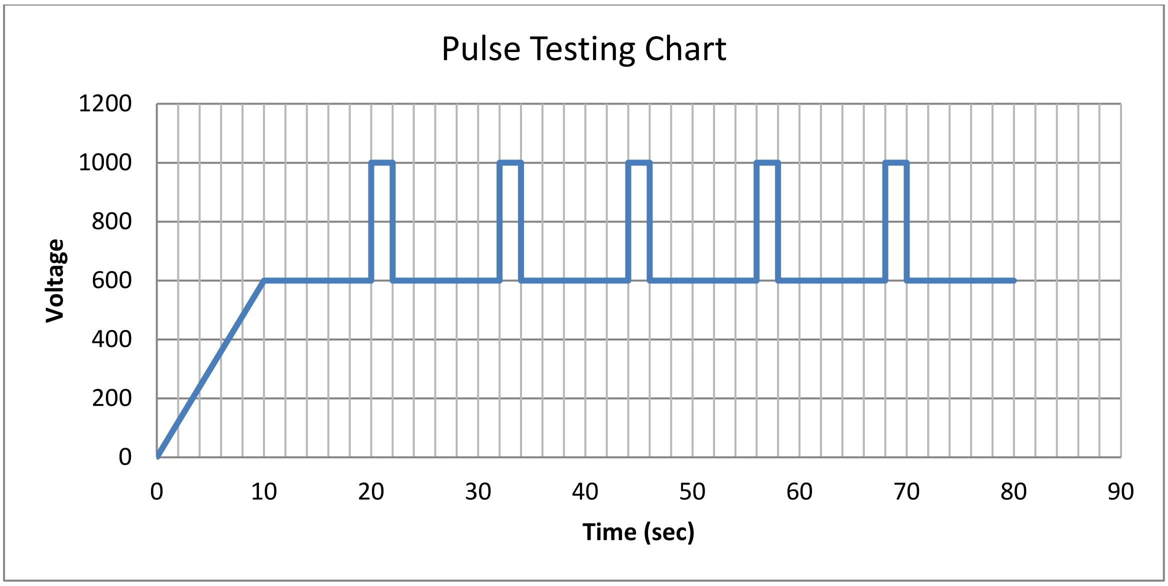
The setup for testing the 600V BLDC controller is given below:



The motor controller can be tested both idle and while running a motor. In the latter case the motor controller will stop the motor on the first high voltage pulse.

9.2 Pulse setup

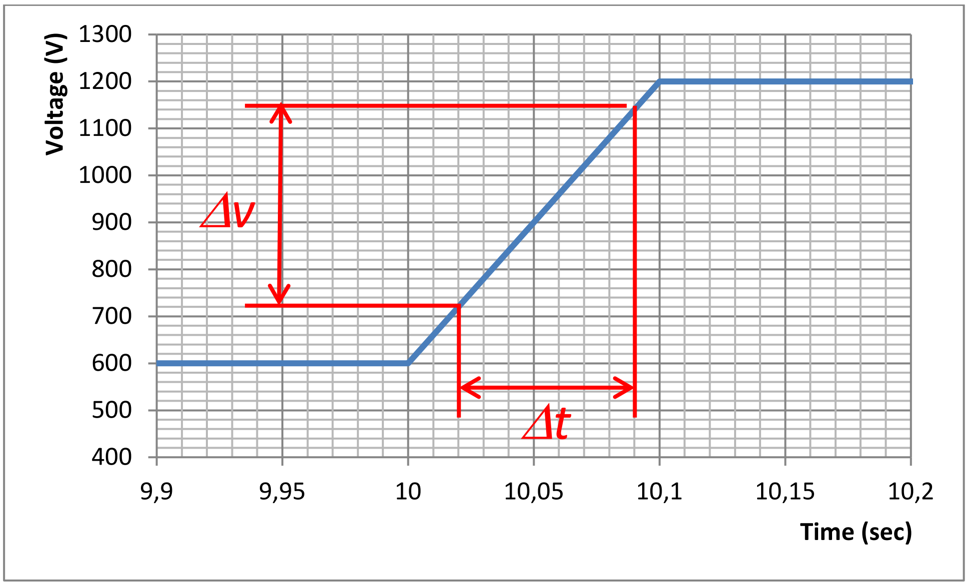
The maximum input voltage coming from the V pulse power supply is defined as 600V with a maximum of 1000V in pulses of up to 5, each with duration of maximum 2 seconds and at 12sec interval as shown below:



The maximum pulse train repetition rate is every 10min.

9.3 Slew rate limitations of overvoltage pulse

The slew rate $\frac{dv}{dt}$ of an overvoltage pulse should not exceed 6V/ms (600V / 100ms) as shown below:

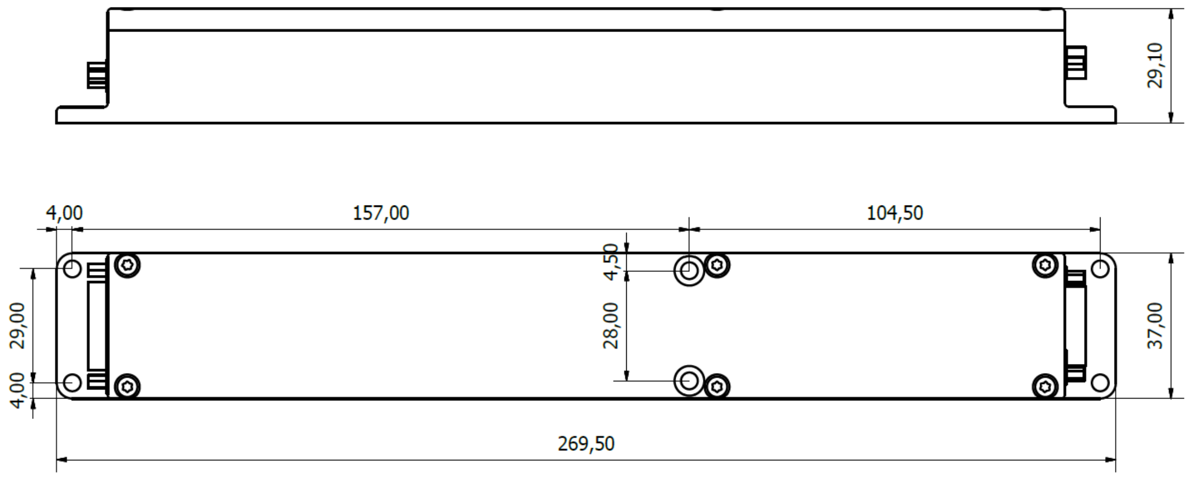


10 Mechanical

Note – The Motor Controller is supplied in a completely encapsulated chassis.

Consult NSE for STP-files.

10.1 Dimensions short version



10.2 Dimensions long version