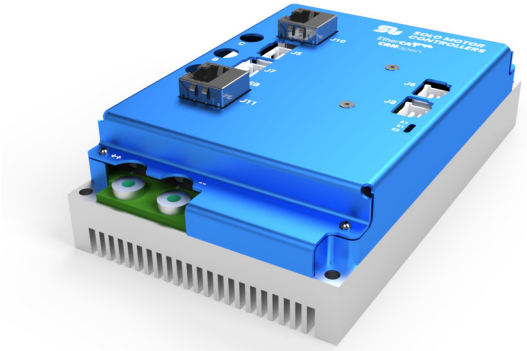
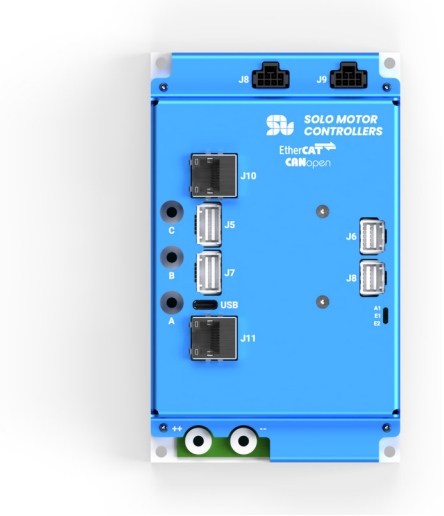
SOLO MOTOR CONTROLLERS

solomotorcontrollers.com

SOLO PRO 60-160 — HARDWARE USER MANUAL

Document Number: SOLO-PRO60160-HW-UM-001
Revision: 02
Date: 2026-09-25
Status: Released
Part Number: SLSGB002PW2000
Power Range: 8-60 VDC, 130 ADC / 92 Arms continuous
DSP: TMS320F28388DZWTS (Texas Instruments F28388D)





EtherCAT CANopen

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

TABLE OF CONTENTS

1. About This Document 5
- 1.1 Purpose and Scope 5
- 1.2 Safety Symbols 6
- 1.3 Abbreviations 6
- 1.4 Revision History 8
- 1.5 Further Information 8
- 1.6 Trademarks 8

2. Product Safety 9
- 2.1 General Safety Precautions 9
- 2.2 Intended Use 10
- 2.3 Prohibited Use 10

3. Product Overview 11
- 3.1 What the Drive Provides 11
- 3.2 Dual-Core Architecture — Two Independent Cores in Parallel 12
- 3.3 Interactional Sections 13
- 3.4 Functional Block Diagram 13
- 3.5 Architecture 15
- 3.6 Control Principle 16
- 3.7 Ordering and Part Numbers 19

4. User Core — Open Access 20
- 4.1 What the User Core Is 20
- 4.2 Programming the User Core 20

5. Technical Specifications 22
- 5.1 Power 22
- 5.2 Control and Timing 23
- 5.3 Thermal & Environmental 24
- 5.4 Mechanical 24
- 5.5 Absolute Maximum Voltage Ratings 24
- 5.6 Processing and Memory 27

6. Mechanical Integration 28
- 6.1 Dimensions and Mounting 28
- 6.2 Thermal Considerations 29

7. Connectors, Sections & Pinout 30
- 7.1 Connector Organization 30

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.2 Sections [3, 5, 7] — Motor Outputs 31
7.3 Sections [20, 21] — Supply Inputs 32
7.4 Sections [1, 8] — EtherCAT Ports 33
7.5 Section [2] — USB 2.0 Type-C 33
7.6 Section [4] J7 — Encoder Connector 35
7.7 Section [6] J5 — Absolute and Hall Encoder Connector 37
7.8 Section [11] J6 — Communication and Analogue Connector 39
7.9 Section [12] J8 — GPIO Connector 40
7.10 Section [10] J9 — STO and Sleep Connector 42
7.11 Section [9] J8 — Active Brake Chopper Connector 43
7.12 JTAG Connector 44
7.13 Mating Connector Part Numbers 45
8. Networking & Communications 46
8.1 EtherCAT 46
8.2 CANopen (DS402) 47
8.3 USB 48
9. Position Sensing 49
9.1 Digital Hall Sensors 49
9.2 Incremental Encoder — Single-Ended 50
9.3 Incremental Encoder — Differential 51
9.4 BiSS-C Absolute Encoders — Primary and Secondary 51
9.5 Sin/Cos Absolute Encoder 52
9.6 PT1000 Temperature Sensor 54
10. Analogue and Digital Control 56
10.1 Analogue versus Digital Control 56
10.2 Analogue Command Inputs AI1_IN and AI2_IN 56
10.3 Analogue Wiring — Controller with NPN Outputs 57
10.4 Analogue Wiring — Controller with PNP Outputs 58
10.5 Analogue Wiring — Embedded MCU Boards 58
10.6 General-Purpose Input Wiring 59
10.7 General-Purpose Output Wiring 59
10.8 Digital Mode 60
11. Safe Torque Off (STO) 61
11.1 Function 61
11.2 Electrical Characteristics 62
11.3 Wiring the STO Inputs 62
11.4 Timing 64
12. Active Brake Chopper 65
12.1 Principle 65

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

12.2 Wiring 65
12.3 Setting the Activation Voltage 66
13. Sleep Mode and Firmware Update 68
13.1 Sleep Mode 68
13.2 Firmware Update (DFU Mode) 68
14. LED Indicators 70
15. Complete Wiring Examples 71
15.1 Wiring Legend 71
15.2 Standalone Wiring — No External Modules 71
15.3 Embedded MCU Board Using Analogue/PWM 72
15.4 Embedded MCU Board Using CANopen 73
15.5 Embedded MCU Board Using EtherCAT 74
15.6 General Wiring Considerations 75
16. Getting Started / Initial Setup 77
16.1 Required Equipment 77
16.2 First Power-Up 77
16.3 SOLO Motion Terminal — Initial Configuration 78
17. Regulatory Compliance & Approvals 79
18. Revision History 80

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

1. ABOUT THIS DOCUMENT

1.1 PURPOSE AND SCOPE

The SOLO PRO 60-160 is a complete, ready-to-use motor drive for 8–60 VDC systems, delivering up to 130 A DC (92 Arms) of continuous output current and up to 6 kW of continuous output power. It drives DC brushed, BLDC, PMSM and EC coreless motors in closed loop, with torque, speed and position control, and it needs neither firmware development nor any power-electronics design: the inverter, the gate drivers, the current and voltage sensing, the DC-bus capacitance, the active brake chopper and the isolated Safe Torque Off circuitry are all built in and pre-qualified.

The user connects the supply, the motor, the position sensor and the command interface, configures the drive through the SOLO Motion Terminal, and the unit performs Field Oriented Control of the motor. Commands can arrive as analogue voltages or PWM pulses, or as data packets over USB, CANopen or EtherCAT.

The drive is built around a dual-core DSP, mounted on the unit as a **System-on-Module (SOM)**, which is where the name comes from. Two independent processors therefore work in parallel inside the drive:

- **Motion Core.** Programmed and maintained by SOLO, this core runs the production motor-control firmware: Field Oriented Control of the motor, the position-sensing interfaces, the protections, and the EtherCAT and CANopen communication stacks. It requires no firmware development. The user configures it through the SOLO Motion Terminal and commands it over the communication interfaces or the analogue inputs. For most users this is the whole drive.
- **User Core.** A second, fully open 200 MHz processor, available to run the user's own application inside the drive (supervisory logic, an application-specific state machine, custom command handling) without adding an external microcontroller. It is optional: the drive is complete without it. Section 4 covers it.

This manual specifies the electrical and mechanical characteristics of the drive, the function and pinout of every connector, the communication interfaces, the supported position sensors, the Safe Torque Off and active brake chopper functions, and the wiring required to commission a system. It provides the information needed to integrate the SOLO PRO 60-160 into a machine.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

The reader is assumed to be familiar with electrical drives and industrial wiring practice. No prior experience with this specific product is assumed. Where a design constraint is not self-evident, the text states the underlying reason so that it can be applied correctly to a given system.

1.2 SAFETY SYMBOLS

Four callout types appear throughout this manual. They follow the ANSI Z535 convention, in which the severity of the potential consequence determines the label:

Symbol	Meaning
i NOTE	Additional information or guidance. No risk of damage.
⚠ CAUTION	Possible minor equipment damage or data loss if disregarded.
⚠ WARNING	Possible personal injury or significant equipment damage.
⛔ DANGER	Immediate risk of serious injury or death.

⛔ **DANGER:** Do not connect or disconnect any connector, motor lead or supply cable while the drive is powered. The DC bus carries 4700 µF of capacitance, which holds a hazardous charge after the supply is removed. Wait until the bus has discharged and the **A1** LED has gone out before touching any terminal.

⚠ **WARNING:** The SOLO PRO 60-160 has **no reverse-polarity protection** on its supply input. Confirm the polarity of the DC supply at sections [16] and [17] before switching it on. Applying the supply in reverse will destroy the unit.

⚠ **CAUTION:** The drive contains ESD-sensitive components. Handle it at a grounded workstation and retain it in antistatic packaging until installation.

1.3 ABBREVIATIONS

Abbreviation	Definition
ADC	Analog-to-Digital Converter
ASRDC	Analogue Speed Resolution Division Coefficient (scales the analogue speed reference)
BAV	Brake Activation Voltage (external resistor input of the brake chopper)
BiSS-C	Bidirectional Serial Synchronous, protocol C (an open absolute-encoder standard)
BLDC	Brushless DC motor

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Abbreviation	Definition
BRO	Brake Resistor Output (brake chopper output terminals)
CAN	Controller Area Network
CLA	Control Law Accelerator (a co-processor within the TI DSP)
DFU	Device Firmware Upgrade
DSP	Digital Signal Processor
DVC	Decisive Voltage Class (UL 61800-5-1 circuit classification)
FOC	Field Oriented Control
GND	Ground
GPI/O	General-Purpose Input / Output
HSO	High-Speed Observer (SOLO's sensorless estimator for high-speed motors)
INC	Incremental (encoder type)
IPC	Inter-Processor Communication
JTAG	Joint Test Action Group (standard debug interface)
LSS	Layer Setting Services (CANopen — sets node ID and bit rate)
PHY	Physical Layer transceiver (here, the Ethernet line driver)
PMSM	Permanent Magnet Synchronous Motor
PTC	Positive Temperature Coefficient (here, the PT1000 sensor input)
PWM	Pulse-Width Modulation
RTD	Resistance Temperature Detector (e.g. PT1000)
SOM	System-on-Module
STO	Safe Torque Off
SVM	Space Vector Modulation
VCP	Virtual COM Port

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

1.4 REVISION HISTORY

Rev	Date	Firmware	Author	Summary of Changes
V1.0.0	31/05/2023	0x0000B00F	SOLO Motor Controllers	First release
V1.0.1	10/05/2024	0x0000B020	SOLO Motor Controllers	P/F pin description changed; certification table updated; temperature ratings updated per UL 61800-5-1; PT1000 formulas changed
01	2026-07-26	—	SOLO Motor Controllers	Restructured hardware user manual
02	2026-09-25	—	SOLO Motor Controllers	Encoder frequency specification corrected to the control module's ratings: 10 MHz for incremental encoders, and a 2–8 MHz clock range for BiSS-C

1.5 FURTHER INFORMATION

This manual covers the **hardware** of the SOLO PRO 60-160. Everything beyond it is documented separately on the SOLO website, **solomotorcontrollers.com**: configuring and tuning the drive with the **SOLO Motion Terminal**, the **CANopen (DS402)** and **EtherCAT** communication profiles and their object dictionaries, **User Core** programming, and application notes.

1.6 TRADEMARKS

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

CANopen® and CiA® are registered community trademarks of CAN in Automation e.V.

All other trademarks are the property of their respective owners.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

2. PRODUCT SAFETY

2.1 GENERAL SAFETY PRECAUTIONS

The SOLO PRO 60-160 is a power converter capable of delivering 6 kW into a motor. It can produce sufficient energy to cause injury, fire, or violent unintended motion of a machine if misapplied. Review this section before applying power.

The supply input accepts 8 to 60 VDC continuously. The absolute maximum at the supply terminals is +66 V. The hardware over-voltage protection trips at 66.4 V and the software protection at 63 V, while the active brake chopper starts dissipating at approximately 61 V by default. These thresholds sit close together, so a supply that overshoots on load release will trip the drive rather than damage it, but only if the brake chopper and its resistor are correctly sized (Section 12).

The logic-level inputs are **not** all rated alike. The general-purpose I/O accepts up to 5 V, the single-ended encoder inputs up to 5 V, the differential encoder and BiSS-C inputs up to 12 V, the analogue inputs up to 10 V, and the PT1000 and DFU1 inputs only 3.3 V. Confirm the rating of each pin group against the absolute-maximum table in Section 5.5 rather than assuming a common level.

> ⚠ **WARNING:** The PTC+/PTC− and DFU1 pins are 3.3 V inputs and are **not** 5 V tolerant. Applying more than 3.3 V to these pins, even briefly, can permanently damage the drive.
>
> ⚠ **WARNING:** Wiring the STO inputs is **mandatory** for normal operation. With STO1 and STO2 open or grounded the drive holds the power stage disabled and the motor cannot produce torque. See Section 11.
>
> ⚠ **WARNING:** If either STO input is opened while the motor is turning, the motor **coasts** to a stop under its own inertia; STO removes torque but does not brake the load. Where coasting is hazardous, provide an independent mechanical brake or other external safety measure.
>
> ⚠ **CAUTION:** Never connect a supply cable to a motor output (sections [3], [5], [7]). Doing so will cause serious damage to the unit.
>
> ⚠ **CAUTION:** The two switched 5 V outputs are intended to supply sensors and small external logic only. +5V_OUT1 provides up to 1 A (5 W); +5V_OUT_P and +5V_OUT_S provide up to 200 mA each for absolute encoders. Do not use them as a general-purpose system supply.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

> **NOTE:** Limit encoder and Hall sensor cables to 3 m, and bond the cable shield to ground at one end only. Grounding a shield at both ends forms a ground loop that injects noise into the feedback signals.

The complete machine must comply with the standards applicable to its market and application. For industrial drives this is typically the IEC 61800 series. The certification status of the drive itself is given in Section 17. System-level certification remains the responsibility of the machine builder.

2.2 INTENDED USE

The SOLO PRO 60-160 is intended as the motor drive of an industrial or mobile machine, driving DC brushed, BLDC, PMSM or EC coreless motors from a DC supply of 8 to 60 V. It is supplied as an enclosed assembly in a machined aluminium housing with an integrated heatsink. No ingress-protection rating has been established for that housing, so the unit is still intended to be mounted inside a machine enclosure that provides the environmental and touch protection required by the application.

2.3 PROHIBITED USE

Do not use the SOLO PRO 60-160 in any of the following ways:

- With the STO inputs left unwired, on the assumption that the drive will run.
- With the supply polarity reversed, or with a supply that can exceed 66 V under any condition.
- In a safety-critical application without an independent, validated safety system.
- Outside the specified board and heatsink temperature ranges.
- In an environment subject to condensation or to conductive dust and contamination.
- Without a correctly sized brake resistor, where the load has significant inertia and can regenerate into the DC bus.
- As a general-purpose 5 V power supply for external equipment.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3. PRODUCT OVERVIEW

3.1 WHAT THE DRIVE PROVIDES

The SOLO PRO 60-160 is a high-power motor controller designed for high-current, low-voltage applications: BLDC, PMSM, DC brushed and EC coreless motors, at supply voltages up to 60 V and continuous currents up to 130 A DC or 92 Arms. Everything needed between a DC supply and a motor shaft is inside the unit, so a working drive is a matter of wiring and configuration rather than development.

What the unit contains:

- A **complete 8–60 V, 130 A inverter** with its gate drivers, phase and bus current sensing, phase and bus voltage sensing, and 4700 µF of DC-bus capacitance.
- A **dual-core DSP with production motor-control firmware:** Field Oriented Control with cascaded torque, speed and position loops, automatic motor-parameter identification and self-tuning, Space Vector Modulation, and embedded S-curve motion profiling.
- **Bus over-voltage, bus under-voltage, over-current and over-temperature protection**, in hardware and in firmware.
- An **active brake chopper** with a user-selectable activation voltage, for four-quadrant regenerative operation.
- **Isolated, dual-channel Safe Torque Off** for safe emergency stops.
- **USB, CANopen (DS402) and EtherCAT** interfaces, plus analogue and PWM command inputs.
- **Dual-channel position sensing** covering Hall sensors, single-ended and differential incremental encoders, Sin/Cos encoders and BiSS-C absolute encoders, plus a PT1000 temperature-sensor input.
- A **low-power sleep mode** drawing approximately 2.6 mA, for battery-powered machines.

No part of the drive has to be designed and no firmware has to be written. What the integrator supplies is the DC supply, the motor, a position sensor if the application needs one, a brake resistor if the load regenerates, the STO wiring, and the command interface.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3.2 DUAL-CORE ARCHITECTURE — TWO INDEPENDENT CORES IN PARALLEL

The drive runs on a dual-core TMS320F28388D DSP, which provides two 32-bit C28x CPUs in parallel at 200 MHz, each with its own double-precision floating-point unit and Control Law Accelerator. The two cores have distinct, complementary roles: the **Motion Core** executes the production motor-control firmware, while the **User Core** is left fully open for the user's own application. They run simultaneously and exchange data over an on-chip inter-processor link, so user code cannot interrupt the motor-control loops.

Motion Core (programmed and maintained by SOLO):

- Field Oriented Control with nested position, speed, and torque loops, using Space Vector Modulation
- Drives BLDC, PMSM (surface-magnet and interior-magnet types), DC brushed, and EC coreless motors
- Two independent position-sensing channels (primary for control, secondary for monitoring)
- EtherCAT with two on-board PHYs and DS402 device profiling
- CANopen (DS402) through an on-board CAN transceiver
- USB Full-Speed (Type-C) for configuration and firmware updates through the SOLO Motion Terminal
- Automatic identification of motor parameters and self-tuning
- Embedded motion profiling (S-curve) for position and speed
- Bus over-voltage, bus under-voltage, over-current and over-temperature protection
- PT1000 temperature-sensor input for motor or heatsink monitoring
- Four-quadrant regenerative operation, with the active brake chopper absorbing the returned energy

User Core (user-programmable):

- A dedicated 200 MHz C28x CPU with double-precision floating-point unit and Control Law Accelerator, independent of the Motion Core
- Direct access to all Motion Core data (commanded and measured torque, speed and position, and the current feedback) over the on-chip IPC channel
- Programmed and debugged through the on-board JTAG connector, inside the enclosure

The User Core is an option, not a requirement. A drive commanded over analogue inputs, USB, CANopen or EtherCAT uses only the Motion Core, and nothing in the rest of this manual depends on the User Core being programmed.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3.3 INTERACTIONAL SECTIONS

The SOLO PRO 60-160 can be decomposed into **17 interactional sections**, shown in Figure 1. Every connector, terminal and indicator belongs to one of them, and the whole of this manual refers to them by number. Section 7 describes each section in detail and gives its pinout. Section 5.5 gives the maximum voltage that may be applied to each.

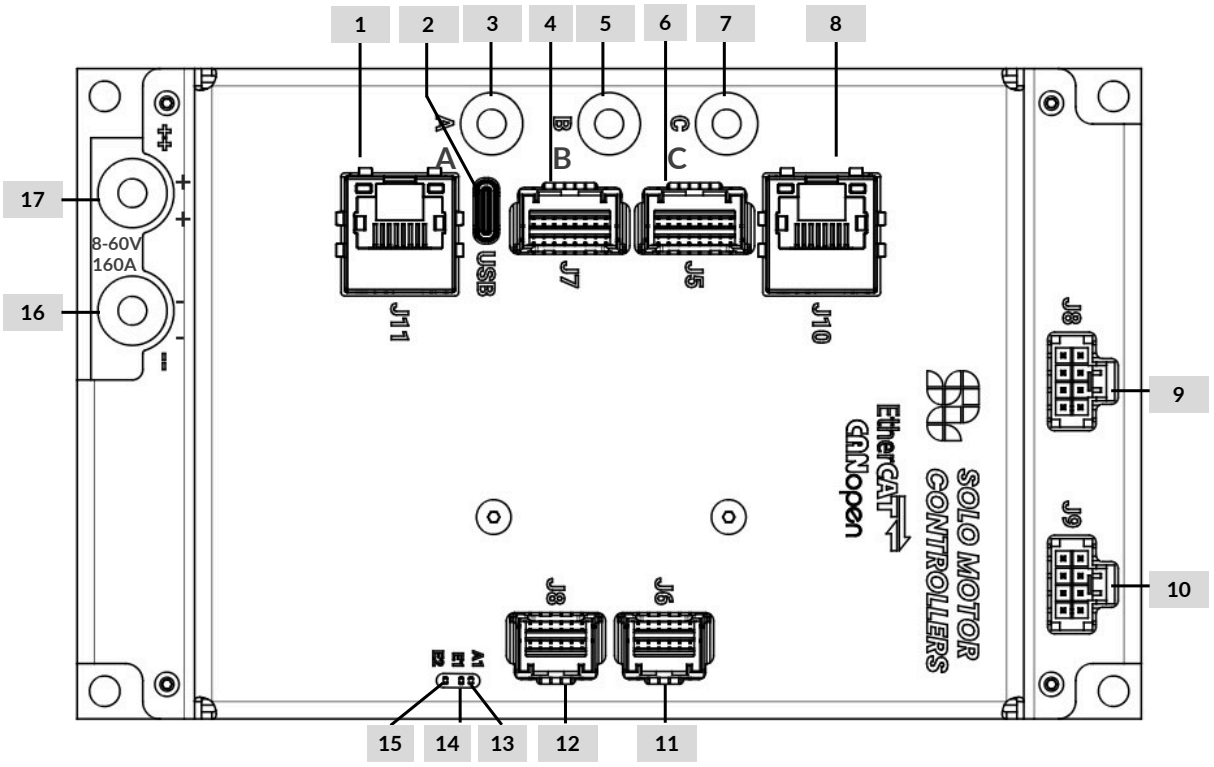


Figure 1. The interactional sections of the SOLO PRO 60-160, as the unit ships.

> ⚠ **WARNING:** Do not exceed the maximum ratings given in Section 5.5 for any section. Exceeding them can damage the drive or create a hazard for the operator.

3.4 FUNCTIONAL BLOCK DIAGRAM

Figure 2 shows the functional block diagram of the SOLO PRO 60-160, with the command and feedback interfaces on one side and the motor and supply terminals on the other.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

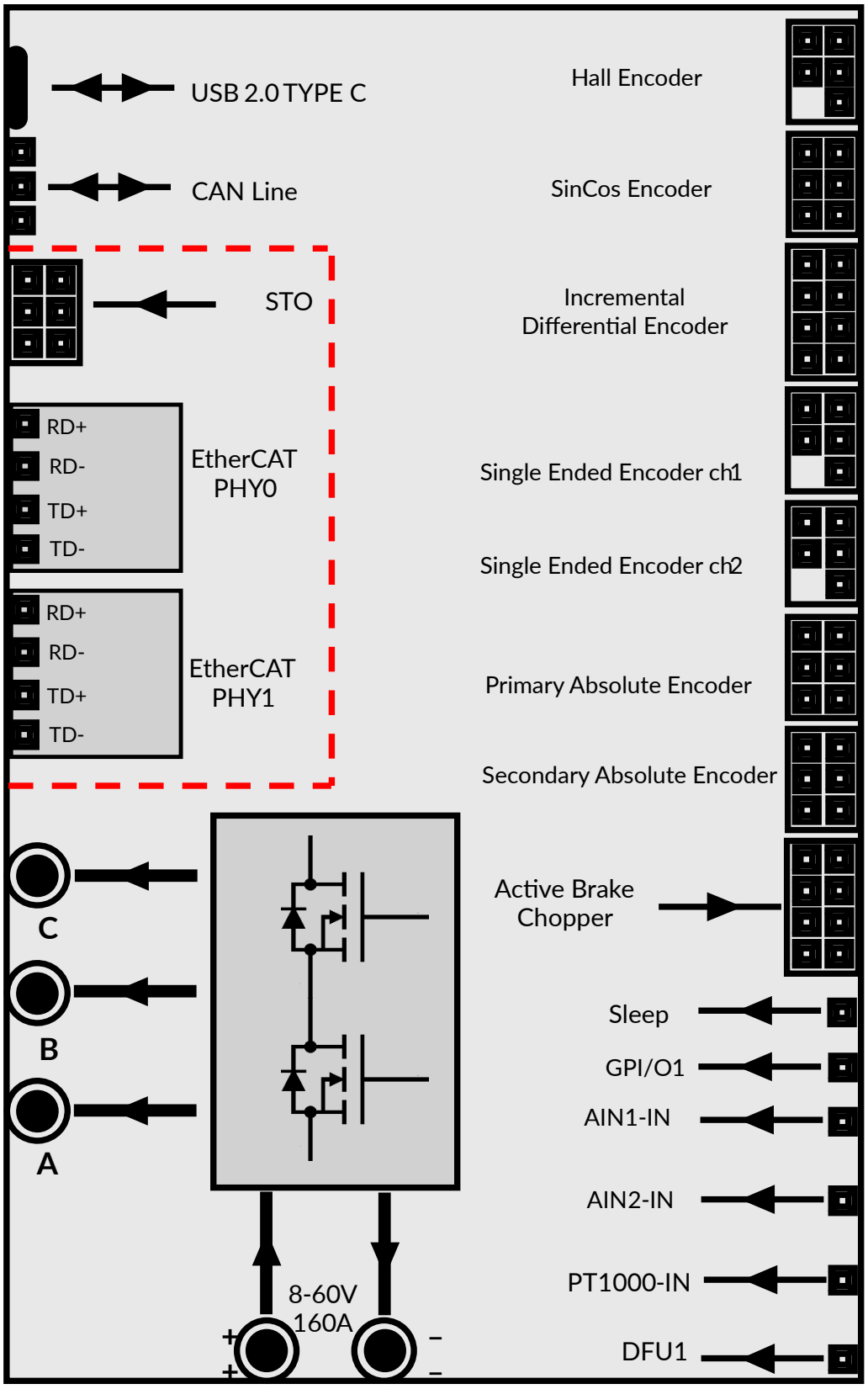


Figure 2. SOLO PRO 60-160 functional block diagram.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3.5 ARCHITECTURE

Figure 3 shows the internal architecture. The control module sits at the centre, with its Motion Core and User Core running side by side and exchanging data over the inter-processor link (IPC). It drives the gate drivers and the power MOSFETs and reads back the phase current and voltage measurements. Around it are the elements that make the unit a complete drive: the on-board voltage regulators generating the +12 V, +5 V and +3.3 V rails from the DC bus; the 4700 µF bus capacitance; the over-voltage detection and active brake chopper; and the dual-channel STO circuit, whose two optically isolated inputs each gate one of the power switches that supply the gate drivers.

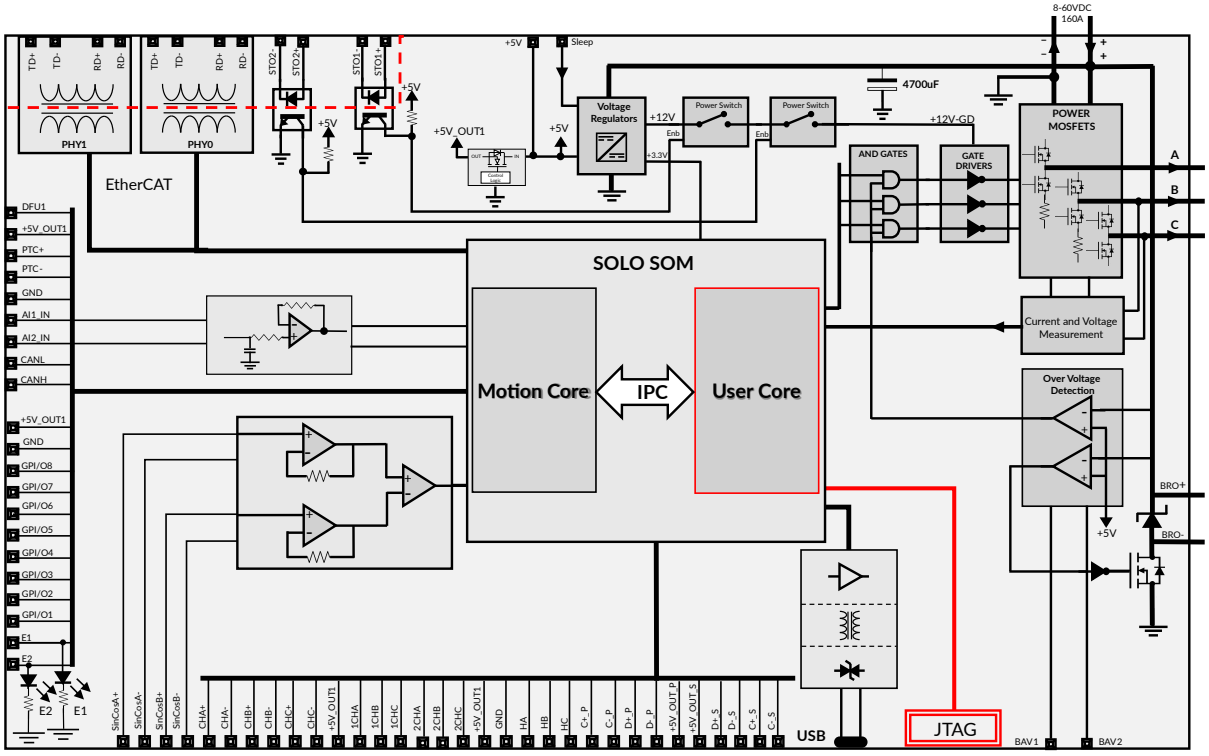


Figure 3. Architecture of the SOLO PRO 60-160 — the control module, the gate drivers and power stage, the measurement chain, the STO power switches, and the brake chopper. The User Core and the resources assigned to it are drawn in red.

Note the position of the STO circuit in this diagram: the two isolated channels act on the enable inputs of the power switches feeding the gate drivers, so an STO request removes gate-drive energy in hardware, independently of firmware. The function is therefore a hardware-level protection, not a software interlock.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3.6 CONTROL PRINCIPLE

The SOLO PRO 60-160 operates in closed loop with cascaded torque, speed and position controllers. Cascading them allows each quantity to be regulated independently, and that is what produces robust, smooth performance on systems whose load and dynamics vary. For three-phase motors this cascade is implemented as Field Oriented Control (FOC), also called vector control.

The architecture rests on four fundamental controllers, the first three of which form the cascade:

1. **The torque controller.** The innermost and fastest loop. Motor torque is produced by current injected into the stator, so torque control is implemented as current control, and the loop is often called the current controller for that reason. It stabilizes the demanded current in the motor so the system can overcome changes in load dynamics. On the SOLO PRO 60-160 this loop is synchronized to the PWM frequency and executes in **7 µs**, giving an FOC loop rate up to approximately 140 kHz.
2. **The speed controller.** Sitting outside the torque controller and running at least ten times slower, it holds the shaft speed at the demanded value regardless of load variation by adjusting the torque reference. Speed is regulated *through* torque rather than directly, because an electrical motor is fundamentally a torque-producing machine: speed is the result of applied torque acting against the load.
3. **The position controller.** The outermost and slowest loop. It sets the shaft to a commanded position by commanding a speed that reduces the error. The torque and speed loops beneath it must be tuned before this loop can be used.
4. **The motor electrical angle** is computed internally by the drive and is required by every closed-loop mode, because without it the controller does not know the correct direction in which to inject current.

3.6.1 THREE-PHASE MOTORS AND FIELD ORIENTED CONTROL

Figure 4 shows the FOC architecture used for BLDC and PMSM motors, with its nested torque, speed and position loops.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

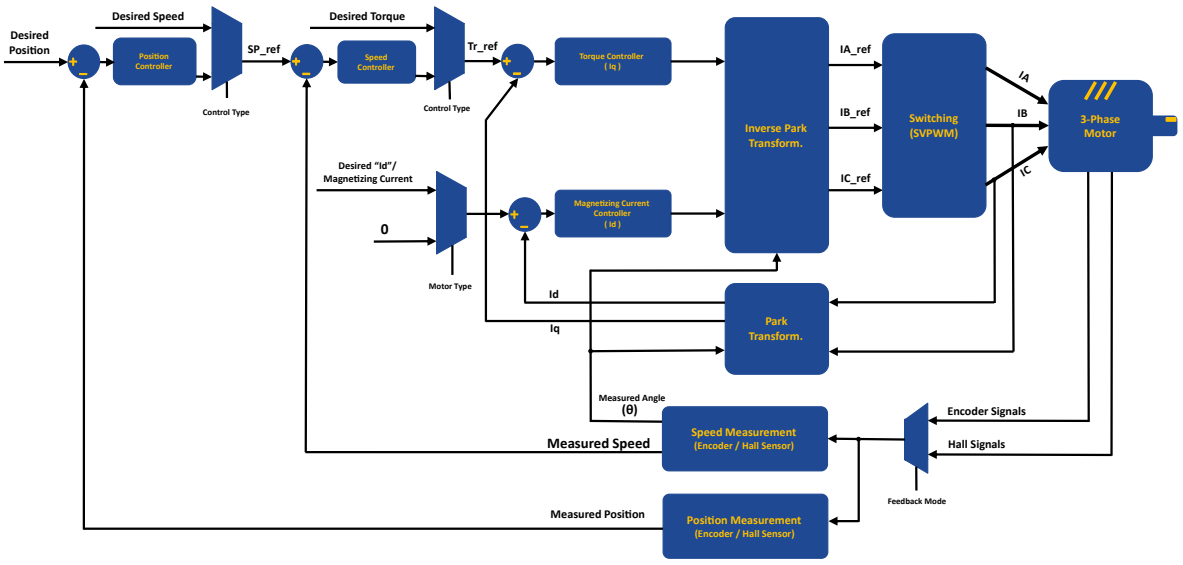


Figure 4. Field Oriented Control architecture of the SOLO PRO 60-160 for three-phase motors (nested torque, speed and position loops).

Controlling torque, speed or position of a three-phase motor in FOC mode requires four feedback quantities:

- **Current feedback**, needed for torque control. It is measured internally by the SOLO PRO 60-160, with a measurement resolution of **80 mA**.
- **Speed**, derived from the position sensor mounted on the motor (encoder or Hall sensors).
- **Position**, from an encoder. Servo operation depends on it.
- **Motor electrical angle**, computed internally by the drive.

3.6.2 DC BRUSHED MOTORS

A DC brushed motor is electrically simpler: commutation occurs mechanically through the brushes, so no rotor-angle computation or three-phase management is required. The SOLO PRO 60-160 applies the same nested torque-speed-position cascade with a single control channel rather than three, as shown in Figure 5. As with three-phase motors, adding an incremental encoder enables closed-loop position (servo) control, and the tuning procedure is identical apart from minor differences in the processing.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

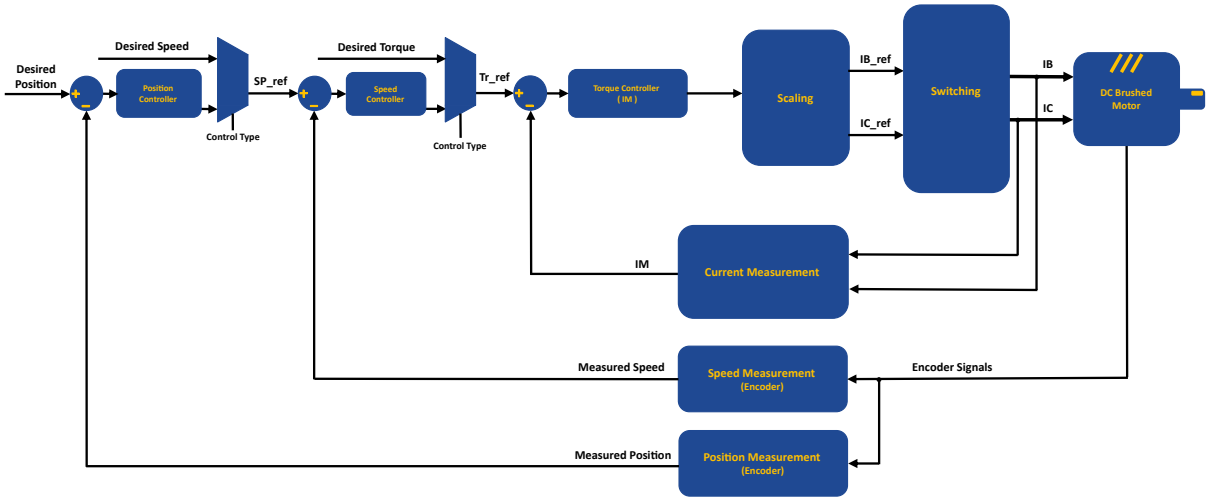


Figure 5. Control architecture of the SOLO PRO 60-160 for DC brushed motors (single torque-speed-position cascade).

3.6.3 SENSORLESS CONTROL

The drive can also run a three-phase motor **without a position sensor**. Instead of reading the rotor angle from an encoder or Hall sensors, the Motion Core estimates it in real time from the motor's own electrical behaviour: the measured phase currents and the applied voltages. This removes the encoder, its cable and its connector from the system, lowering cost and eliminating a common point of failure. It suits fans, pumps, compressors and similar applications.

Sensorless estimation is inherently weak at very low speed, where the signals the estimator relies on become small. For the high-speed end, SOLO provides a dedicated **High-Speed Observer (HSO)** method, optimized to keep the angle estimate accurate and stable as the electrical frequency rises, the regime where high-pole-count or high-RPM motors operate.

> **i NOTE:** Sensorless and sensored operation use the same FOC structure; only the source of the rotor angle differs. A position sensor is still required where holding torque at zero speed, or absolute position knowledge at power-up, is needed.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

3.7 ORDERING AND PART NUMBERS

Field	Value
Product part number	SLSGB002PW2000
Power range	8–60 VDC, 130 ADC / 92 Arms continuous, 6000 W
DSP	TMS320F28388DZWTS (dual-core, carried on the on-board SOM)
Motor output terminals — sections [3], [5], [7]	Würth Elektronik mating part 5580516
Supply terminals — sections [16], [17]	Würth Elektronik mating part 5580516
Encoder connectors — sections [4] J7, [6] J5	Molex mating part 2132271611
Communication / GPIO connectors — sections [11] J6, [12] J8	Molex mating part 2132271271
Brake chopper / STO connectors — sections [9] J8, [10] J9	Molex mating part 1053081212
JTAG connector — internal	SM12B-SURS-TF (JST), 12-pin, 1.0 mm pitch
USB port — section [2]	USB 2.0 Type-C

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

4. USER CORE — OPEN ACCESS

This chapter is **optional reading**. The SOLO PRO 60-160 is a complete drive without it: if the application commands the drive over the analogue inputs, USB, CANopen or EtherCAT, there is nothing here that needs to be configured or programmed. The chapter is for users who want to run their own code *inside* the drive instead of adding an external microcontroller beside it.

4.1 WHAT THE USER CORE IS

The drive's DSP has two independent 200 MHz CPUs. The first, the **Motion Core**, runs SOLO's motor-control firmware and is not user-modifiable. The second, the **User Core**, is left completely free, with its own Control Law Accelerator, and can be programmed by the user.

Core	Function	Clock	Firmware
Motion Core	Motor control, EtherCAT, CANopen, encoder handling, protections	200 MHz	Programmed and maintained by SOLO; not user-modifiable
User Core	User application	200 MHz	Fully open, with no locked regions or licensing restrictions

Typical uses are supervisory logic, an application-specific state machine, custom command handling, or data processing that would otherwise need a separate microcontroller alongside the drive, saving that device, its board space and its toolchain.

The two cores share a block of RAM and a set of interrupt flags inside the DSP, forming the **Inter-Processor Communication (IPC)** channel. Through it, User Core code reads every Motion Core value (commanded and measured torque, speed and position, and the current feedback) and issues commands back, with under 1 µs of latency and no external wiring.

4.2 PROGRAMMING THE USER CORE

The User Core is reached through the JTAG connector inside the enclosure, a 12-pin **SM12B-SURS-TF** (JST, 1.0 mm pitch) header carrying TDI, TDO, TMS, TCK, TRST and the device reset XRS. It works with the TI XDS100V2, XDS110 and XDS200 probes, and with the general-purpose JTAG programmer offered by SOLO. Figure 6 shows the connection.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

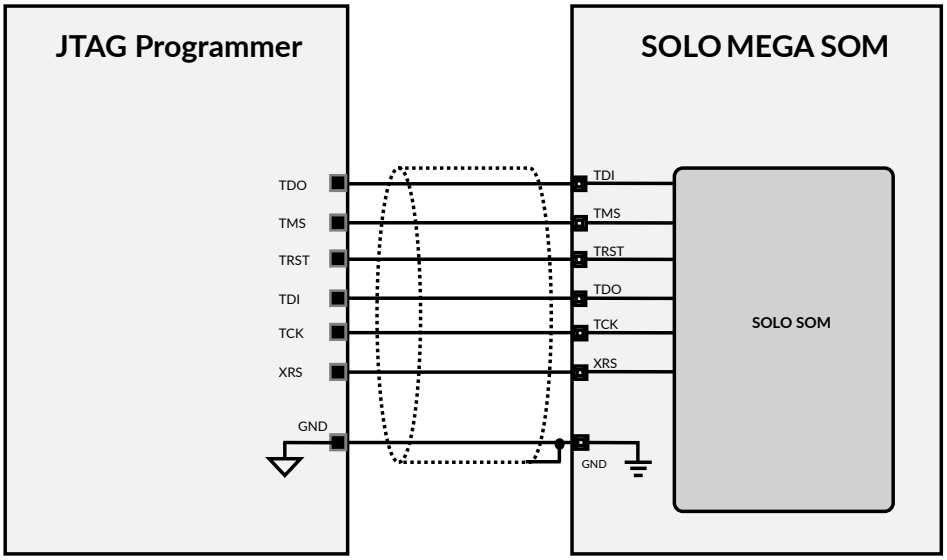


Figure 6. JTAG wiring of the SOLO PRO 60-160 to an external debug probe.

Code can be written in C with the Texas Instruments C2000 tools, **Code Composer Studio** and **C2000Ware**, both available at no cost from ti.com. It can equally be generated from a model in **MATLAB/Simulink** using the Embedded Coder Support Package for Texas Instruments C2000 Processors, which builds the model and loads it through the same JTAG probe.

> **NOTE:** The JTAG connector reaches only the User Core. The Motion Core is locked: its firmware is supplied and supported by SOLO and cannot be modified. No access to it is needed, because the user interacts with it through the SOLO Motion Terminal, the communication interfaces and the IPC channel.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

5. TECHNICAL SPECIFICATIONS

The following tables specify the values required to design a system around the drive and to verify operation within the rated limits. Where additional explanation is warranted, it is given in the accompanying text.

5.1 POWER

Description	Units	Value
DC supply voltage range (continuous)	VDC	8 to 60
Active brake chopper activation voltage (default)	VDC	61
Software over-voltage activation voltage	VDC	63
Hardware over-voltage activation voltage	VDC	66.4
DC bus under-voltage limit	VDC	7
Maximum continuous output current	ADC	130
Maximum continuous output current	Arms	92
Maximum continuous output power	W	6000
Internal bus capacitance	µF	4700
Switching frequency (output PWM frequency)	kHz	8 to 80
+5V_OUT1 auxiliary output	—	+5 V, 1 A (5 W)
+5V_OUT_P / +5V_OUT_S encoder supplies	—	+5 V, 200 mA each
Sleep-mode current consumption	mA	≈ 2.6

The four voltage thresholds above form a graded response to a rising DC bus. The **brake chopper** engages first, at approximately 61 V, and dissipates returned energy in the external brake resistor. If the bus keeps rising, the **software** over-voltage protection trips at 63 V and the firmware disables the output and reports the fault. The **hardware** over-voltage protection at 66.4 V is the last line of defence and acts independently of firmware. The **absolute maximum** at the supply terminals is +66 V (Section 5.5). Because the margin between the nominal 60 V maximum supply and these thresholds is narrow, size the brake resistor for the worst-case regeneration of the application (Section 12).

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

The switching frequency is selectable from 8 kHz to 80 kHz. A higher frequency reduces current ripple and audible noise but increases switching losses in the power stage. Choose it from the motor's electrical time constant and the thermal budget of the installation.

5.2 CONTROL AND TIMING

Description	Units	Value
Analogue speed / torque command	VDC	0–10 V analogue, or a PWM input above 5 kHz
Digital direction control (GPI/O)	VDC	0–3.3 / 5
Modes of operation	—	Torque, speed, position
Motors supported	—	DC brushed, BLDC, PMSM, EC coreless
Protections	—	Bus over-voltage, bus under-voltage, over-current, over-temperature
Current (torque) loop sampling time	µs	Synchronized to PWM frequency (7 µs minimum)
Current (torque) loop execution time	µs	7
Speed loop sampling time	µs	500
Speed loop execution time	µs	75
Position loop sampling time	µs	500
Position loop execution time	µs	75
Maximum encoder frequency — incremental	MHz	10
Encoder clock frequency — absolute (BiSS-C)	MHz	2 (min) to 8 (max)
Current measurement resolution	mA	80
Modulation	—	Space Vector Modulation (SVM)
Motion profiling	—	Embedded S-curve for position and speed

The loop timing reflects the cascade of Section 3.6: the torque loop samples in step with the PWM and completes in 7 µs, giving an FOC loop rate up to approximately 140 kHz, while the speed and position loops run every 500 µs (2 kHz) and each execute in 75 µs.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

5.3 THERMAL & ENVIRONMENTAL

Description	Units	Value
Board temperature range	°C	-20 to +120
Heatsink (base) temperature range	°C	-20 to +85
Cooling system	—	Natural convection
Ingress protection (IP)	—	Enclosed assembly; contact SOLO for the rating

The drive is cooled by natural convection through its integrated heatsink. The ratings above are the limits at the board and at the heatsink base respectively. The two figures are not interchangeable: the board tolerates up to 120 °C, but the heatsink base must remain at or below 85 °C, and it is the heatsink temperature that governs how much continuous current the unit can deliver in a given enclosure. Provide sufficient free air around the heatsink, or add forced-air cooling, so that the base temperature stays within range at the intended duty.

5.4 MECHANICAL

Description	Units	Value
Size (H × W × D)	mm	47.6 × 154 × 94
Body height, excluding top connectors	mm	41
Heatsink height	mm	20
Mounting hole pitch	mm	146 × 86
Mounting holes	—	4 × Ø4.4 through
Weight (enclosed, with heatsink)	g	Contact SOLO
Form factor	—	Wall mount, enclosed

5.5 ABSOLUTE MAXIMUM VOLTAGE RATINGS

This table specifies, for each section and pin group, the maximum voltage that may be applied. The section numbers refer to Figure 1.

Two columns require careful interpretation. **Typical Max** is the maximum continuous voltage permitted at the pin in normal operation. Design to this value. **Absolute Max** is a short-transient limit that bounds voltage spikes and switching noise lasting microseconds. It is not

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

a level to be applied intentionally. Designing to the Absolute Max value will result in eventual damage to the drive.

> ⚠ **WARNING:** Design the installation against the **Typical Max** column. The **Absolute Max** column bounds brief transients only. Continuously exceeding Typical Max will permanently damage the unit.
>
> ⚠ **WARNING:** The 3.3 V pins are not 5 V tolerant. Applying more than 3.3 V to PTC+, PTC– or DFU1 can permanently damage the device.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Section	Pin / Signal	Dir	Units	Min	Typical Max	Absolute Max
[16], [17]	Supply input	Input	VDC	+8	+60	+66
[10]	Sleep	Input	VDC	0	+60	+60
[4]	SinCosA+/-, SinCosB+/-	Input	VDC	0	+4.5	+5
[11]	PTC+ / PTC-	Input	VDC	0	+3.3	+3.75
[11]	DFU1	Input	VDC	0	+3.3	+3.75
[11]	AI1_IN, AI2_IN	Input	VDC	0	+10	+10.5
[10]	STO1+ / STO1- (Safe Torque Off input 1)	Input	VDC	0	+5	+5.25
[10]	STO2+ / STO2- (Safe Torque Off input 2)	Input	VDC	0	+5	+5.25
[4], [6], [11], [12]	+5V_OUT1 (auxiliary supply)	Output	VDC	+4.95	+5.0	+5.05
[10]	+5V (auxiliary supply)	Output	VDC	+4.95	+5.0	+5.05
[6]	HA, HB, HC	Input	VDC	0	+5	+5.5
[6]	C+_S, C-_S, D+_S, D-_S (secondary BiSS-C)	Input	VDC	0	+12	+12.25
[6]	C+_P, C-_P, D+_P, D-_P (primary BiSS-C)	Input	VDC	0	+12	+12.25
[4]	CHA±, CHB±, CHC± (differential incremental)	Input	VDC	0	+12	+12.25
[4]	1CHA, 1CHB, 1CHC (single-ended encoder 1)	Input	VDC	0	+5	+5.5
[11]	2CHA, 2CHB, 2CHC (single-ended encoder 2)	Input	VDC	0	+5	+5.5
[11]	CANH	—	VDC	-2	—	+7
[11]	CANL	—	VDC	-2	—	+7
[12]	GPI/O1-GPI/O4	In/Out	VDC	0	+5.0	+5.5
[12]	GPI/O5-GPI/O8	In/Out	VDC	0	+5.0	+5.5

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

5.6 PROCESSING AND MEMORY

Parameter	Value	Notes
DSP	TMS320F28388D (ZWT package)	Dual-core C28x with two CLAs
CPU1 / CPU2 clock	200 MHz each	—
CLA clock	200 MHz	One CLA per core
SDRAM	16 MB / 128 Mbit	Used internally by the firmware
PWM switching frequency	8 kHz to 80 kHz	Selectable; see Section 5.1
IPC latency (CPU1 ↔ CPU2)	< 1 µs	Through shared RAM
CAN data rate	Up to 1 Mbit/s	Classical CAN with the CANopen layer
EtherCAT PHY data rate	100 Mbit/s	DP83822, 100BASE-TX
EtherCAT cycle time	≥ 125 µs	Dependent on network configuration

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

6. MECHANICAL INTEGRATION

6.1 DIMENSIONS AND MOUNTING

The SOLO PRO 60-160 is a wall-mount assembly in a machined aluminium enclosure with an integrated finned heatsink, measuring 47.6 × 154 × 94 mm overall. It mounts on four Ø4.4 mm through-holes on a 146 × 86 mm pitch. The fully dimensioned drawing is given in Figure 7. All dimensions are in millimetres. Use it to lay out the mounting points, the cable entries and the keep-out zones in the enclosure.

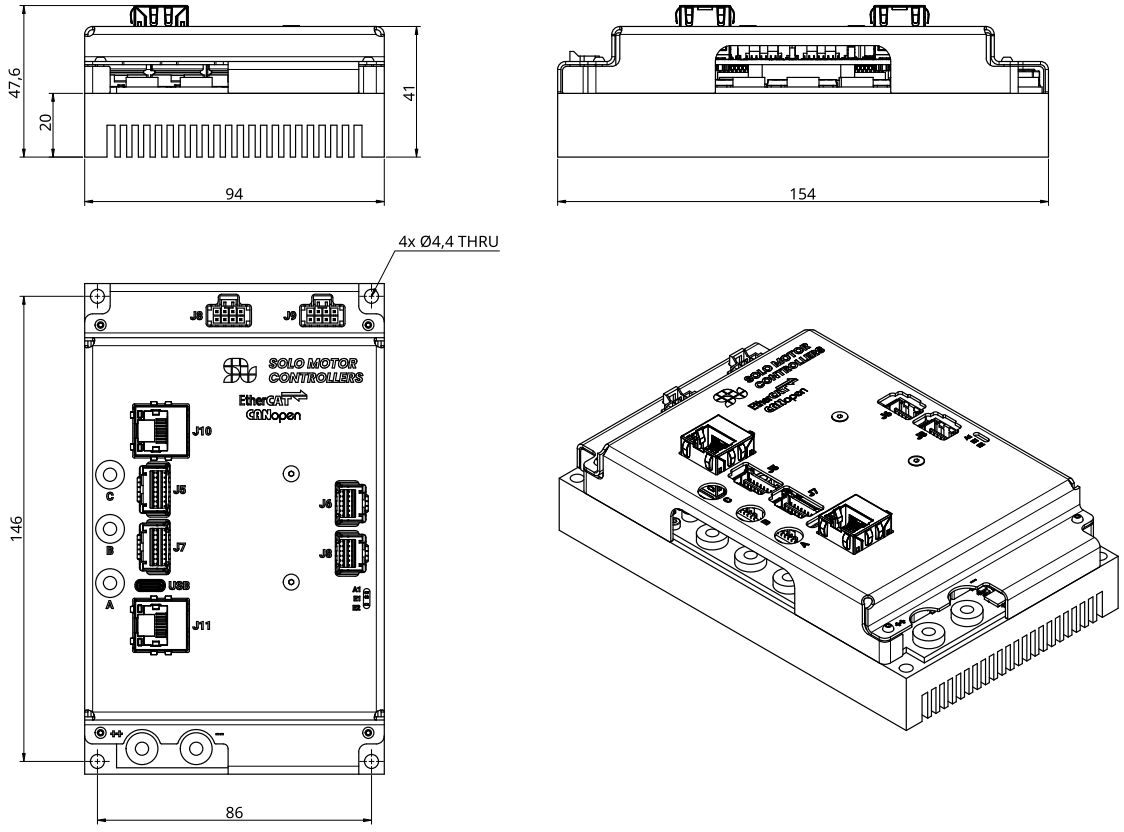


Figure 7. SOLO PRO 60-160 mechanical dimensions — all dimensions in millimetres.

Mount the unit so that the heatsink fins run vertically and are not obstructed, since the unit relies on natural convection. Support the assembly at all its mounting points: the mass is enough to load the connectors and the board if the unit is held only at one end in a vibrating installation.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

6.2 THERMAL CONSIDERATIONS

The continuous current the drive can deliver in a given installation is limited by the heatsink base temperature, not by the board rating. Keep the base at or below 85 °C at the intended duty cycle and ambient temperature, allowing for the switching frequency in use. Losses in the power stage rise with switching frequency, so a design running at 80 kHz needs more thermal headroom than the same design at 8 kHz.

> ⚠ **CAUTION:** The heatsink reaches temperatures that can cause burns. Allow the unit to cool before handling it after operation.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7. CONNECTORS, SECTIONS & PINOUT

7.1 CONNECTOR ORGANIZATION

This chapter is the primary reference for wiring the drive. Each of the 17 sections of Figure 1 is described in turn, with its pinout where it is a multi-pin connector. The mating part numbers for every connector are collected in Section 7.13.

Section(s)	Designator	Content
[3], [5], [7]	A, B, C	Motor output terminals
[16], [17]	+, -	DC supply input terminals
[1], [8]	—	EtherCAT ports (PHY1, PHY0)
[2]	—	USB 2.0 Type-C port
[4]	J7	Encoder connector — differential incremental, Sin/Cos, single-ended encoder 1
[6]	J5	Absolute (BiSS-C primary and secondary) and Hall encoder connector
[11]	J6	Communication and analogue connector — CAN, analogue inputs, PT1000, DFU1, single-ended encoder 2
[12]	J8	GPIO connector — GPI/O1–8, E1 and E2 outputs
[10]	J9	STO and Sleep connector
[9]	J8	Active brake chopper connector
—	—	JTAG connector, inside the enclosure (User Core debug)
[13], [11], [12]	A1, E1, E2	Indicator LEDs (Section 14)

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.2 SECTIONS [3, 5, 7] — MOTOR OUTPUTS

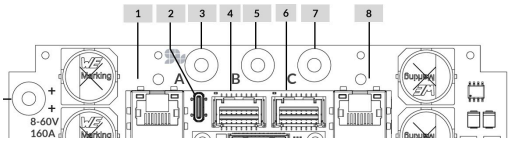


Figure 8. Sections [3], [5], [7] — motor output terminals A, B and C.

Name	Description / Notes	I/O
A	Motor output 1	—
B	Motor output 2	—
C	Motor output 3	—

These terminals connect to the motor windings:

- **Three-phase motors (BLDC, PMSM).** Connect pins A, B and C to the three motor phase wires.
- **DC brushed motors.** Only B and C are used. Connect them to the two motor leads.

> ⚠ **WARNING:** Never connect a power supply cable to a motor output. This will cause serious damage to the unit.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.3 SECTIONS [20, 21] — SUPPLY INPUTS

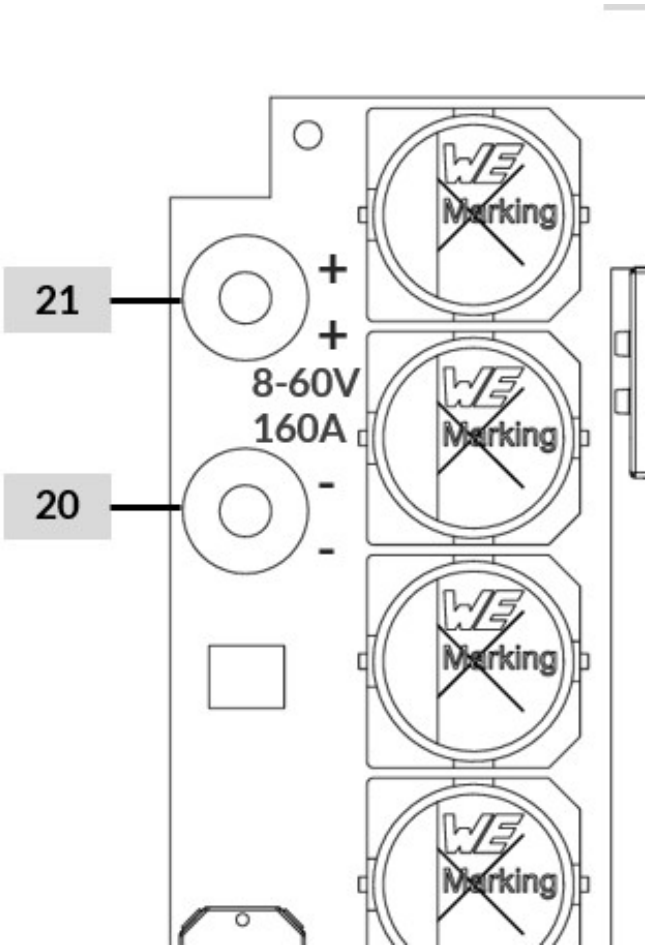


Figure 9. Sections [16], [17] — DC supply input terminals.

Name	Description / Notes	I/O
+++	Positive voltage input	—
- - -	Negative voltage input (ground)	—

The supply input accepts 8 to 60 VDC continuously, chosen to suit the voltage rating of the connected motor. The maximum rated input is 60 V. The drive enters over-voltage protection if the supply or bus voltage exceeds approximately 61 V, which is also where the brake chopper

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

engages by default. To move that threshold, see Section 12.3.

Fit a fuse in the positive supply line, rated for the current the application draws and for the prospective fault current of the supply. Every complete wiring example in Section 15 shows this fuse.

> ⚠ **WARNING:** The SOLO PRO 60-160 has no reverse-polarity protection. Verify the polarity of the supply before switching it on; connecting it in reverse will destroy the unit.

7.4 SECTIONS [1, 8] — ETHERCAT PORTS

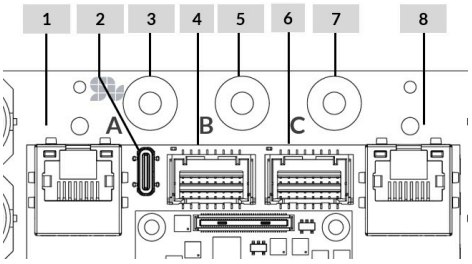


Figure 10. Sections [1], [8] — the two EtherCAT ports.

Section	Name	Description / Notes	I/O
[1]	EtherCAT PHY1	EtherCAT port 1 — TD+, TD–, RD+, RD–	—
[8]	EtherCAT PHY0	EtherCAT port 0 — TD+, TD–, RD+, RD–	—

Two **DP83822** 100BASE-TX PHYs are connected to the EtherCAT Slave Controller inside the DSP, and their transmit and receive pairs are brought out at these two sections. Having two ports allows drives to be daisy-chained: data enters one port, passes through the node and leaves by the other, with no external switch. Section 8.1 gives the routing and isolation requirements.

7.5 SECTION [2] — USB 2.0 TYPE-C

The port is section **[2]** in Figure 1, between the EtherCAT port J11 and motor terminal A.

Name	Description / Notes	I/O
USB	Virtual COM port, or device firmware upgrade	—

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

This USB 2.0 Type-C port carries digital command and feedback packets and is also the path for firmware updates. In digital mode the port presents itself to the host as a Virtual COM Port (VCP), which allows the drive to be operated in standalone digital control mode over a single USB cable, with only the motor connected to the output.

Parameter	Value
USB standard	USB 2.0 Full-Speed
Connector	USB Type-C (reversible orientation)
Modes	Virtual COM Port for the SOLO Motion Terminal; DFU for firmware updates
Maximum recommended cable length	3 m
Power	The USB cable does not power the drive; the external 8–60 VDC supply is always required

> ⚠ **CAUTION:** The drive must be powered from its external DC supply (8–60 V) whenever it is connected to a host over USB. The USB cable supplies no power to the unit.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.6 SECTION [4] J7 — ENCODER CONNECTOR

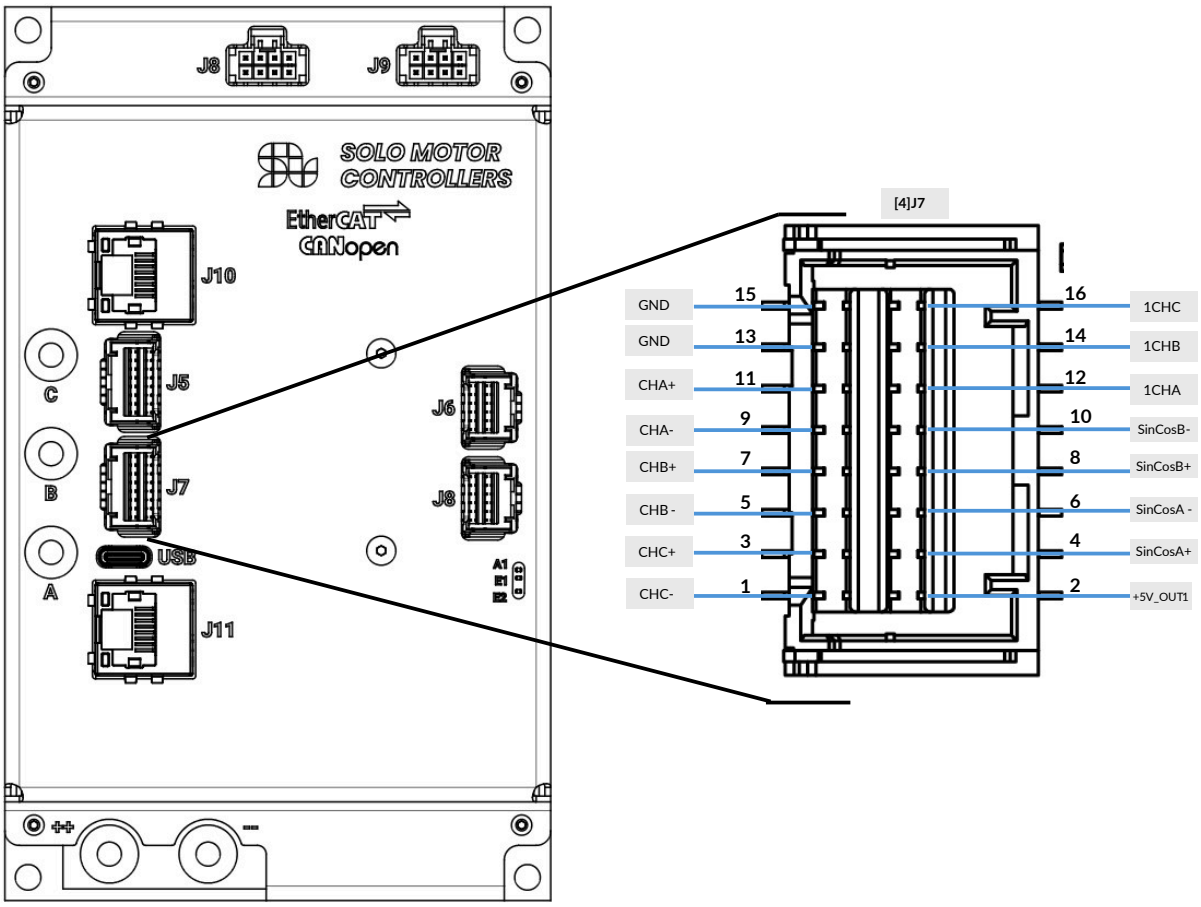


Figure 11. Section [4], connector J7 — encoder connector.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Pin	Name	Description / Notes	I/O
1	CHC-	Differential incremental encoder, index C-	I
2	+5V_OUT1	+5 V / 1 A auxiliary output for the encoder	—
3	CHC+	Differential incremental encoder, index C+	I
4	SinCosA+	Sin/Cos encoder, Sin+	I
5	CHB-	Differential incremental encoder, channel B-	I
6	SinCosA-	Sin/Cos encoder, Sin-	I
7	CHB+	Differential incremental encoder, channel B+	I
8	SinCosB+	Sin/Cos encoder, Cos+	I
9	CHA-	Differential incremental encoder, channel A-	I
10	SinCosB-	Sin/Cos encoder, Cos-	I
11	CHA+	Differential incremental encoder, channel A+	I
12	1CHA	Single-ended encoder 1, channel A	I
13	GND	Ground	—
14	1CHB	Single-ended encoder 1, channel B	I
15	GND	Ground	—
16	1CHC	Single-ended encoder 1, index C	I

This connector accepts three encoder families on one housing: **differential incremental** (CHA±, CHB±, CHC±), **Sin/Cos** (SinCosA±, SinCosB±) and **single-ended incremental channel 1** (1CHA, 1CHB, 1CHC). Section 9 gives the wiring for each.

The GND pins are the ground and analogue return reference of the drive. When sending analogue commands, the ground of the commanding device (PLC, Arduino, Raspberry Pi or similar) must be connected to this point, so that both ends share a reference for the analogue voltage.

+5V_OUT1 is a +5 V / 1 A (5 W) output for supplying an encoder or another external peripheral.

> **i NOTE:** For three-phase motors the index signal (channel C) is **mandatory**, because the firmware uses it during the one-time encoder calibration that aligns the encoder count with the rotor magnetic position. DC brushed motors do not require the index pulse.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.7 SECTION [6] J5 — ABSOLUTE AND HALL ENCODER CONNECTOR

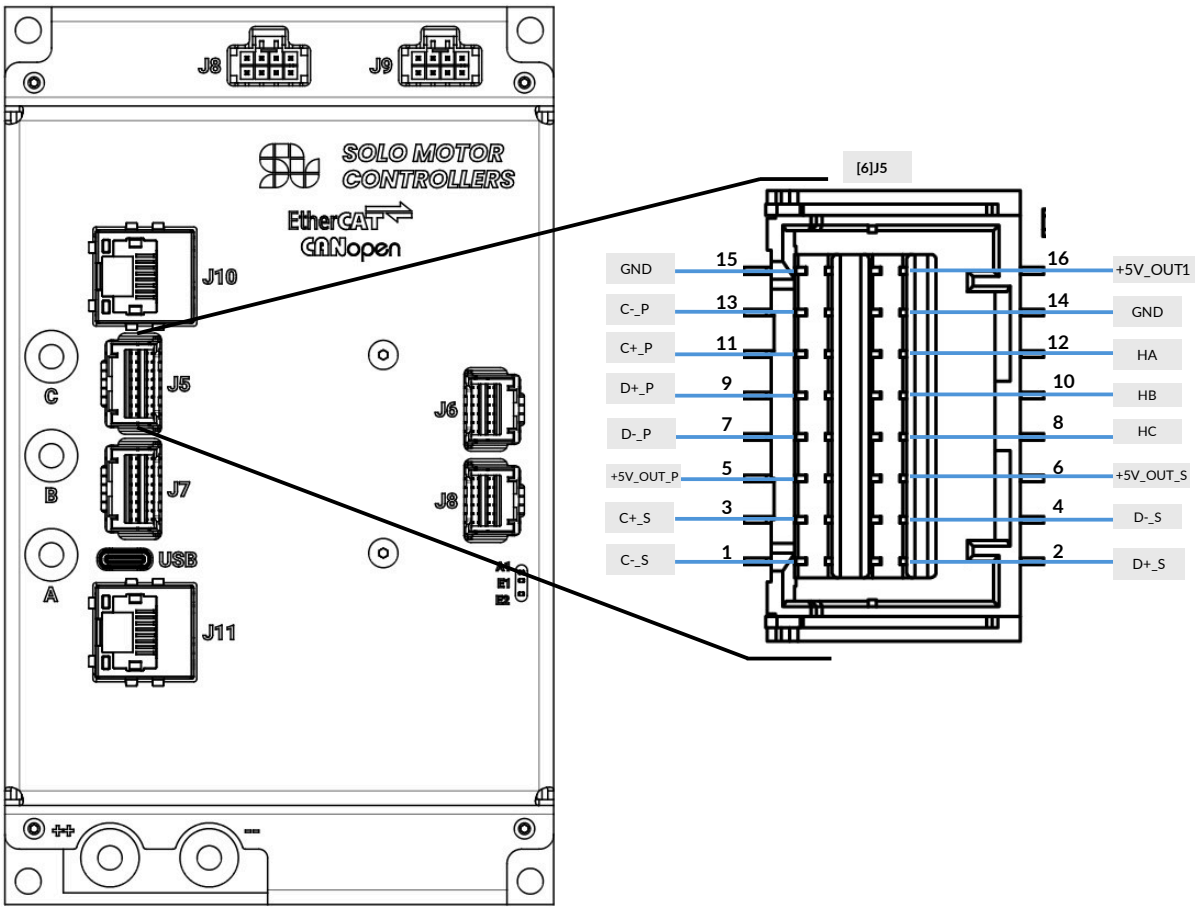


Figure 12. Section [6], connector J5 — absolute (BiSS-C) and Hall encoder connector.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Pin	Name	Description / Notes	I/O
1	C-_S	Secondary BiSS-C clock -	O
2	D+_S	Secondary BiSS-C data +	I
3	C+_S	Secondary BiSS-C clock +	O
4	D-_S	Secondary BiSS-C data -	I
5	+5V_OUT_S	+5 V / 200 mA output for the secondary absolute encoder	—
6	+5V_OUT_P	+5 V / 200 mA output for the primary absolute encoder	—
7	D-_P	Primary BiSS-C data -	I
8	HC	Hall sensor / encoder channel C	I
9	D+_P	Primary BiSS-C data +	I
10	HB	Hall sensor / encoder channel B	I
11	C+_P	Primary BiSS-C clock +	O
12	HA	Hall sensor / encoder channel A	I
13	C-_P	Primary BiSS-C clock -	O
14	GND	Ground	—
15	GND	Ground	—
16	+5V_OUT1	+5 V / 1 A auxiliary output for the Hall sensors	—

This connector serves the absolute encoders and the Hall sensors. It accepts primary and secondary differential absolute-encoder signals at +3.3 V or +5 V levels, and provides two dedicated +5 V / 200 mA supplies for the absolute encoders plus the +5 V / 1 A auxiliary output for Hall sensors.

> ⚠ **CAUTION:** Use the +5 V outputs only to supply the encoder or the Hall position sensors. Do not use them for other peripherals.
>
> ℹ **NOTE:** Limit the absolute-encoder or Hall-sensor cable to 3 m, and bond the cable shield to ground to improve immunity against external EMI.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.8 SECTION [11] J6 — COMMUNICATION AND ANALOGUE CONNECTOR

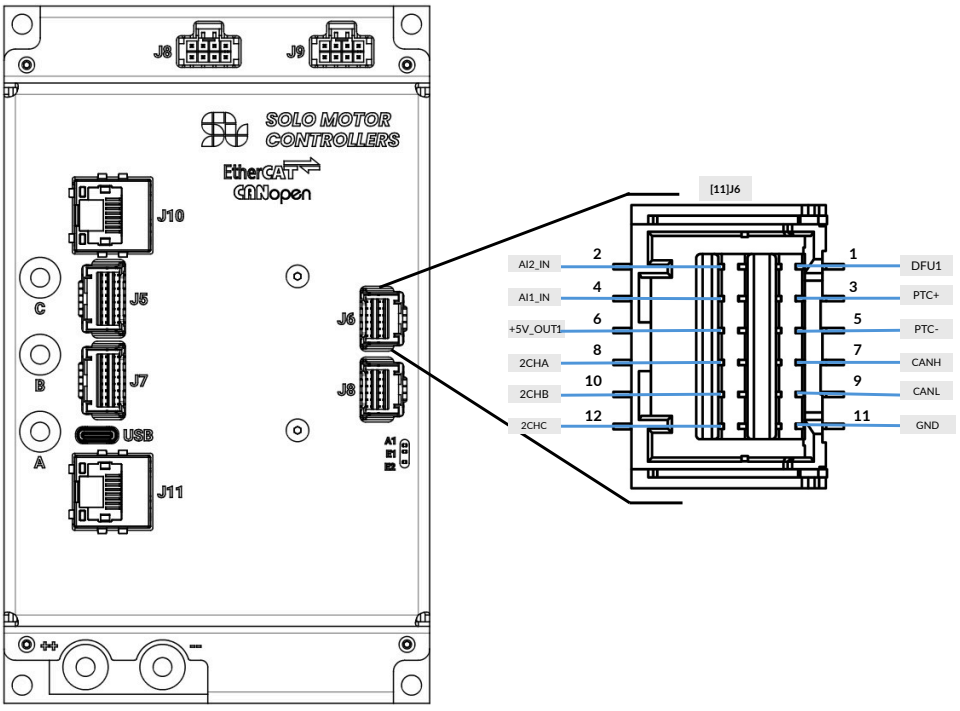


Figure 13. Section [11], connector J6 — communication and analogue connector.

Pin	Name	Description / Notes	I/O
1	DFU1	Firmware-upgrade mode is selected by pulling this pin up (Section 13.2)	I
2	AI2_IN	Analogue input 2, 0–10 V range	I
3	PTC+	PT1000 temperature sensor input +	I
4	AI1_IN	Analogue input 1, 0–10 V range	I
5	PTC–	PT1000 temperature sensor input –	I
6	+5V_OUT1	+5 V / 1 A auxiliary output	—
7	CANH	CAN bus high (ISO 11898)	—
8	2CHA	Single-ended encoder 2, channel A	I
9	CANL	CAN bus low (ISO 11898)	—
10	2CHB	Single-ended encoder 2, channel B	I
11	GND	Ground	—
12	2CHC	Single-ended encoder 2, index C	I

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

This connector gathers the CAN bus, the two analogue command inputs, the PT1000 temperature-sensor input, the DFU1 forced-boot input and the second single-ended encoder channel. The analogue inputs are described in Section 10.2, the PT1000 input in Section 9.6, the CAN bus in Section 8.2 and DFU1 in Section 13.2.

> ⚠ **WARNING:** PTC+, PTC– and DFU1 are 3.3 V inputs with an absolute maximum of +3.75 V. Do not connect them to a 5 V source. DFU1 is driven through a 27 kΩ resistor from +5V_OUT1, which places the pin at approximately 3.3 V (Section 13.2).

7.9 SECTION [12] J8 — GPIO CONNECTOR

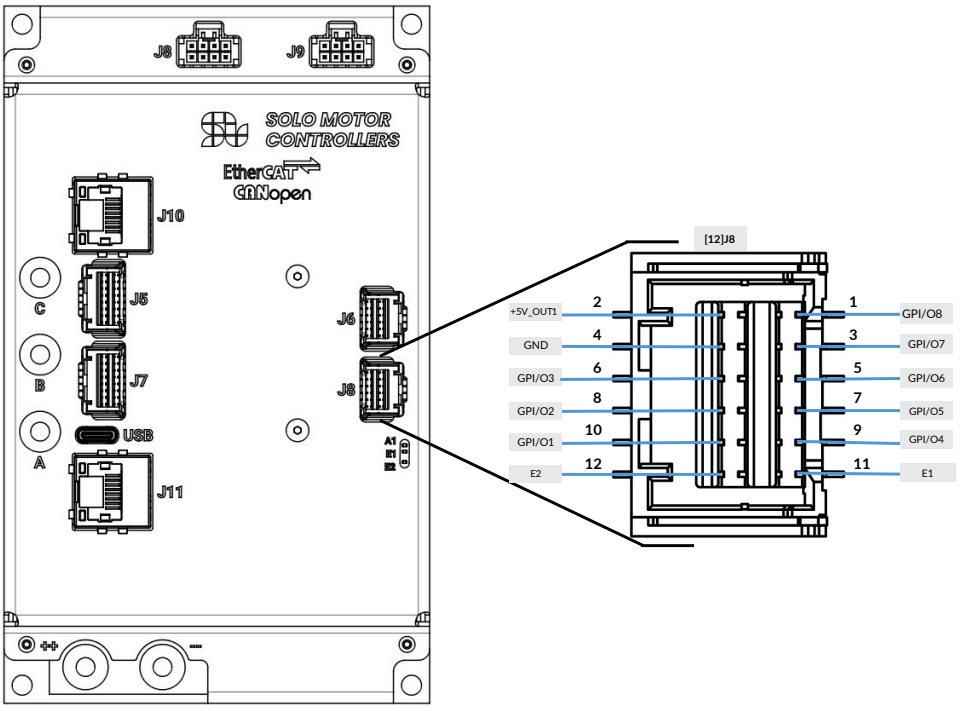


Figure 14. Section [12], connector J8 — GPIO connector.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Pin	Name	Description / Notes	I/O
1	GPI/O8	General-purpose I/O 8	I/O
2	+5V_OUT1	+5 V / 1 A auxiliary output	—
3	GPI/O7	General-purpose I/O 7	I/O
4	GND	Ground	—
5	GPI/O6	General-purpose I/O 6	I/O
6	GPI/O5	General-purpose I/O 5	I/O
7	GPI/O4	General-purpose I/O 4	I/O
8	GPI/O3	General-purpose I/O 3	I/O
9	GPI/O2	General-purpose I/O 2	I/O
10	GPI/O1	General-purpose I/O 1	I/O
11	E1	Error indicator output; mirrors the E1 LED on the board	O
12	E2	Heartbeat indicator output; mirrors the E2 LED on the board	O

Each GPI/O pin has an internal **3.3 kΩ pull-down** resistor, so an unconnected input reads as a low level and no external pull-down is required. The maximum input voltage is **5 V**.

The E1 and E2 outputs repeat the state of the corresponding board LEDs, which allows the error and heartbeat indications to be mirrored on an enclosure front panel. Drive each panel LED through a current-limiting resistor.

> ⚠ **CAUTION:** A general-purpose output can source a maximum of **10 mA**. Exceeding this will damage the unit. To switch a heavier load such as a relay, a solenoid or a valve, use the output to drive a transistor, as shown in Section 10.7.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.10 SECTION [10] J9 — STO AND SLEEP CONNECTOR

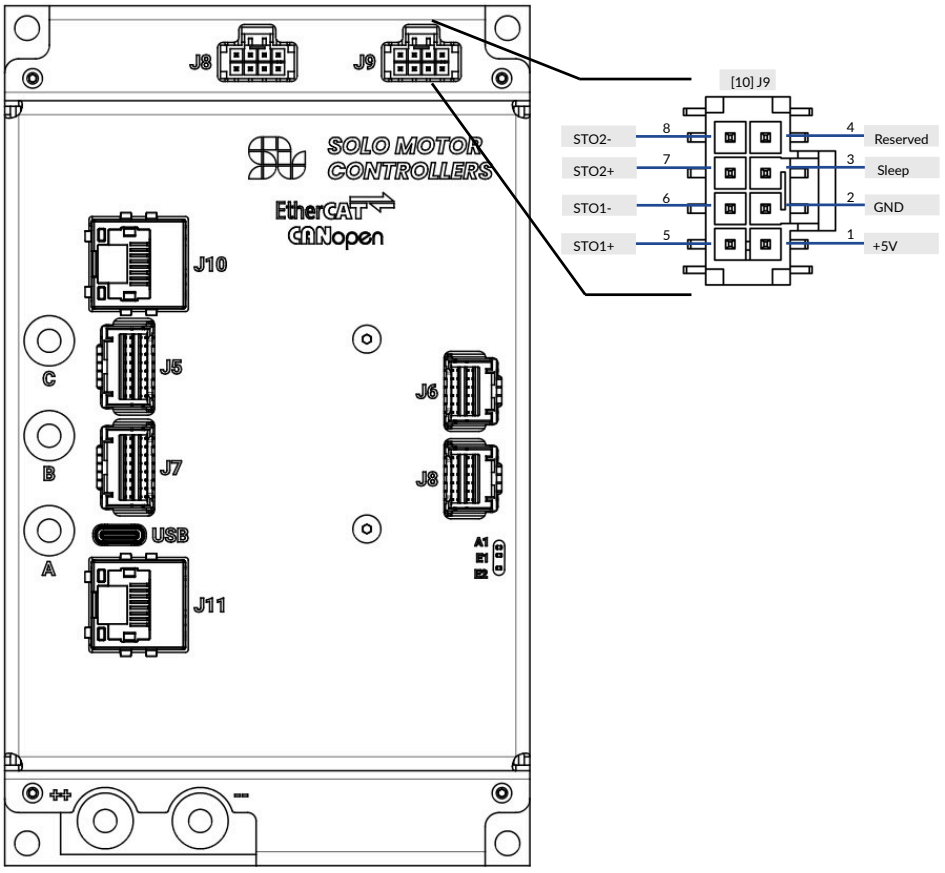


Figure 15. Section [10], connector J9 — STO and Sleep connector.

Pin	Name	Description / Notes	I/O
1	+5V	+5 V / 1 A auxiliary supply output	O
2	GND	Ground of the drive	—
3	Sleep	Sleep mode input (Section 13.1)	I
4	Reserved	Reserved for future purposes	—
5	STO1+	STO channel 1 positive input (optically isolated)	I
6	STO1–	STO channel 1 negative input (optically isolated)	I
7	STO2+	STO channel 2 positive input (optically isolated)	I
8	STO2–	STO channel 2 negative input (optically isolated)	I

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Safe Torque Off is a hardware-level protection that removes the torque-producing energy from the motor, letting it stop under its own natural time constant. The function and its three wiring options are described in Section 11.

> ⚠ **WARNING:** Wiring the STO inputs is mandatory for normal operation of the SOLO PRO 60-160. Leave pin 4 unconnected.

7.11 SECTION [9] J8 — ACTIVE BRAKE CHOPPER CONNECTOR

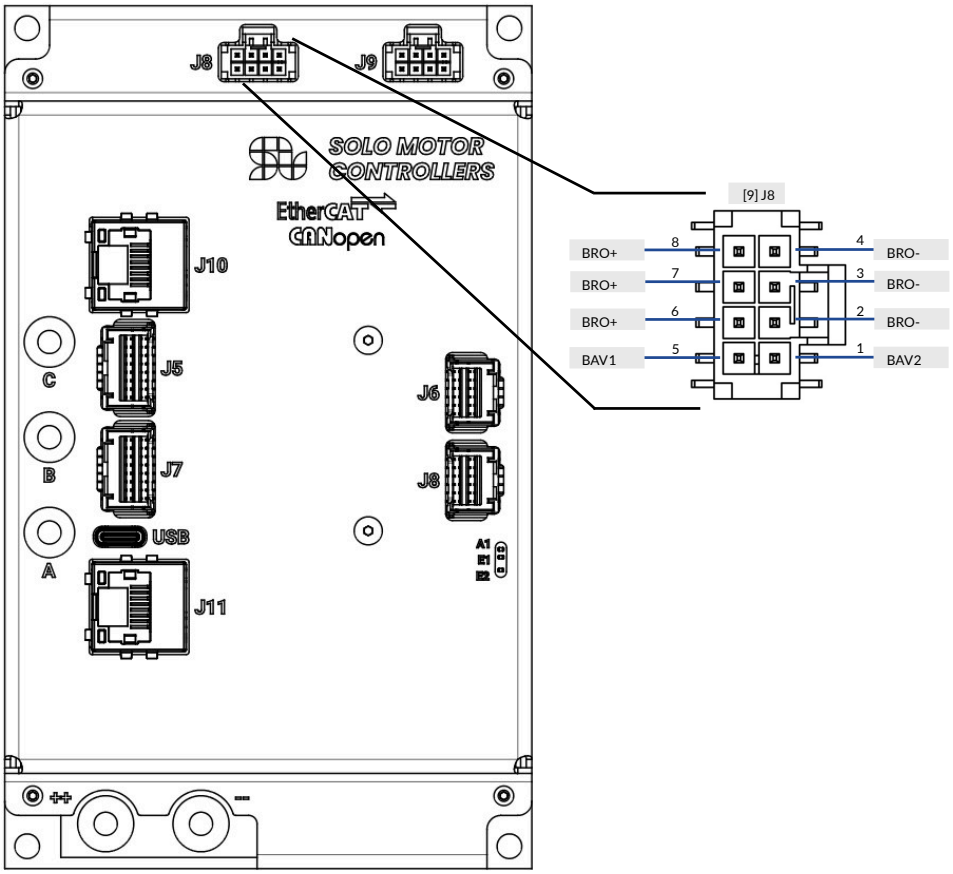


Figure 16. Section [9], connector J8 — active brake chopper connector.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Pin	Name	Description / Notes	I/O
1	BAV2	Brake activation voltage — external resistor input 2	I
2	BRO-	Brake chopper negative output	O
3	BRO-	Brake chopper negative output	O
4	BRO-	Brake chopper negative output	O
5	BAV1	Brake activation voltage — external resistor input 1	I
6	BRO+	Brake chopper positive output	O
7	BRO+	Brake chopper positive output	O
8	BRO+	Brake chopper positive output	O

The brake resistor connects across BRO+ and BRO–. Three pins are provided for each polarity and all three should be used, so that the braking current is shared between contacts rather than carried by a single one. The activation threshold is set by a resistor across BAV1 and BAV2. Section 12 covers the function, the resistor selection and the threshold calculation.

7.12 JTAG CONNECTOR

The JTAG header is **inside the enclosure**, on the control module, and carries no section number. Figure 6 shows its wiring.

Name	Description / Notes	I/O
JTAG	On-board JTAG connector for debugging with a standard TI probe	—

This 12-pin single-row connector (**SM12B-SURS-TF**, JST, 1.0 mm pitch) gives a standard TI debug probe direct access to the DSP for loading and debugging User Core code. It carries TDI, TDO, TMS, TCK, TRST and the device reset XRS, and is compatible with the TI XDS100V2, XDS110 and XDS200 probes. SOLO also offers a general-purpose JTAG programmer for faster bring-up. See Section 4.2 for the wiring.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

7.13 MATING CONNECTOR PART NUMBERS

Section	Manufacturer	Mating part number
[4], [6]	Molex	2132271611
[11], [12]	Molex	2132271271
[9], [10]	Molex	1053081212
[3], [5], [7], [16], [17]	Würth Elektronik	5580516

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

8. NETWORKING & COMMUNICATIONS

All the functionality of the SOLO PRO 60-160 can be controlled digitally by exchanging data packets over **USB**, **CAN bus** (using the CANopen protocol) or **EtherCAT**. The CAN transceiver and both EtherCAT PHYs are integrated in the unit. No external transceiver circuitry is required.

8.1 ETHERCAT

EtherCAT is a high-speed industrial bus used to connect a controller, usually a PLC or an industrial PC acting as the master, to a series of drives. Its principal characteristic is deterministic timing: every node is updated within the same cycle, which keeps multiple axes synchronized. The SOLO PRO 60-160 implements the **DS402** device profile over EtherCAT.

Two **DP83822** 100BASE-TX PHYs are connected to the EtherCAT Slave Controller within the DSP, and the two ports (PHY0 at section [8] and PHY1 at section [1]) allow drives to be daisy-chained without an external switch.

The Ethernet signals are high-speed differential pairs and must be treated as controlled-impedance transmission lines. Otherwise the data is corrupted between the drive and the network connector. When bringing them out to a connector:

- Route the transmit and receive pairs (TD+/TD–, RD+/RD–) as **100 Ω differential** pairs, with each trace **50 Ω single-ended** to ground.
- Provide galvanic isolation between the EtherCAT cabling and the drive by placing an isolating LAN transformer in each port's signal path. This isolation is mandatory: it protects the unit from cable-borne surges and breaks ground loops between nodes at different ground potentials. Use either an RJ45 connector with integrated magnetics, or a discrete isolating LAN transformer ahead of the jack.
- Do not overlap the circuit-ground and chassis-ground planes beneath the PHY traces, and place a capacitor between chassis ground and circuit ground close to the magnetics to give high-frequency currents a path to chassis without a DC connection.
- Keep each EtherCAT segment within the 100 m limit of 100BASE-TX.

The complete wiring of the EtherCAT ports to an external board is shown in Figure 43, Section 15.5.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

8.2 CANOPEN (DS402)

CAN is a robust, lower-speed bus common in vehicles and in simpler industrial systems. The SOLO PRO 60-160 implements **CANopen with the DS402 motion profile**, which is the standard method of commanding a drive over CAN. The on-board transceiver performs the physical signalling, so only **CANH** and **CANL** (section [11] J6, pins 7 and 9) plus a common ground need to be routed to the network connector.

Design considerations:

- The firmware uses classical CAN at up to **1 Mbit/s**.
- A CAN bus must be terminated with a **120 Ω** resistor at each of its two physical ends, and nowhere else. Fit a terminator only if this drive is the last node on the bus.
- Set the node address and bit rate from the SOLO Motion Terminal, or over the bus using CANopen LSS.
- The on-board transceiver is not isolated. Where galvanic isolation between the drive and the CAN network is required, as it commonly is when nodes sit at different ground potentials, add an isolated transceiver such as the ISO1042 externally.

Figure 17 shows the CAN bus wiring.

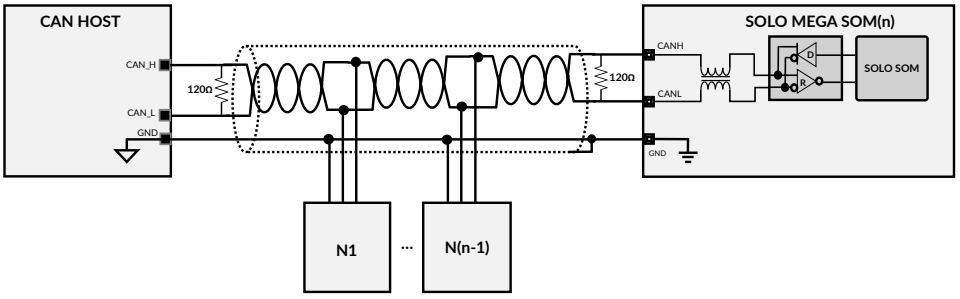


Figure 17. CAN bus wiring (CANH / CANL to the network connector).

> **i NOTE:** To improve immunity against external EMI, bond the cable shield to ground, either to the drive ground or to the CAN host ground, at one end only.

For the full object dictionary and the DS402 state machine, refer to the CANopen user manual on the SOLO website.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

8.3 USB

The USB 2.0 Type-C port (sections [2] and [19]) is the connection to a PC for configuration, tuning and monitoring. The drive enumerates as a virtual COM port, and the SOLO Motion Terminal uses it to set up the drive, tune the loops and observe live signals. It is also the path for firmware updates.

With USB the drive can be operated with the simplest possible wiring: a single USB cable to the host plus the DC supply and the motor. In this configuration the full digital feature set is available. Figure 18 shows the connection.

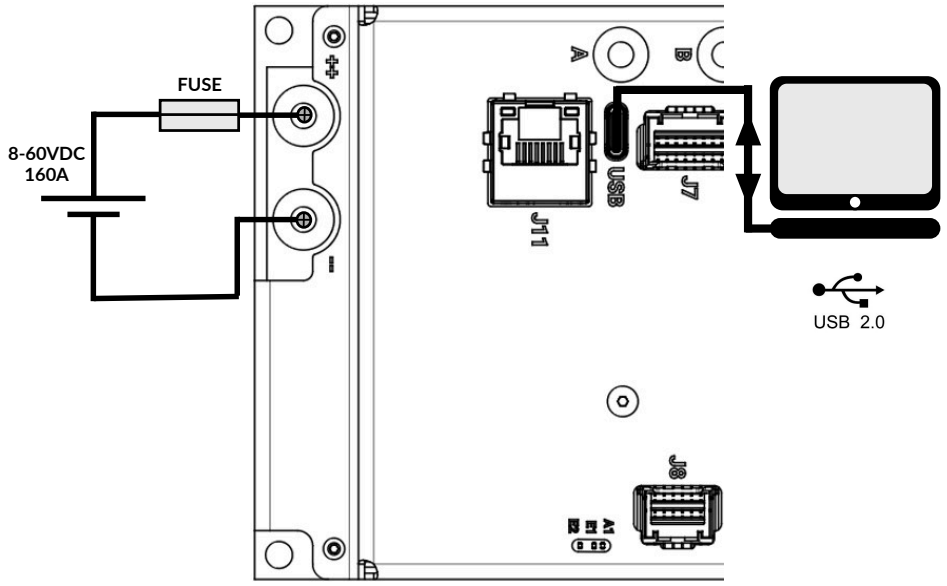


Figure 18. USB 2.0 Type-C wiring.

- The drive must be powered from its external 8–60 VDC supply when connected to a host over USB. The cable does not power the unit.
- The Type-C connector is reversible, with no up or down orientation, which makes it robust for industrial use.
- Keep the USB cable within 3 m.

USB is intended for configuration and monitoring rather than real-time control. Use EtherCAT or CANopen for closed-loop control during operation.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

9. POSITION SENSING

Accurate control of motor position or speed requires knowledge of the rotor position, provided by a sensor mounted on the motor. The SOLO PRO 60-160 supports a range of sensor types so that the sensor can be matched to the required accuracy, cost and robustness, across **two independent channels**: the **primary** channel is used by the control loops to run the motor, and the **secondary** channel is independent and intended for monitoring, reading a load-side position to detect a slipped coupling or a broken belt, for example.

Every sensor type requires a one-time setup and calibration through the SOLO Motion Terminal before the motor is run. Two wiring rules apply to all of them: keep the cable within **3 m**, and bond the shield to ground at **one end only**.

> ℹ **NOTE:** A position sensor is not always required. The drive also supports sensorless control, including the High-Speed Observer method for high-speed motors. See Section 3.6.3.

9.1 DIGITAL HALL SENSORS

Hall sensors provide coarse position feedback through three digital signals that change state as the rotor magnets pass them. This is enough for commutation and a coarse speed estimate, and with correct setup it supports torque, speed and position control of BLDC and PMSM motors. Connect the sensor outputs HALL A, HALL B and HALL C to **HA**, **HB** and **HC** on section [6] J5 (pins 12, 10 and 8), and supply the sensors from **+5V_OUT1** (pin 16). The inputs accept up to 5 V.

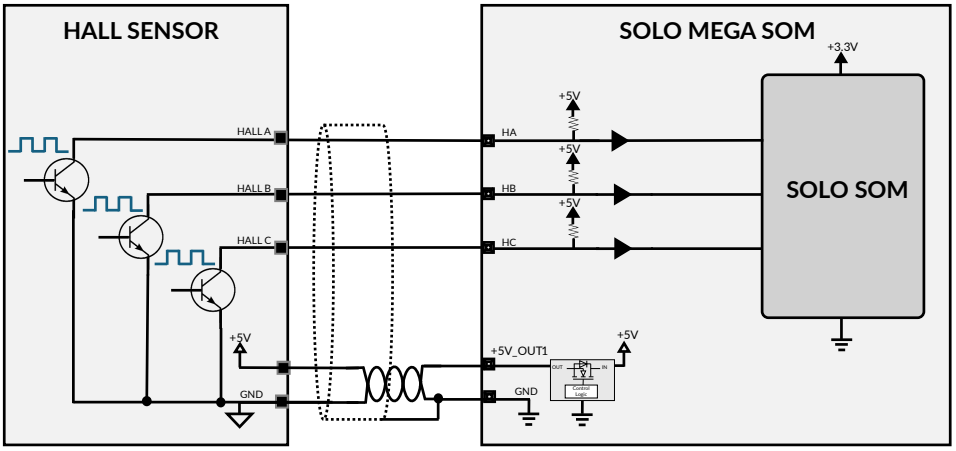


Figure 19. Digital Hall sensor wiring (HA / HB / HC).

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

> ℹ **NOTE:** Hall-based operation requires a one-time setup and calibration before running the motor. The ground of the drive must be connected to the Hall sensor ground.

9.2 INCREMENTAL ENCODER — SINGLE-ENDED

A single-ended incremental encoder transmits each channel on a single conductor referenced to ground rather than as a differential pair. This is lower in cost but more susceptible to noise, and is therefore suited to short cable runs in low-noise environments. Adding an incremental encoder makes the drive a servo drive, with closed-loop control of torque, speed and position.

Two single-ended channels are available:

Channel	Signals	Location	Purpose
Encoder 1 (primary)	1CHA, 1CHB, 1CHC	Section [4] J7, pins 12, 14, 16	Motion control
Encoder 2 (secondary)	2CHA, 2CHB, 2CHC	Section [11] J6, pins 8, 10, 12	Monitoring

Figure 20 shows channels A, B and C of a single-ended encoder connected to 1CHA, 1CHB and 1CHC.

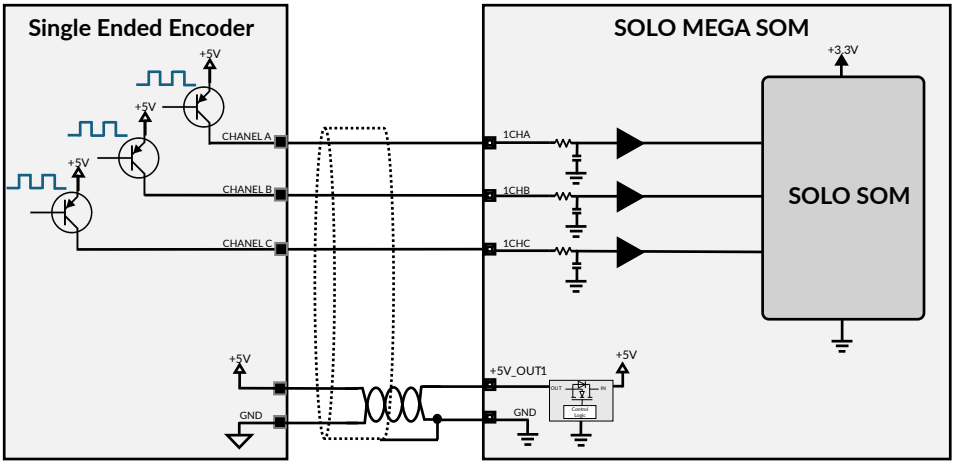


Figure 20. Single-ended incremental encoder wiring (1CHA / 1CHB / 1CHC).

> ℹ **NOTE:** The ground of the drive must be connected to the encoder ground. Bond the cable shield either to the drive ground or to the controller ground, at one side only.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

9.3 INCREMENTAL ENCODER — DIFFERENTIAL

A differential incremental encoder transmits each channel as a balanced pair. Interference coupled into the cable affects both conductors nearly equally, and the receiver, which responds only to the difference between them, rejects it. That is what makes this type suitable for long or electrically noisy runs.

Connect the encoder's positive outputs to **CHA+**, **CHB+** and **CHC+** and the negative outputs to **CHA–**, **CHB–** and **CHC–** on section [4] J7 (pins 11, 7, 3 and 9, 5, 1). The inputs accept up to 12 V.

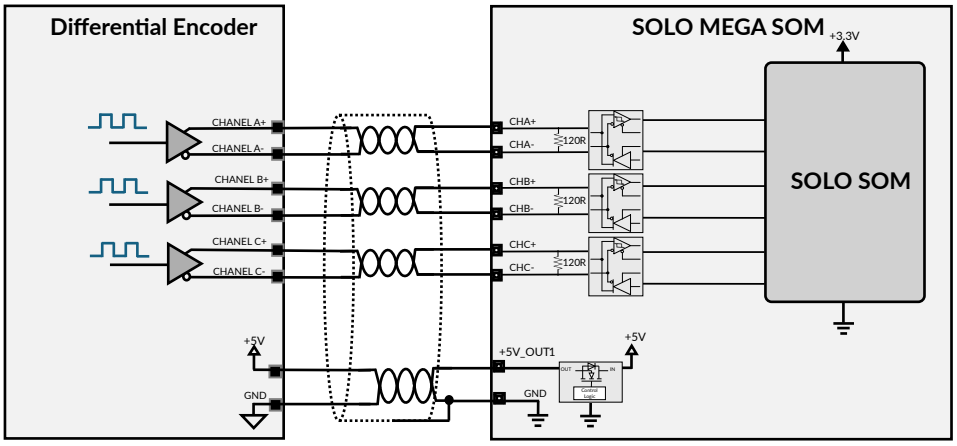


Figure 21. Differential incremental encoder wiring (CHA± / CHB± / CHC±).

> **i NOTE:** Wire each positive/negative pair as a **twisted pair**, as shown in Figure 21. This reduces coupled noise substantially. Connect the drive ground to the encoder ground.

9.4 BISS-C ABSOLUTE ENCODERS — PRIMARY AND SECONDARY

An absolute encoder reports the exact shaft angle at power-up, with no requirement to move the motor to a reference position first. BiSS-C is an open digital standard for absolute encoders. On the **primary** channel the SOLO PRO 60-160 operates as a full BiSS-C **master**: it generates the clock, reads back the position data, and can both read from and write to the encoder's internal registers, which supports operations such as configuring the encoder or clearing its error and warning flags.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Channel	Clock	Data	Supply
Primary	C+_P / C-_P — section [6] J5, pins 11, 13	D+_P / D-_P — pins 9, 7	+5V_OUT_P, pin 6 (200 mA)
Secondary	C+_S / C-_S — pins 3, 1	D+_S / D-_S — pins 2, 4	+5V_OUT_S, pin 5 (200 mA)

The clock and data each use a differential pair, and the inputs accept +3.3 V or +5 V logic levels (12 V absolute maximum). Figure 22 shows the connection.

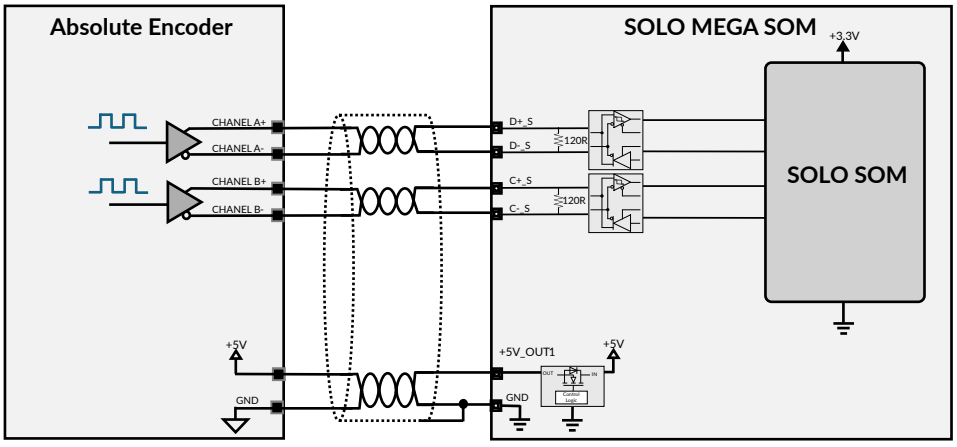


Figure 22. Absolute (BiSS-C) encoder wiring, primary and secondary channels.

> **NOTE:** Wire the clock and the data pairs as **twisted pairs** and bond the shield at one end only. Full BiSS-C master operation, including writes to the encoder registers, is a property of the primary channel. Use it for the encoder that closes the control loop.

9.5 SIN/COS ABSOLUTE ENCODER

A Sin/Cos encoder outputs two analogue signals, a sine and a cosine, as the shaft rotates. Measuring both lets the drive interpolate the angle finely between the coarse counts. Connect them to **SinCosA+/A–** and **SinCosB+/B–** on section [4] J7 (pins 4, 6, 8, 10).

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

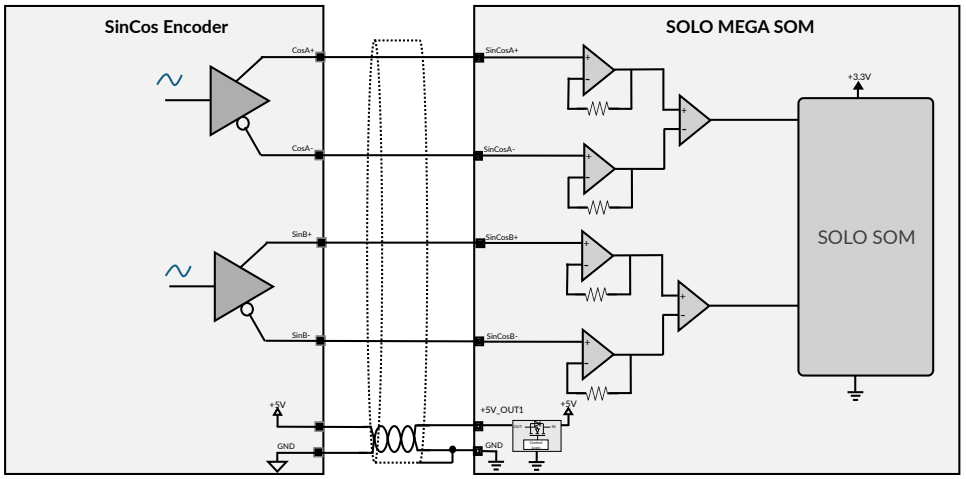


Figure 23. Sin/Cos encoder wiring (SinCosA± / SinCosB±).

The signals drive the analogue inputs of the drive, so they must be presented within the **0–5 V** input window, as shown in Figure 24:

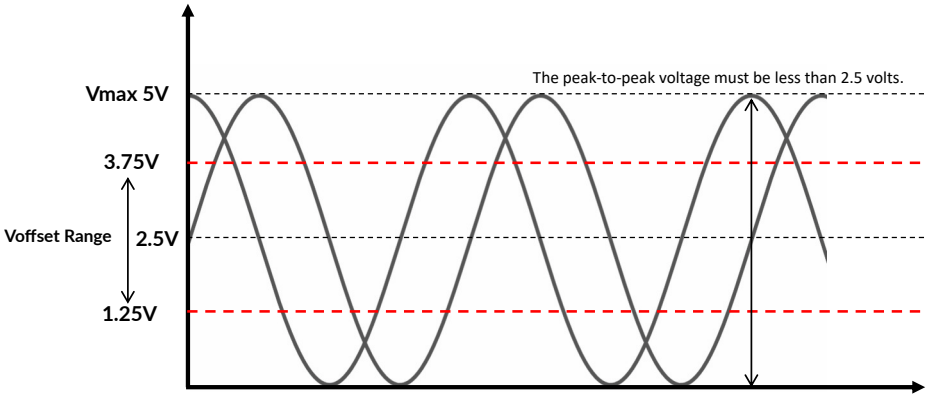


Figure 24. Sin/Cos input range: sine and cosine centred on the 2.5 V mid-rail, with the swing kept inside the 0–5 V window.

Parameter	Value
Input window	0 to 5 V
Nominal centre (offset) voltage	2.5 V
Permitted centre (offset) voltage range	1.25 V to 3.75 V
Maximum peak-to-peak amplitude	< 2.5 V

The waveform does not have to use the whole window. Any swing that stays inside the rails is acceptable, a reduced range such as 0.3 V to 4.8 V included, provided it remains centred within the permitted offset range and its peak-to-peak amplitude stays below 2.5 V. Because a

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

larger amplitude gives the angle interpolation more resolution, use as much of the window as the signal chain allows, within that limit, for the best position accuracy.

9.6 PT1000 TEMPERATURE SENSOR

A PT1000 is a platinum resistance thermometer whose resistance increases predictably with temperature (1000 Ω at 0 °C). Mounting one on the motor windings or on a heatsink lets the drive monitor for over-temperature and reduce output before damage occurs. Connect it across **PTC+** and **PTC–** on section [11] J6 (pins 3 and 5).

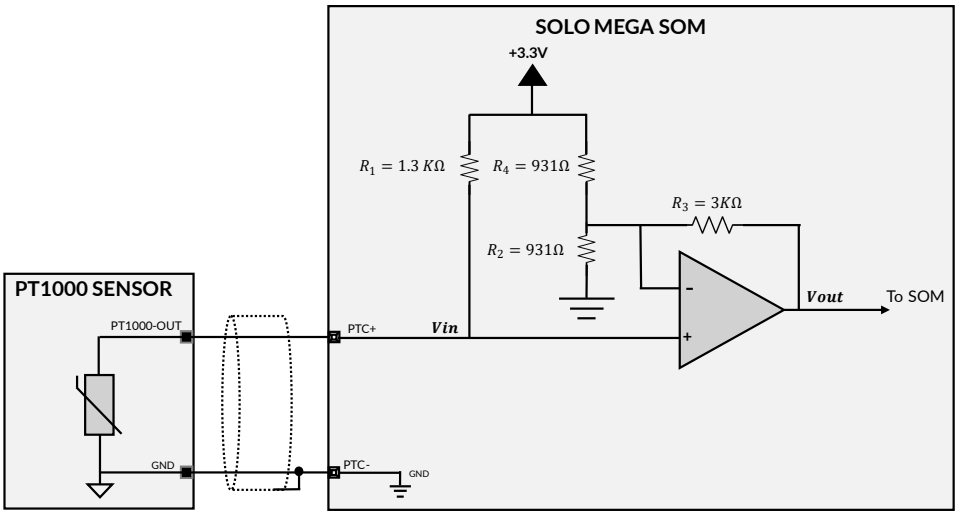


Figure 25. PT1000 temperature-sensor wiring (PTC+ / PTC–), showing the on-board bridge network.

The sensor forms part of an on-board resistive network fed from +3.3 V, whose output voltage is read by the drive. The network component values are marked on Figure 25 (R1 = 1.3 kΩ, R2 = 931 Ω, R3 = 3 kΩ, R4 = 931 Ω).

To obtain a temperature reading:

1. Read the PT1000 output voltage (**Vout**) over one of the communication interfaces: USB, CAN bus or EtherCAT.
2. Calculate **Vin** from Vout using the network relationship given in Figure 25.
3. Compute the PT1000 resistance. Because the sensor is a resistor, it forms a divider with R1, so its resistance follows from Vin and the divider relationship.
4. Convert the resistance to a temperature using the PT1000 characteristic curve or table. Figure 26 shows a sample characteristic curve; refer to the datasheet of the specific sensor for its own curve.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

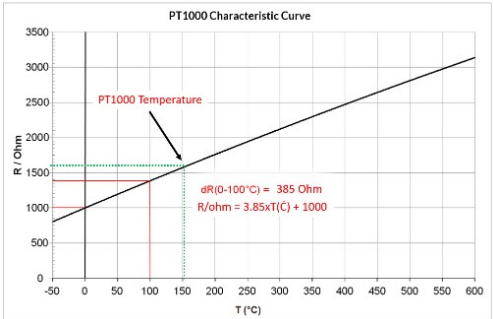


Figure 26. A sample PT1000 resistance-versus-temperature characteristic curve.

> ⚠ **CAUTION:** The PT1000 input pins are limited to 3.3 V in normal operation. Exceeding the 3.75 V absolute maximum can permanently damage the drive.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

10. ANALOGUE AND DIGITAL CONTROL

10.1 ANALOGUE VERSUS DIGITAL CONTROL

The SOLO PRO 60-160 offers two command modes, and the choice between them determines the wiring of the whole installation.

In **analogue mode**, the drive accepts a torque or speed reference, together with the current limit and the direction of rotation, through analogue means: a pure analogue voltage or a PWM pulse train on the analogue inputs, and a logic level on a general-purpose input for direction. This suits a PLC with analogue outputs, or a simple installation with a potentiometer.

In **digital mode**, every command and every feedback value is transferred as a data packet over USB, CAN bus (CANopen) or EtherCAT. This gives access to the complete feature set, every mode, parameter and diagnostic, and is the mode used for multi-axis and networked systems.

10.2 ANALOGUE COMMAND INPUTS AI1_IN AND AI2_IN

AI1_IN (section [11] J6, pin 4) and **AI2_IN** (pin 2) accept either a pure analogue voltage in the **0–10 V** range or a **PWM signal whose frequency is at least 5 kHz**. Depending on the selected mode, the applied level is interpreted as the torque or speed reference, or the current limit. The inputs are rated to +10 V continuous, +10.5 V absolute maximum.

In **closed-loop torque mode**, the applied level sets the current injected into the motor, up to the configured current limit and a maximum of 130 A DC. The resulting torque follows from

> Applied motor torque = current acting in torque generation × motor torque constant

where the current acting in torque generation is I_M for DC motors and I_q, the quadrature current, for three-phase BLDC or PMSM motors.

In **closed-loop speed mode**, the applied level sets the speed reference between zero and the maximum speed for the configured motor type, divided by the **ASRDC** coefficient (Analogue Speed Resolution Division Coefficient). ASRDC defaults to 1; raising it compresses the

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

reference range, which increases the resolution of the analogue input for low-speed motors. The maximum speeds are:

Motor code	Motor type	Maximum speed at full-scale analogue input	Controller sampling rate
0	DC brushed	8000 RPM / ASRDC	2 kHz
1	Normal brushless (BLDC, PMSM)	8000 RPM / ASRDC	2 kHz
2	Ultra-fast brushless (BLDC, PMSM)	30000 RPM / ASRDC	2 kHz

For accurate speed measurement on three-phase motors, set the number of motor poles through the SOLO Motion Terminal or over USB, CAN or EtherCAT. The default is 8.

10.3 ANALOGUE WIRING — CONTROLLER WITH NPN OUTPUTS

PLC outputs are generally either NPN or PNP. In an **NPN (sinking)** configuration an activated output pulls the corresponding pin to ground. Figure 27 shows GPI/O1 connected to an NPN output of the controller, with the controller's 0–10 V analogue outputs driving AI1_IN and AI2_IN.

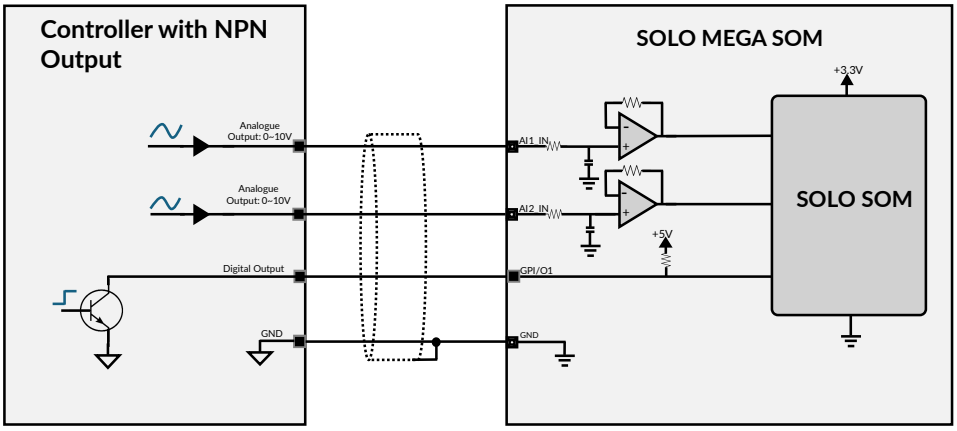


Figure 27. Analogue wiring with a controller having NPN (sinking) outputs.

i NOTE: Bond the cable shield to ground to improve immunity against EMI. **The ground of the drive must be connected to the controller ground.** An analogue signal has no meaning without a shared reference.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

10.4 ANALOGUE WIRING — CONTROLLER WITH PNP OUTPUTS

In a **PNP (sourcing)** configuration an activated output pulls the corresponding pin up to the controller supply. Figure 28 shows the equivalent wiring for a PNP-output controller.

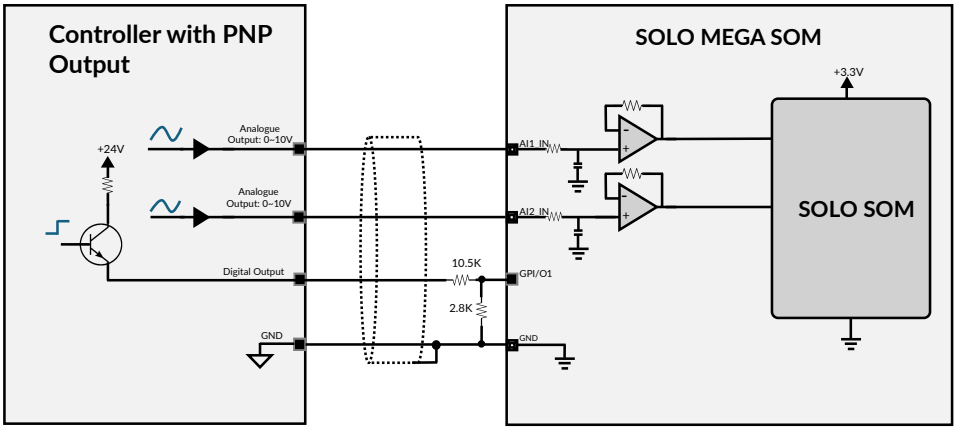


Figure 28. Analogue wiring with a controller having PNP (sourcing) outputs.

> ⚠ **CAUTION:** With a PNP output the pin is driven to the controller's supply rail. Confirm that this rail does not exceed the 5 V limit of the GPI/O pins, or the 10 V limit of the analogue inputs, before connecting.

10.5 ANALOGUE WIRING — EMBEDDED MCU BOARDS

The drive is compatible with any embedded MCU board using 3.3 V or 5 V logic, such as an Arduino or a Raspberry Pi. As shown in Figure 29, GPI/O1 connects to any digital output of the MCU, and AI1_IN or AI2_IN to an analogue or PWM output.

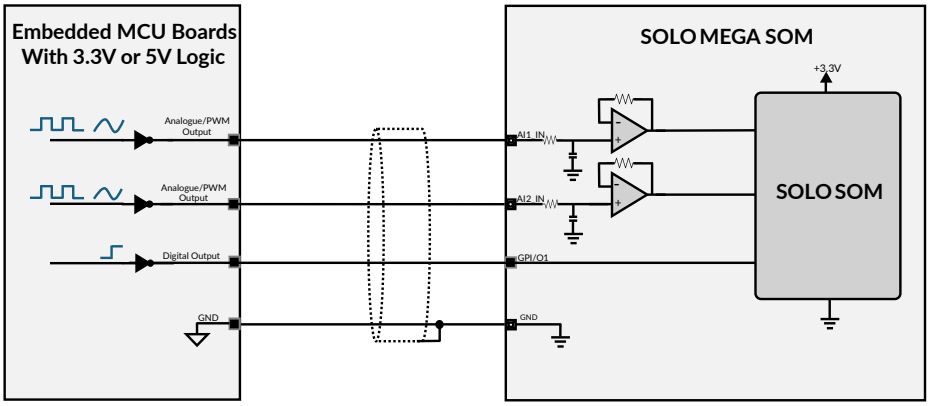


Figure 29. Analogue wiring with an embedded MCU board.

- The PWM frequency must be at least **5 kHz**.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

- The ground of the drive must be connected to the ground of the MCU board.
- Bond the cable shield to the drive ground or to the controller ground, at one side only.

10.6 GENERAL-PURPOSE INPUT WIRING

A general-purpose pin used as an input accepts an on/off logic signal, most commonly the direction command in analogue mode. Each pin has an internal 3.3 kΩ pull-down, so an open input reads low. Figure 30 shows the wiring.

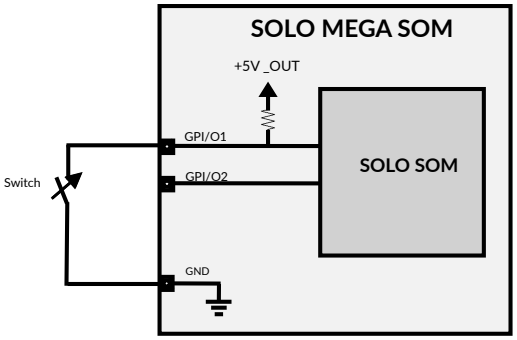


Figure 30. General-purpose input wiring (GPI/O1).

> ⚠ **CAUTION:** The general-purpose pins are 5 V inputs. Applying more than 5 V will damage the unit.

10.7 GENERAL-PURPOSE OUTPUT WIRING

A general-purpose pin used as an output can drive external circuits such as an electrical valve, a solenoid or a contactor. Because the pin sources at most **10 mA**, anything beyond a logic input must be switched through a transistor. Figure 31 shows a BJT driving a relay, which in turn switches the external load.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

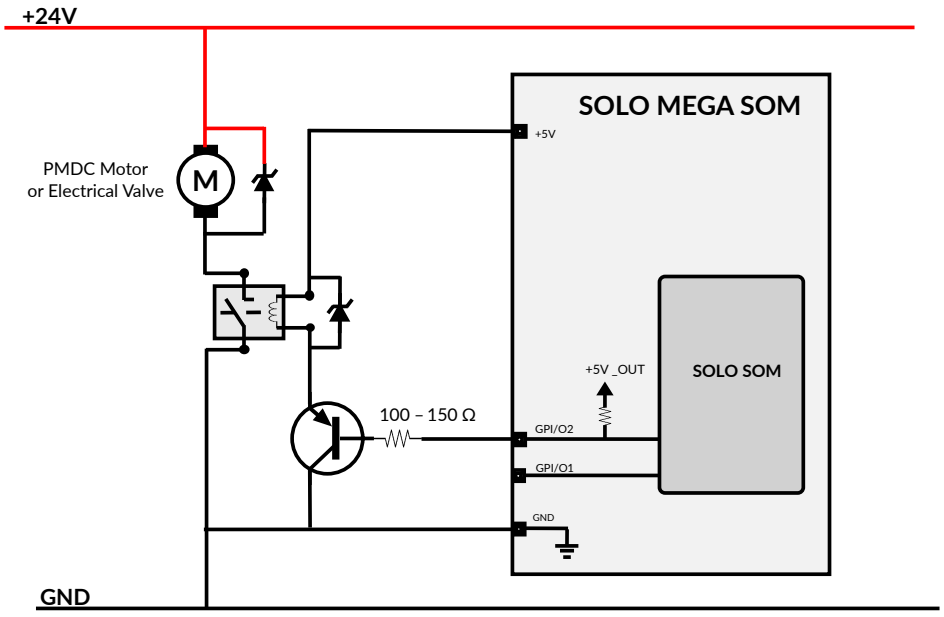


Figure 31. General-purpose output wiring (GPI/O2) driving a relay through a transistor.

> ⚠ **CAUTION:** The maximum current available from a general-purpose output is **10 mA**. Drawing more than this will damage the unit. Fit a flyback diode across any inductive load such as a relay coil.

10.8 DIGITAL MODE

In digital mode all functionality is reached by exchanging data packets. The three transports are described in Section 8: **USB** (Section 8.3) for the simplest single-cable setup and for configuration, **CANopen** (Section 8.2) for multi-drop networks, and **EtherCAT** (Section 8.1) for deterministic, synchronized multi-axis systems. Complete wiring examples for each appear in Section 15.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

11. SAFE TORQUE OFF (STO)

11.1 FUNCTION

Safe Torque Off is a hardware-level safety function that removes the torque-producing energy from the motor: it disables the path to the power stage so the motor can no longer generate movement, while the rest of the system may remain powered. It is the foundation for safe-stop functions in machinery and a building block for higher-level safety functions.

On the SOLO PRO 60-160, STO is implemented with **two independent, optically isolated request channels**, STO1 and STO2, on section [10] J9. Each channel's opto-isolator gates one of the power switches that supply the gate drivers, as shown in Figure 3. When STO is requested, the gate-driver supply is removed and the inverter physically cannot energize the motor. Because the trip path is entirely in hardware, it does not depend on firmware execution.

The function operates on **negative logic**:

- **Enabled state.** With the STO inputs driven to a high logic level (+5 V), the power electronics driving the motor are active.
- **Disabled (safe) state.** With the STO pins open-circuit or connected to ground (0 V), the drive immediately interrupts power to the motor, which then stops according to its natural time constant.

> ⚠ **WARNING:** Wiring the STO inputs is **mandatory** for normal operation. An unwired drive holds the power stage disabled.
>
> ⚠ **WARNING:** If either or both STO inputs are opened, the motor **coasts** to a stop under its inertia. This coasting motion can be hazardous. Implement external measures, such as a mechanical brake or a guard interlock, to prevent unintended motion where coasting is not acceptable.
>
> ⚠ **WARNING:** Selecting and qualifying the external safety components, and validating the complete safety function to the level required by the application, is the responsibility of the machine builder. Do not rely on STO for personnel safety until the implementation has been verified and certified for the application.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

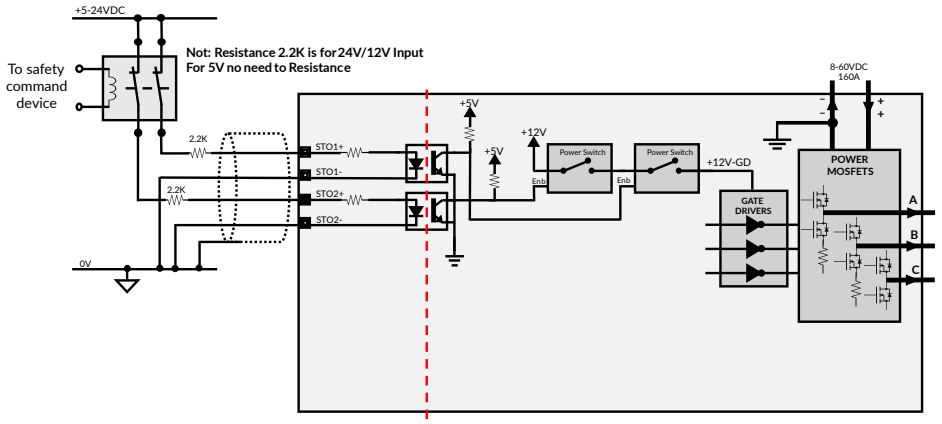
11.2 ELECTRICAL CHARACTERISTICS

Parameter	Description	Value
Type of input	STO1+, STO1–, STO2+, STO2– input type	Optically isolated
Voltage range	Acceptable voltage that may be applied to the STO inputs	+3.3 V to +5 V
Input current	STO1 and STO2 channel input current	2.1 mA to 3.3 mA
Low-level input voltage threshold	For +3.3 V logic / for +5 V logic	—
High-level input voltage threshold	For +3.3 V logic / for +5 V logic	—
Pulse time	Maximum width of a short pulse that the STO unit ignores	< 1 ms
Deactivation time	Minimum time to deactivate the STO unit	> 13 ms
Activation time	Minimum time to activate the STO unit	> 7 ms

11.3 WIRING THE STO INPUTS

There are three ways to wire the STO inputs.

Method 1: safety relay with an external supply. This is the configuration for production use. A safety relay, driven by the machine's safety circuit, switches the STO inputs from an external +5 V to +24 VDC supply, as shown in Figure 32. The two channels are switched independently, and that is where the redundancy comes from.



Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Figure 32. STO wiring to a safety relay using an external supply voltage.

> **ℹ NOTE:** With a +12 V or +24 V external supply, fit a **2.2 kΩ** series resistor in each STO input line to limit the opto-isolator current, as shown in Figure 32. With a +5 V supply no series resistor is needed. Bond the cable shield to the external ground to minimize EMI.

Method 2: safety relay with the internal +5 V supply. The drive's own +5 V output (section [10] J9, pin 1) can supply the STO inputs through the safety command device, as shown in Figure 33. This simplifies the wiring, but it also means the safety circuit is powered from the drive it is meant to protect.

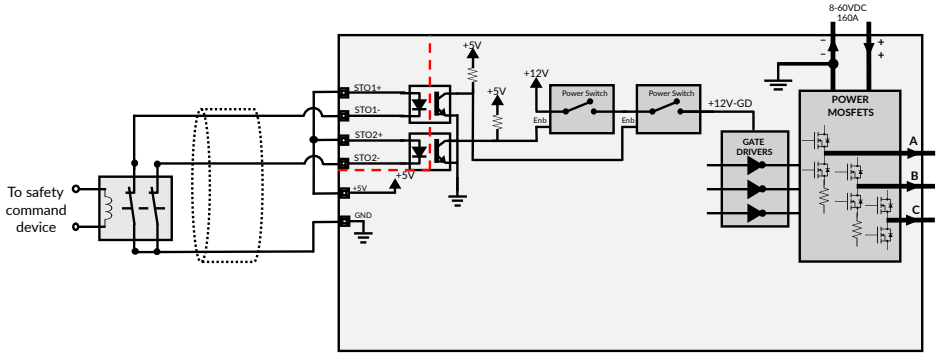


Figure 33. STO wiring to an external safety command device using the internal +5 V supply.

Method 3: bypassing STO. The STO inputs can be tied directly to the internal +5 V supply, with no external commanding device, as shown in Figure 34. This permanently enables the power stage and removes the safety function. It exists only to speed up initial bring-up.

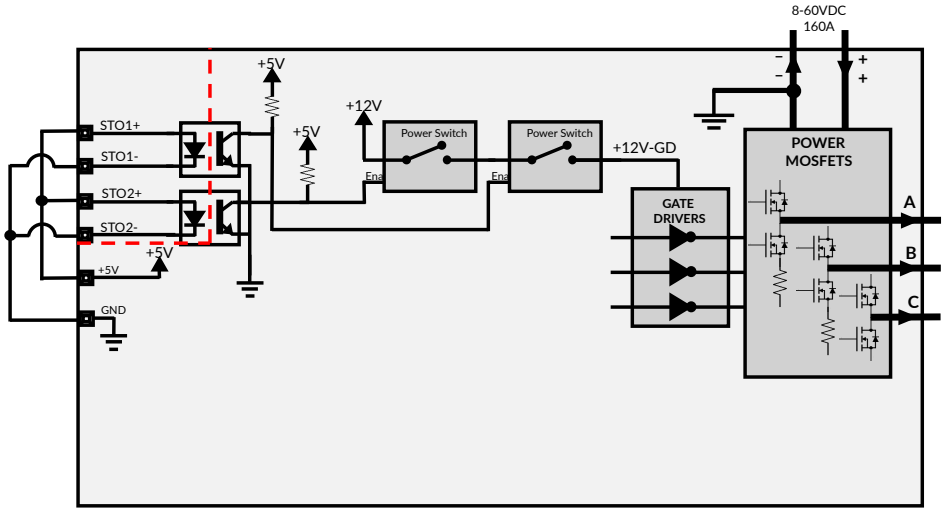


Figure 34. Bypassing STO using the internal +5 V supply, without an external commanding device.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

> ⚠ **WARNING:** Methods 2 and 3 are **not recommended for production use**. Use them only for initial testing and commissioning. Method 3 defeats the STO function entirely: the drive can no longer be brought to a torque-free state by the machine's safety circuit.

11.4 TIMING

The two STO inputs are debounced in hardware, so brief electrical transients do not trip the drive and a genuine request is not missed. Figure 35 shows the relationship between the request and the state of the function.

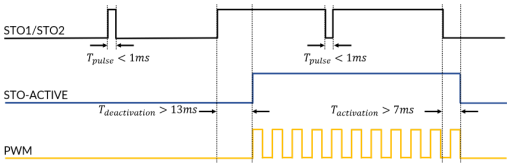


Figure 35. STO activation, deactivation and pulse timing.

- The STO function is **deactivated**, meaning torque is removed, when the external controller holds both STO1 and STO2 open or grounded for at least **13 ms**. This is the *deactivation time*.
- To **reactivate** the function and re-enable the power stage, the controller must reset the STO inputs for at least **7 ms**. This is the *activation time*.
- Pulses shorter than **1 ms** on the STO inputs are ignored and have no effect.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

12. ACTIVE BRAKE CHOPPER

12.1 PRINCIPLE

A motor that is decelerating, or being driven by its load, acts as a generator and returns energy to the DC bus. With a bus capacitance of 4700 µF and a supply that cannot absorb reverse current, that returned energy raises the bus voltage, and if it rises far enough it destroys the drive or the power supply. The active brake chopper prevents this by dissipating the excess energy in an external resistor.

The principle is simple: whenever the DC bus voltage exceeds the activation threshold, the chopper connects the **BRO+** and **BRO–** outputs across an external high-power resistor, and the energy is dissipated there instead of charging the bus. The threshold defaults to approximately **61 V** and can be tuned down to 10 V with an external resistor across **BAV1** and **BAV2**.

> ⚠ **WARNING:** If the load driven by the motor has significant inertia, using the active brake chopper is **mandatory**. Without it, excessive regeneration will damage the drive or the power supply through an over-voltage condition.

12.2 WIRING

Figure 36 shows the brake chopper wiring: the power resistor **RC** across BRO+ and BRO–, and the threshold-setting resistor **RBA** across BAV1 and BAV2.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

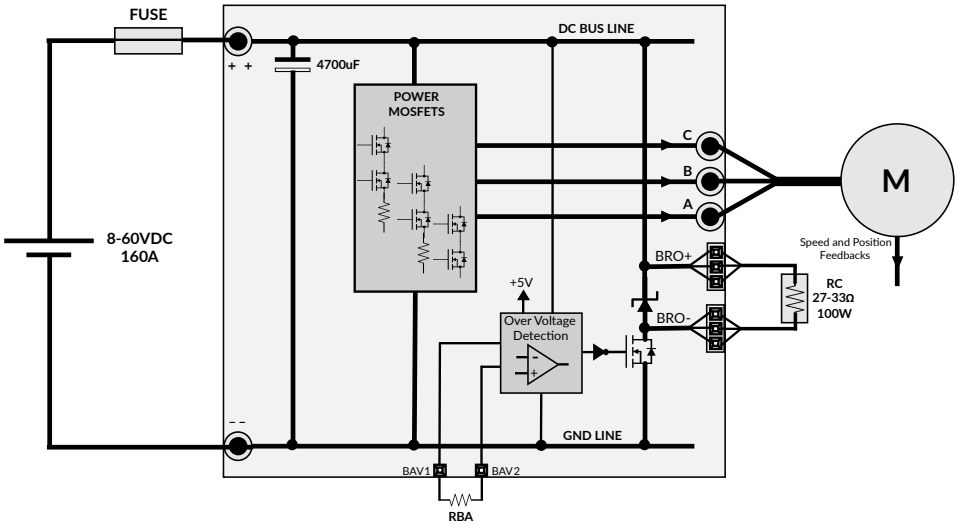


Figure 36. Active brake chopper wiring — the RC power resistor across BRO+/BRO- and the RBA threshold resistor across BAV1/BAV2.

The power resistor must have a resistance of at least **27 Ω** (27–33 Ω is the intended range) and a power rating of **100 W**. Use all three BRO+ and all three BRO– pins so the braking current is shared across contacts.

> ⚠ **WARNING:** Do not use a power resistor with a resistance below 27 Ω. Doing so may destroy the brake circuitry through excessive power dissipation.
>
> ⚠ **CAUTION:** Select the power rating of the brake resistor for the energy the application actually returns. An undersized resistor will overheat and fail. The regeneration current can also be limited from the SOLO Motion Terminal.

Some suitable power resistors are listed below.

Part number	Resistance and power
HSC10027RJ	27 Ω, 100 W
HS100E6 33R F M193	33 Ω, 100 W

Whenever the brake circuit conducts, the **B1** LED of section [9] turns on (Section 14).

12.3 SETTING THE ACTIVATION VOLTAGE

Leaving BAV1 and BAV2 **open** gives the default activation voltage of approximately **61 V**. Fitting a resistor **RBA** across them lowers the threshold, down to 10 V.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

The threshold is set by a resistive divider referred to an internal 3.3 V reference. Calculate the required value in two steps:

Step 1: the equivalent upper-arm resistance for the desired threshold.

> $X = ((V_{brake} / 3.3) \times 10\,000) - 10\,000\ [\Omega]$

Step 2: the resistor to fit across BAV1 and BAV2, which is the value that, in parallel with the drive's internal upper-arm resistance X_0 = 174 848 Ω (the value of X for the default 61 V threshold), yields X:

> $R_{BA} = (X \times X_0) / (X_0 - X)\ [\Omega]$

Choose the nearest available resistor value to the calculated one. The closer it is, the finer the resolution of the activation threshold. Table 1 gives worked examples.

Table 1. Examples of RBA selection for a desired brake activation voltage.

Nominal DC bus voltage (motor rating)	Desired brake activation voltage	RBA value [kΩ] (approximately)
58 V	61.0 V	∞ (open)
48 V	50 V	800
36 V	40 V	314
24 V	26 V	114
12 V	14 V	39

> ⚠ **CAUTION:** Never set the brake activation voltage **below** the applied DC supply voltage. Doing so makes the brake resistor dissipate continuously, wasting power and heating the resistor for no benefit. Always keep the threshold above the nominal bus voltage of the system.
>
> **i NOTE:** Verify the threshold before committing a motor to the drive: power the unit at its nominal bus voltage with no motor connected and confirm that the **B1** brake LED stays off. If B1 is permanently on with no motor connected, the activation voltage has been set below the supply voltage and must be recalculated.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

13. SLEEP MODE AND FIRMWARE UPDATE

13.1 SLEEP MODE

The drive has a low-power sleep mode that reduces its current consumption to approximately **2.6 mA**. That matters in battery-powered systems, where the quiescent draw of the drive would otherwise discharge the battery while the machine is idle.

Sleep mode is entered by pulling the **Sleep** input (section [10] J9, pin 3) to ground through an external switch, as shown in Figure 37.

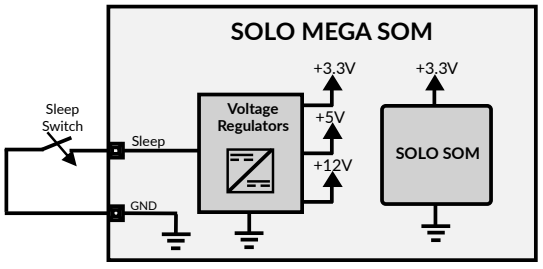


Figure 37. Sleep mode wiring — the Sleep input pulled to ground through an external switch.

> **i NOTE:** To control sleep mode remotely, use a relay, or drive the Sleep input directly from an external controller, grounding it to enter the mode.

13.2 FIRMWARE UPDATE (DFU MODE)

Firmware is updated over the USB port using the SOLO Motion Terminal. Where the drive must be forced into the bootloader, after a corrupted firmware image for instance, the **DFU1** input (section [11] J6, pin 1) selects device firmware upgrade mode.

DFU1 is a **3.3 V** input. It is driven from **+5V_OUT1** (section [11] J6, pin 6) through a **27 kΩ** resistor, which together with the drive's internal 51 kΩ pull-down forms a divider that places the pin at approximately 3.3 V. This is why the series resistor is required and must not be omitted.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

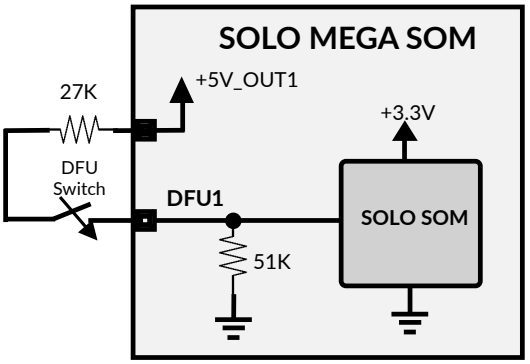


Figure 38. DFU mode wiring — DFU1 pulled up from +5V_OUT1 through a 27 kΩ resistor.

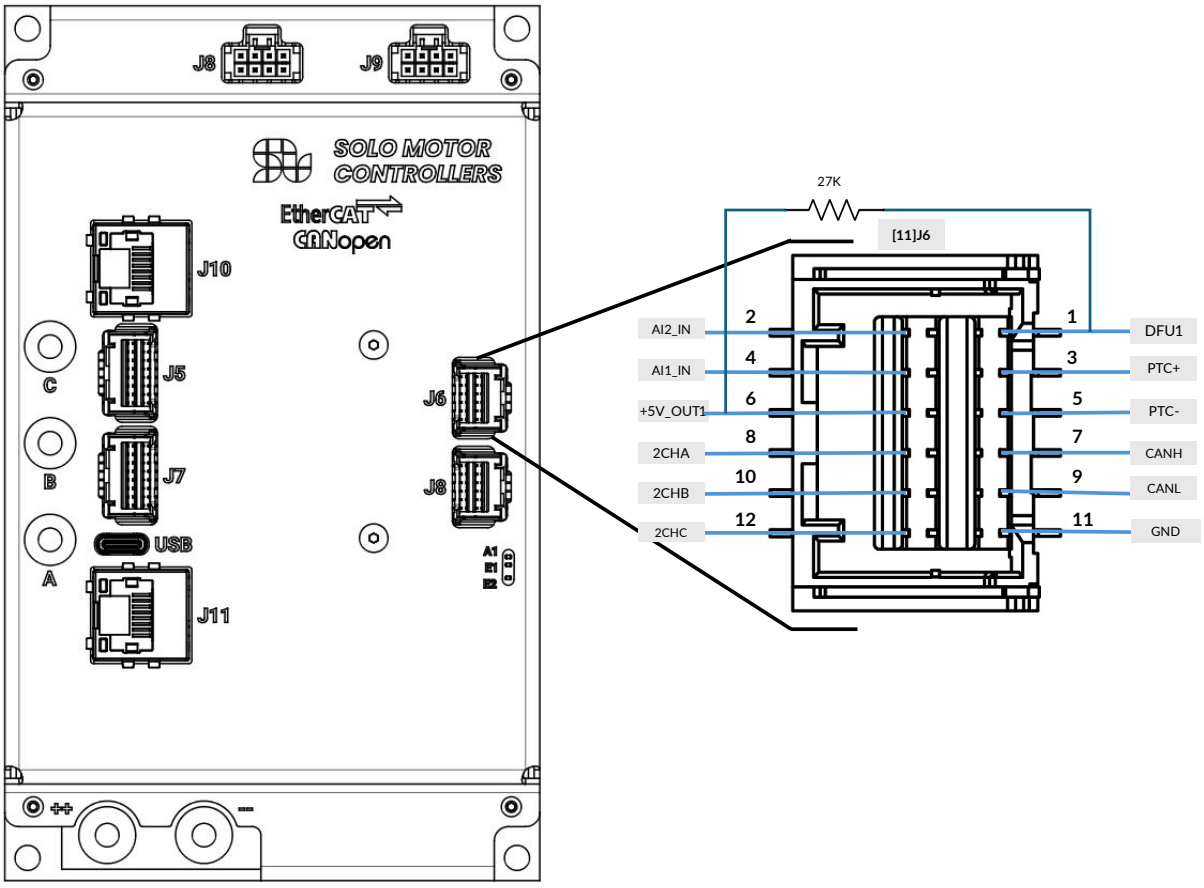


Figure 39. DFU mode wiring shown at connector J6 — DFU1 on pin 1, +5V_OUT1 on pin 6.

> ⚠ **WARNING:** Do not connect DFU1 directly to +5 V. The pin is rated to +3.3 V continuous and +3.75 V absolute maximum; connecting it to 5 V without the 27 kΩ resistor can permanently damage the drive.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

14. LED INDICATORS

The SOLO PRO 60-160 carries three functional LEDs on the enclosure face, plus two more inside it. The three visible ones are sections **[13]**, **[11]** and **[12]** of Figure 1, marked **A1**, **E1** and **E2** on the silkscreen beside connector J8.

Section	Name	Location	Indicates	Behaviour
[13]	**A1**	Control module, visible	Power	Glows continuously once the drive is correctly powered from 8 to 60 V
[11]	**E1**	Control module, visible	Error	Blinks when a fault is active: over-voltage, over-current or over-temperature
[12]	**E2**	Control module, visible	Heartbeat / normal activity	Starts blinking after a successful boot and stays blinking
—	**E1**	Power board, internal	Bus over-voltage error	Indicates a DC bus over-voltage condition
—	**B1**	Power board, internal	Brake activation	On while the brake circuit is actively dissipating energy in the RC resistor

In summary: **A1** shows that the unit has power, **E2** shows that the firmware is running, and **E1** shows a fault. A correctly operating drive shows A1 on, E2 blinking and both E1 indicators off. The E1 and E2 states are also available as outputs on section [12] J8 (pins 11 and 12), so they can be mirrored on an enclosure front panel.

> ℹ **NOTE:** If **B1** is permanently on while no motor is connected to the output, the brake activation voltage has been set below the supply voltage. Recalculate it as described in Section 12.3.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

15. COMPLETE WIRING EXAMPLES

15.1 WIRING LEGEND

The wiring diagrams in this manual use the following conventions.

Symbol	Meaning
Ground symbol	Ground of the SOLO PRO 60-160
External ground symbol	External ground — peripheral, PLC, embedded MCU board, or external supply ground
Fuse symbol	Fuse; the rating must be selected from the requirements of the system
Pulse line	Line carrying PWM pulses (fixed frequency above 5 kHz)
Analogue line	Line carrying a pure analogue voltage
On/off line	Line carrying on/off signals (low frequency)
Filled pin	Input/output pin of the SOLO PRO 60-160
Open pin	Input/output pin of the external controller

15.2 STANDALONE WIRING — NO EXTERNAL MODULES

The drive can be operated with no external modules at all, using only a potentiometer and a switch. Figure 40 shows the wiring for closed-loop operation of a BLDC or PMSM motor from a single potentiometer, with a general-purpose input used for direction.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

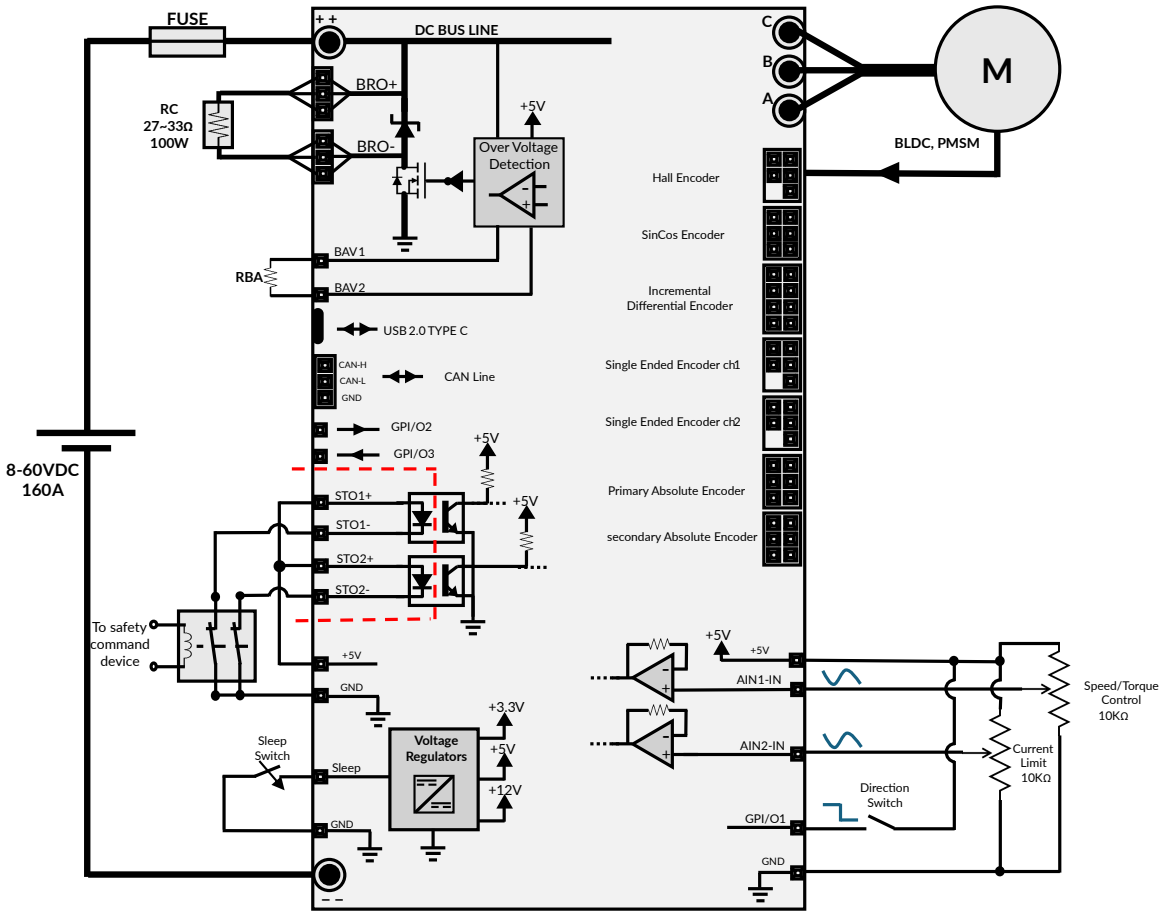


Figure 40. Standalone wiring — closed-loop control from a single potentiometer, with no external modules.

> ⚠ **CAUTION:** To avoid short-circuiting the internal +5 V source of the drive, the resistance of the potentiometer must not fall below **1 kΩ at any position**. Check this against the potentiometer datasheet before use.
>
> **ℹ NOTE:** The GPI/O pins accept up to +5 V, which allows the switch to be fed from the drive's own +5 V output.

15.3 EMBEDDED MCU BOARD USING ANALOGUE/PWM

Figure 41 shows the drive commanded by an embedded MCU board such as an Arduino or a Raspberry Pi, using an analogue voltage or a PWM output for the reference and a digital output for direction.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

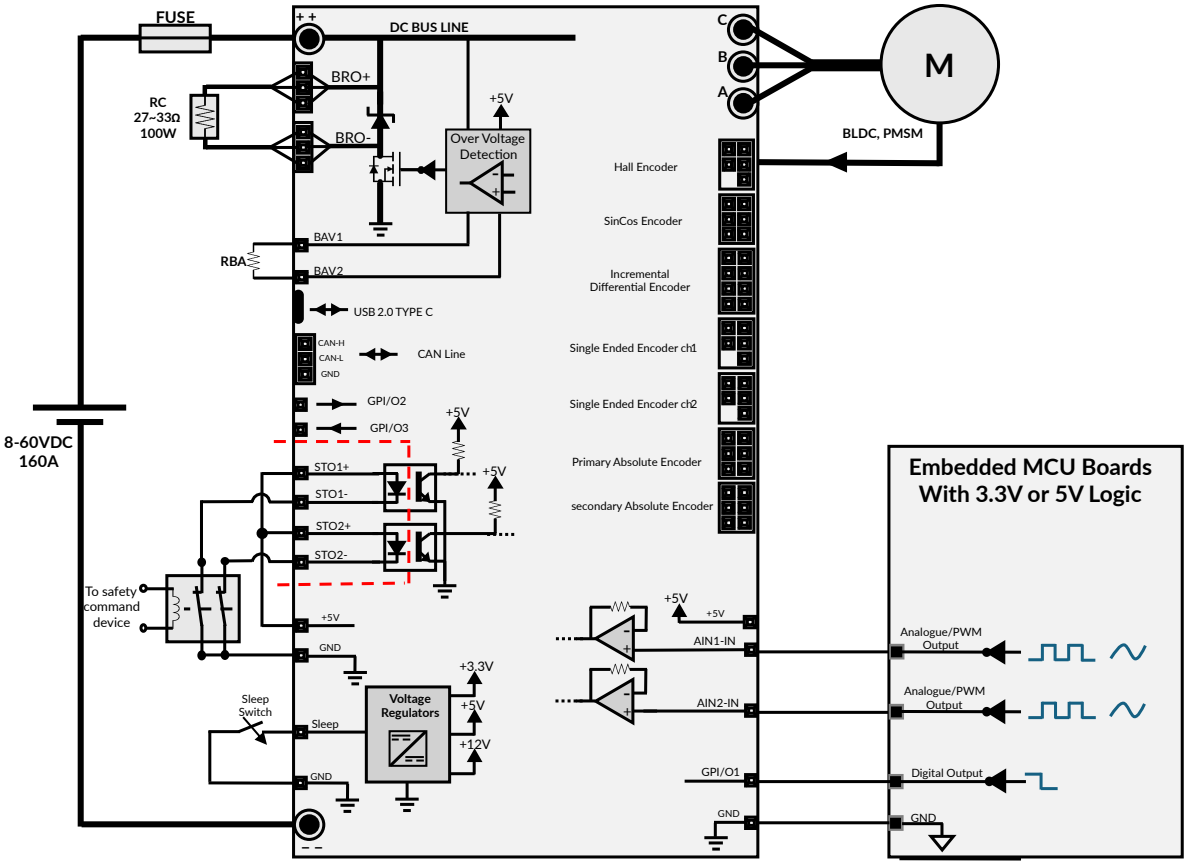


Figure 41. Complete wiring with an embedded MCU board commanding the drive over analogue/PWM.

- The **GND** pin of the drive must be connected to the ground of the MCU board at least at one common point. Without a shared reference the analogue command has no defined value, so this connection matters more than anything else in the configuration.
- The GPI/O pins accept input voltages up to +5 V.
- When using a PWM output to drive AI1_IN or AI2_IN, the PWM frequency must be at least **5 kHz**.

15.4 EMBEDDED MCU BOARD USING CANOPEN

Figure 42 shows the drive commanded digitally over CANopen from an embedded MCU board.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

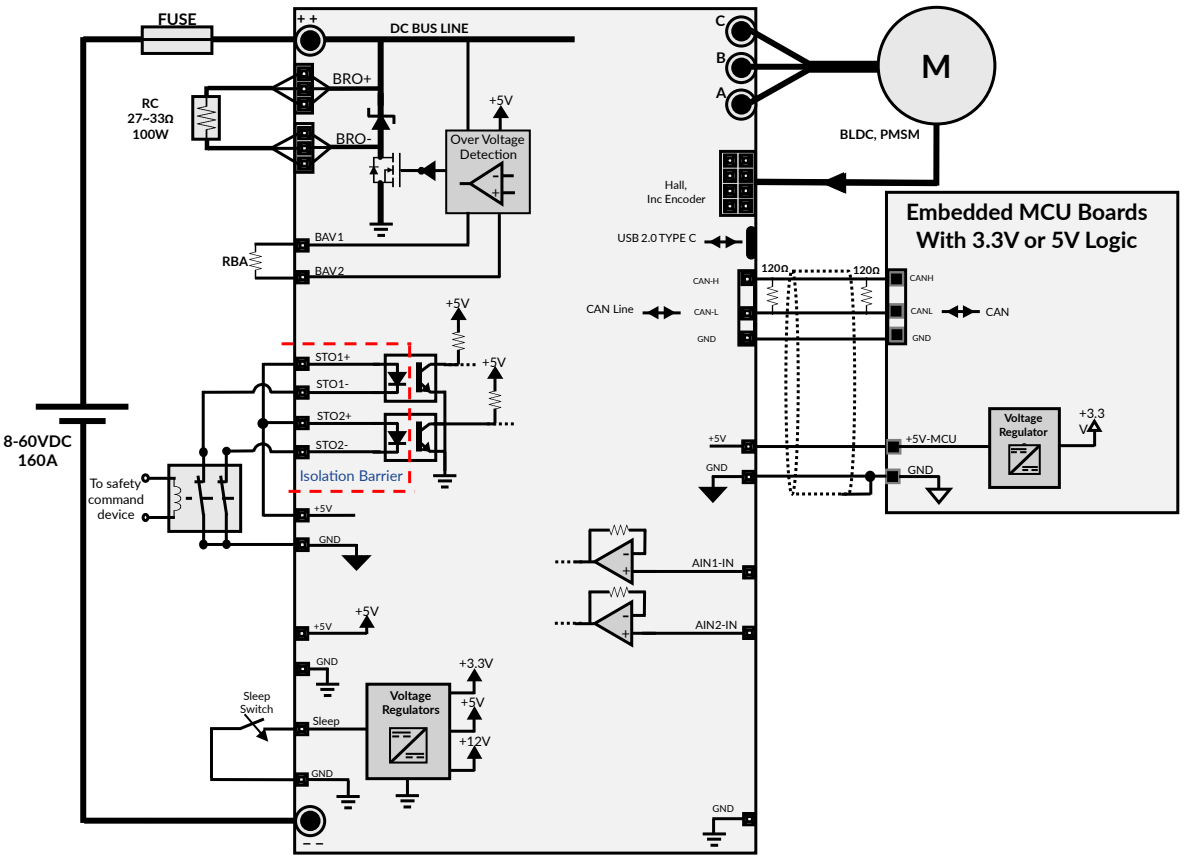


Figure 42. Complete wiring with an embedded MCU board commanding the drive over CANopen.

> **NOTE:** For reliable CAN communication, power the embedded MCU board from the drive's +5 V supply and establish a single common ground, so that no ground loop is formed between the two boards. Bond the cable shield to ground, or to the MCU board ground, at one side only.

15.5 EMBEDDED MCU BOARD USING ETHERCAT

Figure 43 shows how the EtherCAT PHY signals of sections [1] and [8] are wired from an external board to the drive. Observe the routing and isolation requirements of Section 8.1: 100 Ω differential pairs and an isolating LAN transformer in each port's path.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

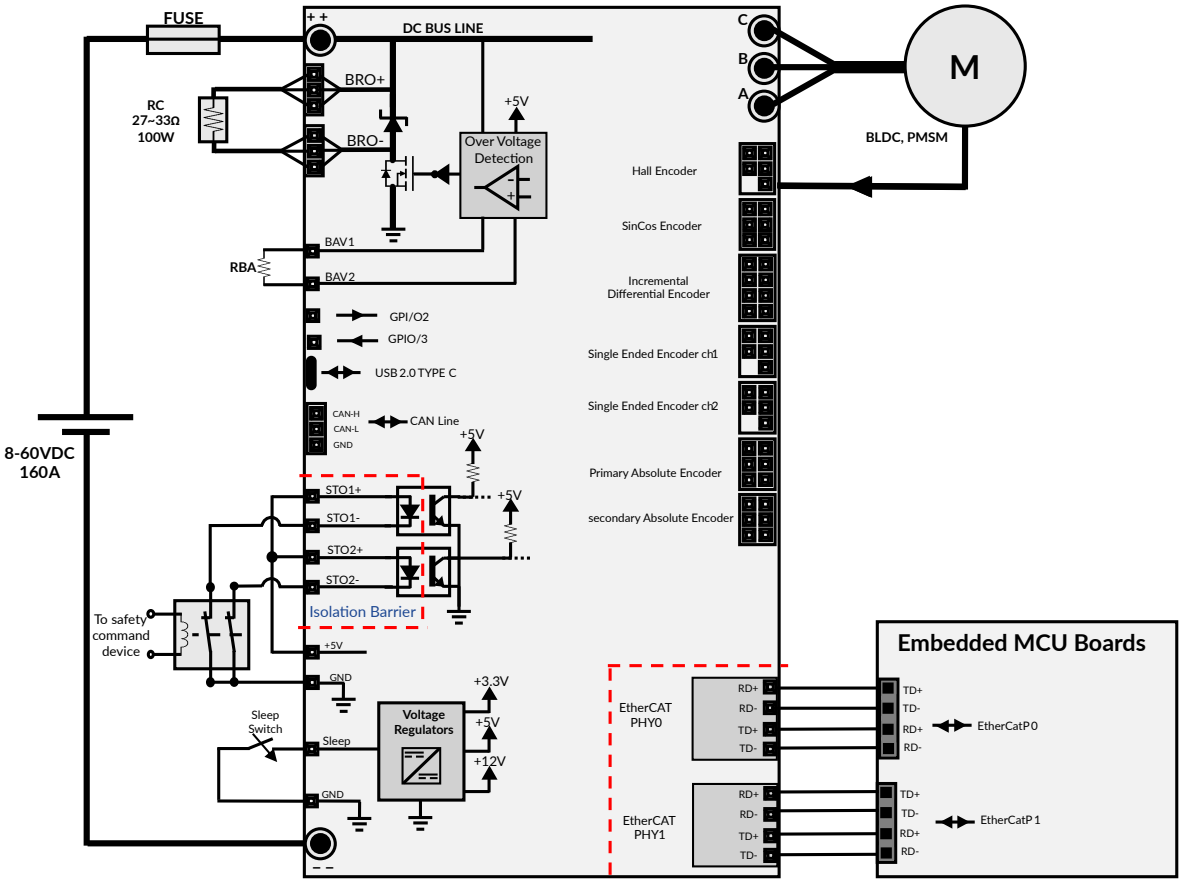
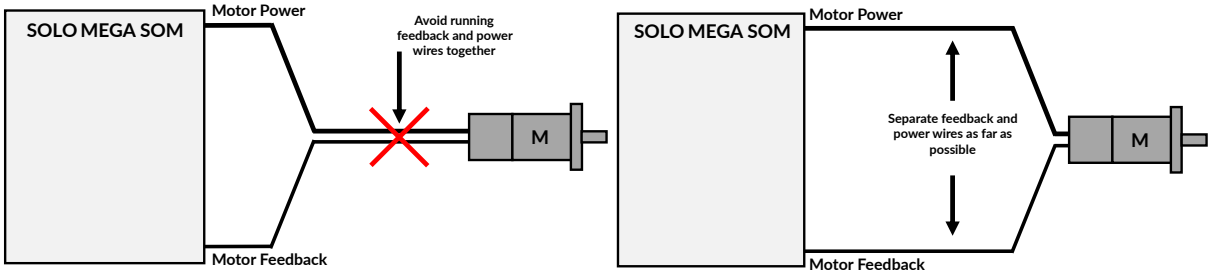


Figure 43. EtherCAT wiring between an external board and the SOLO PRO 60-160.

15.6 GENERAL WIRING CONSIDERATIONS

Most of the noise problems seen in drive installations come down to two wiring mistakes.

Do not run feedback and power wiring together. Encoder, Hall and analogue signals are low-level. Motor phase and supply cables carry switched currents with fast edges. Running them in the same bundle, or parallel over any distance, couples that switching noise into the feedback and degrades both position and current measurement. Separate them, and cross at right angles where a crossing is unavoidable (Figure 44).



Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

Figure 44. Keep feedback wiring away from power wiring.

Do not create ground loops. Connect the ground of the drive to the ground of the external board using a **star** configuration, so that signal and power returns share a single reference point rather than several parallel paths (Figure 45). Where two ground paths exist between the same two units, the loop they enclose carries circulating current and injects switching noise directly into the feedback.

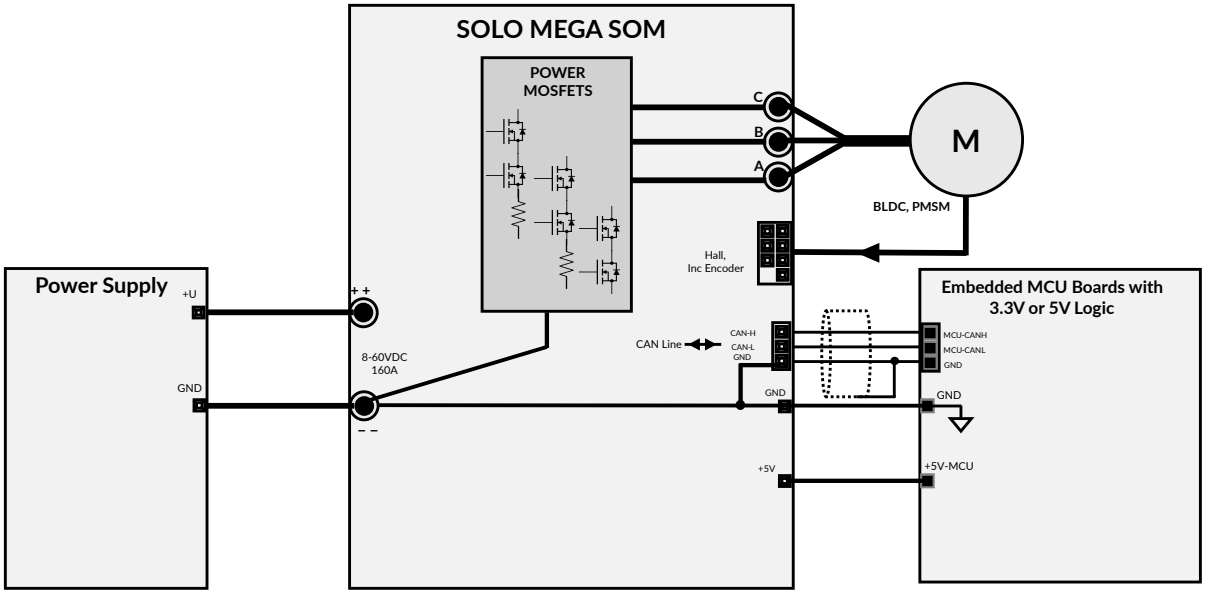


Figure 45. Improper ground wiring: parallel ground paths form a ground loop. Use a single star point instead.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

16. GETTING STARTED / INITIAL SETUP

16.1 REQUIRED EQUIPMENT

Commissioning the drive for the first time requires:

1. The SOLO PRO 60-160 (SLSGB002PW2000).
2. A DC power supply between 8 V and 60 V, sized for the intended motor current, with a fuse in the positive line.
3. A brake resistor of 27–33 Ω / 100 W, where the load can regenerate (Section 12).
4. The STO wiring: a safety relay for production use, or the bypass of Section 11.3 for bench testing only.
5. A USB Type-C cable, up to 3 m.
6. A PC running Windows 10/11 or Linux.
7. The SOLO Motion Terminal software, available from solomotorcontrollers.com.

16.2 FIRST POWER-UP

Perform these steps in order, with the motor **disconnected**, to confirm the drive is operating correctly before connecting the motor.

1. Verify the polarity of the DC supply at sections [16] and [17]. The unit has no reverse-polarity protection.
2. Verify that the supply voltage is between 8 and 60 V, and that it cannot exceed 66 V under any condition, including load release.
3. Confirm that every ground connection is secure and that the installation uses a single star ground point.
4. Wire the STO inputs (Section 11.3). The drive will not enable the power stage otherwise.
5. Connect the brake resistor across BRO+ and BRO–, using all three pins of each polarity.
6. Connect the USB cable between the drive and the PC.
7. Apply power. The **A1** LED lights immediately, confirming the supply.
8. Within approximately two seconds, the **E2** heartbeat LED begins blinking, confirming that the firmware has booted.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

9. Confirm that the **B1** brake LED is **off**. If it is on with no motor connected, the brake activation voltage is set below the supply voltage. Recalculate it (Section 12.3) before continuing.
10. If either **E1** LED is blinking, stop and check the supply voltage and the wiring before proceeding.
11. Open the SOLO Motion Terminal. The drive appears automatically as a virtual COM port.

16.3 SOLO MOTION TERMINAL — INITIAL CONFIGURATION

The Motion Terminal is used to configure the drive for the connected motor and to tune it. It communicates with the drive over USB, and optionally over CANopen.

1. Download and install the software from solomotorcontrollers.com/SOLO-motion-terminal.
2. With the drive powered and connected, open the software.
3. Select the drive's COM port from the list and click **Connect**.
4. Open **Motor Setup** and enter the motor parameters: type, pole-pair count and rated current. The default pole count is 8.
5. Enter the current limit for the application. This bounds the current the drive will inject, independently of the command.
6. Run the automatic parameter identification and self-tuning, then the one-time position-sensor calibration for the sensor in use (Section 9).

From this point, follow the online guides at solomotorcontrollers.com to tune and calibrate the motor. The full tuning and calibration procedure is maintained online and is outside the scope of this manual.

> ⚠ **WARNING:** Connect the motor only after the steps above are complete and the drive powers up cleanly. Secure the motor and the load mechanically before the first enable. An untuned drive can produce sudden motion.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

17. REGULATORY COMPLIANCE & APPROVALS

The compliance status below applies to the SOLO PRO 60-160. Compliance of the complete machine depends on the enclosure, the wiring and the installation. System-level certification is the responsibility of the integrator.

Standard	Code	Class
UL 61800-5-1 / CSA C22.2 No. 274	File number E535351	DVC A
Radiated emissions — enclosure port	CISPR 16-2-3, EN 55016-2-3	B*
Enclosure ports — electrostatic discharge	IEC / EN 61000-4-2	B*
Enclosure ports — radio-frequency electromagnetic field (AM)	IEC / EN 61000-4-3	B*
I/O and DC power ports — fast transients	IEC / EN 61000-4-4	B*
I/O and DC power ports — surges	IEC / EN 61000-4-5	B*
I/O and DC power ports — radio-frequency common mode	IEC / EN 61000-4-6	B*
Enclosure ports — power-frequency magnetic field	IEC / EN 61000-4-8	B*
RoHS	2011/65/EU	—

* Achieved without the use of any external filters.

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.

18. REVISION HISTORY

Rev	Date	Firmware	Author	Change Description
V1.0.0	31/05/2023	0x0000B00F	SOLO Motor Controllers	First release
V1.0.1	10/05/2024	0x0000B020	SOLO Motor Controllers	P/F pin description changed; certification table updated; temperature ratings updated per UL 61800-5-1; PT1000 formulas changed
01	2026-07-26	—	SOLO Motor Controllers	Restructured hardware user manual
02	2026-09-25	—	SOLO Motor Controllers	Encoder frequency specification corrected to the control module's ratings: 10 MHz for incremental encoders, and a 2–8 MHz clock range for BiSS-C

Document Number: SOLO-PRO60160-HW-UM-001 | © SOLO Motor Controllers | solomotorcontrollers.com

Revision 02 — Copyright © 2026, All Rights Reserved. SOLO Motor Controllers.