

# PD-x-1670 Hardware Manual

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**PD-x-1670 is an easy to use and rather compact PANdrive™ smart BLDC motor. The module is controlled via CAN bus interface and comes with two firmware options – TMCL and CANopen. The PD-x-1670 line offer an integrated hall sensor based encoder for closed-loop FOC based operation.**



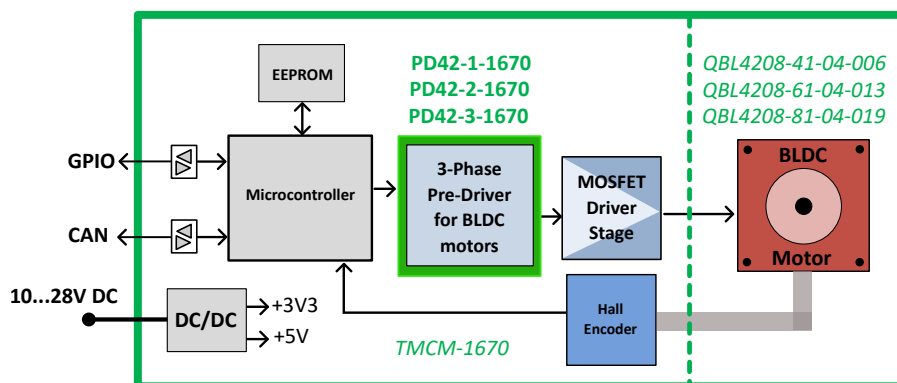
## Features

- **PANdrive™** smart BLDC motor
- Supply Voltage +10 to +28V DC
- CAN bus interface
- TMCL or CANopen protocol
- integrated encoder (hall sensor based)
- FOC based + SVPWM

## Applications

- Lab-Automation
- Manufacturing
- Robotics
- Factory Automation
- CNC

## Simplified Block Diagram



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# 1 Features

The PANdrives™ PD-x-1670 are full mechatronic solutions with state of the art feature set. They are highly integrated and offer convenient handling via CAN interface. The PD-x-1670 includes a BLDC motor, controller and driver electronics and an integrated hall sensor based encoder for closed-loop servo control. They can be used in many decentralized applications and has been designed for up-to 4000rpm rated velocity and 6.25... 18.5 Ncm rated holding torque with 24V DC nominal supply voltage. The PD-x-1670 comes with a CAN bus interface, enable input, two reference switch inputs and one general purpose input and output (open-drain).

## 1.1 General Features

### Main Characteristics

- Supply Voltage +24V nom. (+10V to +28V DC)
- 7.4A peak phase current (about 5.2A RMS)
- Available with enclosure and mounted on 42mm flange size BLDC motor
- Integrated hall sensor based encoder (4096 counts per rotation)
- Permanent onboard parameter storage
- Field-oriented-control (FOC)
- Space-vector-PWM (SVPWM)

### I/Os

- Reference switch inputs (internal pull-ups)
- Enable input to power-on/-off driver H-bridges (internal pull-down)
- General purpose input (internal pull-up)
- General purpose output (Open-drain, max. 100mA)

### CAN Bus Interface

- Standard CAN Bus Interface for control and configuration
- CAN bit rate of 20... 1000kBit/s
- TMCL-based protocol with TMCL firmware option
- CANopen protocol with DS402 device profile with CANopen firmware option



## 2 Order Codes

| Order Code       | Description  | Size (LxWxH)       |
|------------------|--|--------------------|
| PD42-1-1670-TMCL | PANdrive, BLDC, +24V DC, 4000rpm, 0.06Nm, CAN interface, TMCL firmware | 42mm x 42mm x 53mm |
| PD42-2-1670-TMCL | PANdrive, BLDC, +24V DC, 4000rpm, 0.12Nm, CAN interface, TMCL firmware | 42mm x 42mm x 73mm |
| PD42-3-1670-TMCL | PANdrive, BLDC, +24V DC, 4000rpm, 0.18Nm, CAN interface, TMCL firmware | 42mm x 42mm x 93mm |

*Table 1: Order codes PANdrives™ with TMCL firmware*

| Order Code          | Description   | Size (LxWxH)       |
|---------------------|---|--------------------|
| PD42-1-1670-CANopen | PANdrive, BLDC, +24V DC, 4000rpm, 0.06Nm, CAN interface, CANopen firmware | 42mm x 42mm x 53mm |
| PD42-2-1670-CANopen | PANdrive, BLDC, +24V DC, 4000rpm, 0.12Nm, CAN interface, CANopen firmware | 42mm x 42mm x 73mm |
| PD42-3-1670-CANopen | PANdrive, BLDC, +24V DC, 4000rpm, 0.18Nm, CAN interface, CANopen firmware | 42mm x 42mm x 93mm |

*Table 2: Order codes PANdrives™ with CANopen firmware*

| Order Code    | Description  |
|---------------|--|
| PD-1670-CABLE | Cable loom for PD42-x-1670: <ul style="list-style-type: none"> <li>• 1x cable loom for interface connector with 8pin JST PHD series connector</li> </ul> |

*Table 3: Order codes cable loom*



### 3 Mechanical and Electrical Interfacing

#### 3.1 PD-x-1670 Dimensions

The PD42-x-1670 PANdrive™ includes the TCM-1670 BLDC motor controller/driver module, a 42mm flange size BLDC motor with 8 poles and an integrated hall sensor based encoder for closed-loop operation. Currently, there is a choice between three 42mm flange size BLDC motors with different lengths and different torque ranges. The dimensions of the controller/driver unit are approx. 42mm x 42mm flange size and overall length of 53mm, 73mm or 93mm length (without motor axis and connectors).

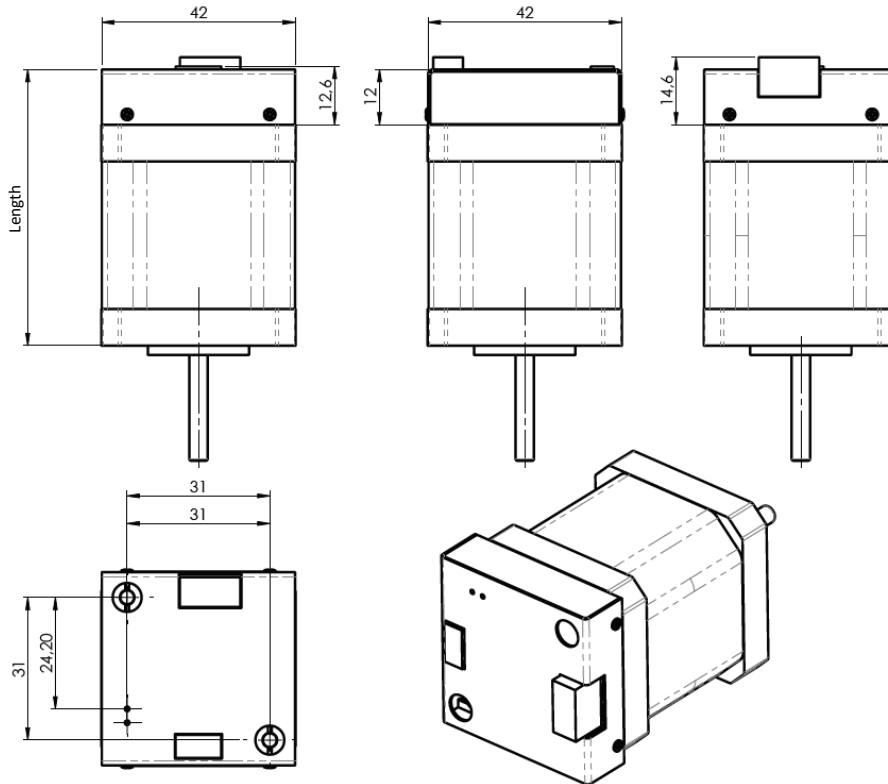


Figure 1: PD42-x-1670 overall dimensions in mm

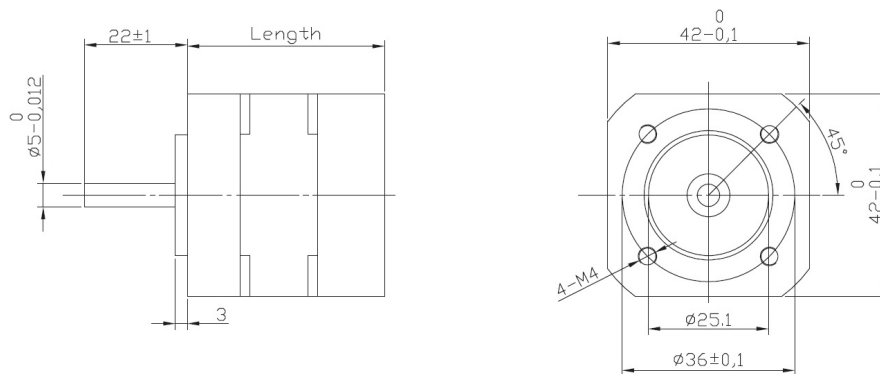


Figure 2: Motor without electronics - all dimensions in mm



When mounted to the BLDC motor the overall size of the PANdrive is the housing height (12mm) plus motor body size. The overall size does not include the connectors and mating connectors and the motor axes.

| Order Code  | Motor body length | Overall length in mm |
|-------------|-------------------|----------------------|
| PD42-1-1670 | 41                | 53                   |
| PD42-2-1670 | 61                | 73                   |
| PD42-3-1670 | 81                | 93                   |

*Table 4: Length of unit*



### 3.2 PD-x-1670 Motor Parameters

| Specifications                      | Unit | PD42-1-1670 | PD42-2-1670 | PD42-3-1670 |
|-------------------------------------|------|-------------|-------------|-------------|
| No. of Poles                        |      | 8           | 8           | 8           |
| No. of Phases                       |      | 3           | 3           | 3           |
| Shaft radial play (450g load)       | mm   | 0.02        | 0.02        | 0.02        |
| Shaft axial play (450g load)        | mm   | 0.08        | 0.08        | 0.08        |
| Max radial force (10mm from flange) | N    | 28          | 28          | 28          |
| Max axial force                     | N    | 10          | 10          | 10          |
| Rated voltage                       | V    | 24          | 24          | 24          |
| Rated phase current                 | A    | 1.79        | 3.47        | 5.14        |
| Rated Speed                         | RPM  | 4000        | 4000        | 4000        |
| Rated Torque                        | Nm   | 0.0625      | 0.125       | 0.185       |
| Max Peak Torque                     | Nm   | 0.19        | 0.38        | 0.56        |
| Torque Constant                     | Nm/A | 0.035       | 0.036       | 0.036       |
| Rated Current (RMS)                 | A    | 1.78        | 3.47        | 5.14        |
| Rated Current (Peak)                | A    | 2.5         | 4.9         | 7.27        |
| Line to Line Resistance             | Ohm  | 1.8         | 0.72        | 0.55        |
| Line to Line Inductance             | mH   | 2.6         | 1.2         | 0.8         |
| Max Peak Current                    | A    | 5.4         | 10.6        | 15.5        |
| Motor Length                        | mm   | 41          | 61          | 81          |
| Insulation Class                    |      | B           | B           | B           |

Table 5: BLDC motor technical data



## 4 Connectors and LEDs

The PD-x-1670 offers two connectors - one 5pin screw-connector for power supply and motor connection and one 8pin connector for the CAN communication, reference switch inputs and general purpose input and output.

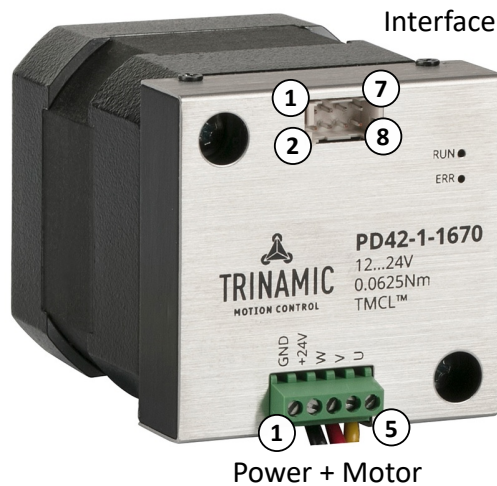


Figure 3: PD-x-1670 connectors

Overview of connector and mating connector types:

| Label                   | Connector type   | Mating connector type  |
|-------------------------|--|--|
| Interface connector     | JST B8B-PHDSS (JST PH series, 8pins, 2mm pitch, double row)        | Connector housing: JST PHDR-08VS<br>Contacts: JST SPHD-001T-P0.5<br>Wire: 0.13...0.33mm <sup>2</sup> , AWG 26...22 |
| Power + Motor connector | Terminal block, 5 positions, side entry, 2.54mm pitch, TE 282834-5 | Solid wire: 0.03...1mm (AWG 17),<br>Stranded wire: 0.03...0.75mm (AWG 18)  |

Table 6: Connector and mating connectors

### 4.1 Power + Motor Connector

| Pin no. | Pin name | Description                          |
|---------|----------|--------------------------------------|
| 1       | GND      | Power supply ground connection       |
| 2       | +24V     | Power supply input (+10V to +28V DC) |
| 3       | W        | Motor coil W connection              |
| 4       | V        | Motor coil V connection              |
| 5       | U        | Motor coil U connection              |

Table 7: PD-x-1670 Power and motor connector pin assignment





**NOTICE**

**Always keep the power supply voltage below the upper limit of 28V!** Otherwise the driver electronics will be seriously damaged. Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.

**NOTICE**

**Add external power supply capacitors!** It is recommended to connect an electrolytic capacitor of significant size (e.g. 1000 $\mu$ F/35V) to the power supply lines next to the PD-x-1670!

Rule of thumb for size of electrolytic capacitor:  $C = \frac{1000\mu F}{A} \times I_{SUPPLY}$

In addition to power stabilization (buffer) and filtering this added capacitor will also reduce any voltage spikes which might otherwise occur from a combination of high inductance power supply wires and the ceramic capacitors. In addition it will limit slew-rate of power supply voltage at the module. The low ESR of ceramic-only filter capacitors may cause stability problems with some switching power supplies.

## 4.2 Interface Connector

| Pin no. | Pin name | Description  |
|---------|----------|--|
| 1       | GND      | Power supply and signal ground connection  |
| 2       | ENABLE   | Enable driver stage input (internal pull-down resistor). Tie to positive voltage (above 2V, e.g. +24V supply) in order to enable driver stage. |
| 3       | CAN_H    | Bi-directional CAN interface, diff. signal (non-inverting)   |
| 4       | CAN_L    | Bi-directional CAN interface, diff. signal (inverting)   |
| 5       | IN0      | General purpose digital input 0. Internal pull-up to +5V   |
| 6       | OUT0     | General purpose output 0, open-drain (100mA sink current max.). Internal 4k7 pull-up resistor to +5V (diode protected).                        |
| 7       | REF_L    | Left reference switch input. Internal pull-up to +5V   |
| 8       | REF_H    | Left reference switch input. Internal pull-up to +5V   |

Table 8: PD-x-1670 Interface connector pin assignment

**NOTICE**

**Tie ENABLE to a positive voltage e.g. power supply input in order to enable driver stage!** Please note that pin 2 of the Interface connector is a driver stage enable input (active high) with an internal pull-down resistor. In order to enable motor driver stage and be able to move the motor using appropriate software commands it is necessary to tie this input to a positive voltage above +2V and less or equal the power supply input voltage.

## 4.3 CAN Connection

For remote control and communication with a host system the PD-x-1670 provides a CAN bus interface. For proper operation the following items should be taken into account when setting up a CAN network:



**Bus Structure** The network topology should follow a bus structure as closely as possible. That is, the connection between each node and the bus itself should be as short as possible. Basically, it should be short compared to the length of the bus.

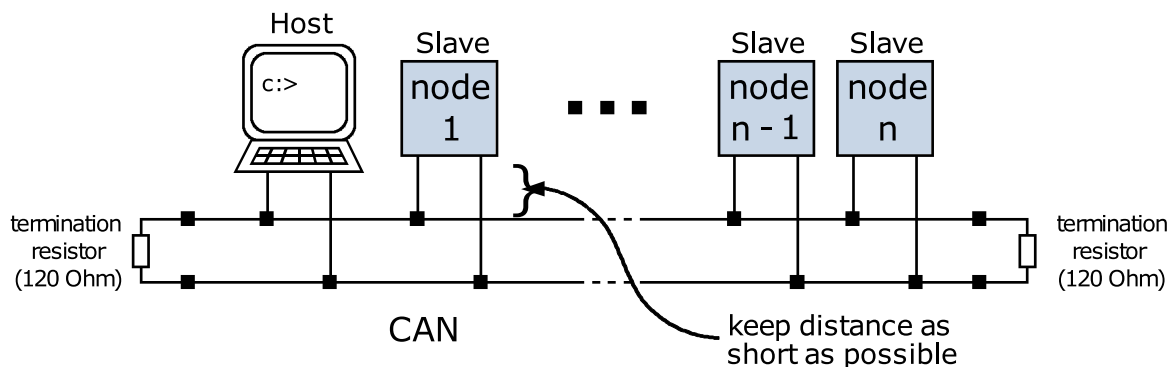


Figure 4: CAN bus structure

**Bus Termination** Especially for longer busses and/or multiple nodes connected to the bus and/or high communication speeds, the bus should be properly terminated at both ends. The PD-x-1670 does not integrate any termination resistor. Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.

**Number of Nodes** The bus transceiver used on the PD-x-1670 (TJA1051) supports at least 100 nodes under optimum conditions. Practically achievable number of nodes per CAN bus highly depend on bus length (longer bus → less nodes) and communication speed (higher speed → less nodes).

**CAN Bus Adapters** To quickly connect to the PD-x-1670 a PC based intergrated development environment TMCL-IDE is available. Latest release can be downloaded for free from our web site: [www.trinamic.com](http://www.trinamic.com). A number of common CAN interface adapters from different manufactures is supported from within this software. Please make sure to check our web site from time to time for the latest version of the software!



## 4.4 LEDs

The PD-x-1670 includes two LEDs: one green status LED and one red error LED. See figure 5 for LED location.



Figure 5: PD-x-1670 LED location

Depending on the firmware option (TMCL or CANopen), these LEDs have different functionality. Main states for TMCL:

| State RUN LED | State Error LED | Description TMCL Firmware                  |
|---------------|-----------------|--|
| Flashing      | off             | Firmware running (normal operation mode)   |
| Fast flashing | Fast flashing   | Bootloader mode, firmware update supported |

Table 9: LED functionality description

For CANopen firmware LED functionality has been implemented based on CANopen standard.



## 5 Functional Description

The PD-x-1670 is a full mechatronic solution including a 42mm flange size BLDC motor. It includes the controller / driver electronics a choice between three different 42mm flange size BLDC motors with different length and torque and an integrated magnetic encoder.

The PD-x-1670 can be controlled via serial CAN bus interface. In addition, there is one driver enable input (high active), two reference switch inputs, one general purpose digital input and one general purpose digital output

The PD-x-1670 with TMCL™ firmware option is supported by the PC based software development environment TMCL-IDE for the Trinamic Motion Control Language (TMCL™). Using predefined TMCL™ high level commands like move to position a rapid and fast development of motion control applications is guaranteed. Please refer to the PD-x-1670 firmware manual for more information about TMCL™ commands.

Communication traffic is kept low since all time critical operations, e.g. ramp calculation are performed on board. Complete stand-alone or full remote control or anything in-between is possible. The firmware of the module can be updated via the serial CAN interface. As an alternative to TMCL, a CANopen firmware is available.

### The PD-x-1670 contains the following main components:

- Microcontroller (ARM Cortex-M4™), responsible for overall control and communication
- Advanced 3-phase pre-driver with MOSFET driver stage
- In-phase current measurement
- CAN interface with transceiver
- On-board voltage regulators (+5V and +3V3) required for supply of all on-board digital circuits

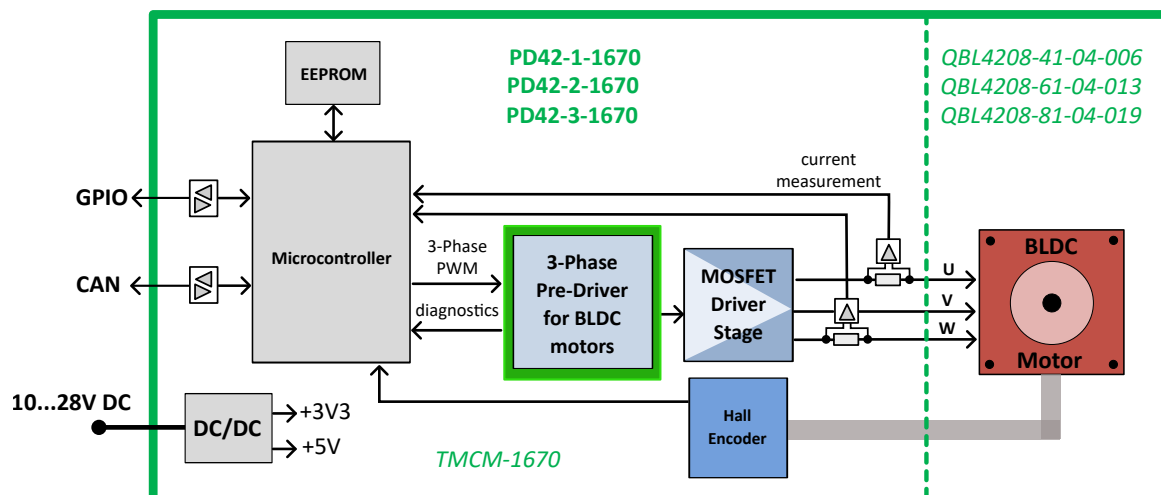


Figure 6: PD-x-1670 block diagram



## 6 Operational Ratings and Characteristics

### 6.1 Absolute Maximum Ratings

| Parameter                                  | Min | Max              | Unit |
|--|-----|------------------|------|
| Supply voltage                             | +10 | +28              | V    |
| Working temperature                        | -20 | +40              | ° C  |
| Motor coil current / sine wave <b>peak</b> |     | 7.4 <sup>1</sup> | A    |
| Motor current ( <b>RMS</b> )               |     | 5.2 <sup>1</sup> | A    |

#### NOTICE

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

### 6.2 I/O Ratings (Ambient Temperature 25° C)

| Parameter  | Symbol    | Min | Typ                | Max            | Unit |
|--|-----------|-----|--------------------|----------------|------|
| Input voltage for digital inputs ENABLE, IN0, REF_L and REF_R          | $V_{IN}$  | 0   | 0...5              | Supply voltage | V    |
| Low level voltage for digital inputs ENABLE, IN0, REF_L and REF_R      | $V_L$     | 0   |                    | 0.8            | V    |
| High level voltage for digital inputs ENABLE, IN0, REF_L and REF_R     | $V_H$     | 2   |                    | Supply voltage | V    |
| External voltage at general purpose output OUT0 (output not activated) | $V_{OUT}$ | 0   | 0...Supply voltage | 40             | V    |
| Max sink current for general purpose output OUT0 (output activated)    | $I_{OUT}$ | 0   |                    | 100            | mA   |

Table 11: I/O ratings

<sup>1</sup> Depending on motor / PANdrive motor current might be limited further (limited to rated motor current).



## 6.3 Other Requirements

| Specifications      | Description or Value  |
|---------------------|---|
| Cooling             | Free air  |
| Working environment | Avoid dust, water, oil mist and corrosive gases, no condensation, no frosting |
| Working temperature | -20° C to +40° C  |

*Table 12: Other Requirements and Characteristics*

## 7 Abbreviations used in this Manual

| Abbreviation | Description                                 |
|--------------|---|
| CAN          | Controller Area Network                     |
| IDE          | Integrated Development Environment          |
| LED          | Light Emmitting Diode                       |
| RMS          | Root Mean Square value                      |
| TMCL         | TRINAMIC Motion Control Language            |
| TTL          | Transistor Transistor Logic                 |
| UART         | Universal Asynchronous Receiver Transmitter |
| USB          | Universal Serial Bus                        |

*Table 13: Abbreviations used in this Manual*



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## 10 Supplemental Directives

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## 11 Revision History

### 11.1 Hardware Revision

| Version | Date        | Author | Description                          |
|---------|-------------|--------|--------------------------------------|
| 1.00    | 2018-FEB-16 | TMC    | First Prototypes                     |
| 1.10    | 2018-APR-26 | TMC    | Several corrections and enhancements |
| 1.20    | 2018-MAY-28 | TMC    | Minor changes and different sensor   |

*Table 14: Hardware Revision*

### 11.2 Document Revision

| Version | Date        | Author | Description                 |
|---------|-------------|--------|-----------------------------|
| 0.90    | 2018-OCT-18 | GE     | First version               |
| 1.00    | 2018-OCT-26 | GE     | Minor updates / corrections |

*Table 15: Document Revision*



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