

ElectroCraft

PRO-A08V48B-SA-CAT

**Programmable Servo Drive
with EtherCAT® for Step,
DC, Brushless DC and AC
Motors**



Programmable Servo Drive

ElectroCraft Document Number
A11356 Rev 1

**Technical
Reference**

ELECTROCRAFT

PRO-A08V48B-SA-CAT

Technical Reference

ElectroCraft Document Number
A11356 Revision 1

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Read This First

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About This Manual

This book is a technical reference manual for:

- **PRO-A08V48B-SA-CAT** hardware version 'B'
Standard hardware configuration supports a differential encoder on Feedback #1.
Optional hardware configuration supports linear halls on Feedback#1.

In order to operate the **PRO-A08V48** drives, you need to perform the following 3 steps:

- Step 1 Hardware installation**
- Step 2 Drive setup** using the ElectroCraft **PROconfig** software for drive commissioning
- Step 3 Motion programming** using one of the options:
 - A **EtherCAT® master**
 - The drive's **built-in motion controller** executing an ElectroCraft Motion PROgramming Language (**MPL**) program developed using ElectroCraft **MotionPRO Suite** software
 - A **distributed control** approach which combines the above options, like for example a host calling motion functions programmed on the drives in MPL

This manual covers **Step 1** in detail. It describes the **PRO-A08V48B-SA-CAT** hardware including the technical data, the connectors and the wiring diagrams needed for installation. The manual also presents an overview of the following steps, and includes the scaling factors between the real SI units and the drive internal units. For detailed information regarding the next steps, refer to the related documentation.

Notational Conventions

This document uses the following conventions:

- **PRO-A08V48** – all products described in this manual
- **IU units** – Internal units of the drive
- **SI units** – International standard units (meter for length, seconds for time, etc.)
- **MPL** – Electrocrafft Motion Program Language
- **CoE** – CAN application protocol over EtherCAT®

Trademarks

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

Related Documentation

Help Screens within the PROconfig software – describes how to use **PROconfig** to quickly setup any ElectroCraft PRO Series drive for your application using only 2 dialogue boxes. The output of PROconfig is a set of setup data that can be downloaded into the drive EEPROM or saved on a PC file. At power-on, the drive is initialized with the setup data read from its EEPROM. With PROconfig it is also possible to retrieve the complete setup information from a drive previously programmed. PROconfig is part of the ElectroCraft Motion PRO Suite. Motion PRO Suite is available as part of a PRO Series Drive Evaluation Kit. Please contact ElectroCraft or your local ElectroCraft sales representative for more information on obtaining MotionPRO Suite or an evaluation kit.

CoE Programming (Document No. A11358) – explains how to program the ElectroCraft programmable drives using **CAN application protocol over EtherCAT®** and describes the associated object dictionary.

Motion Programming using ElectroCraft MotionPRO Suite (Document No. A11229) – describes how to use the MotionPRO Suite to create motion programs using the ElectroCraft Motion PROgramming Language (MPL). The MotionPRO Suite platform includes **PROconfig** for the drive/motor setup, and a **Motion Wizard** for the motion programming. The Motion Wizard provides a simple, graphical way of creating motion programs and automatically generates all the MPL instructions. *With MotionPRO Suite you can fully benefit from a key advantage of ElectroCraft drives – their capability to execute complex moves without requiring an external motion controller, thanks to their built-in motion controller.* Motion PRO Suite is available as part of a PRO Series Drive Evaluation Kit. Please contact ElectroCraft or your local ElectroCraft sales representative for more information on obtaining MotionPRO Suite or an evaluation kit.

If you Need Assistance ...

| If you want to ... | Contact ElectroCraft at ... |
|---|---|
| Visit ElectroCraft online | World Wide Web: www.electrocrafter.com |
| Receive general information or assistance (see Note) | World Wide Web: www.electrocrafter.com Email: drivesupport@electrocrafter.com |
| Ask questions about product operation or report suspected problems (see Note) | Tel : +1 734.662-7771 Email: drivesupport@electrocrafter.com |
| Make suggestions about, or report errors in documentation (see Note) | Mail: ElectroCraft 1 Progress Drive Dover, NH 03820 USA |

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1. Safety information

Read carefully the information presented in this chapter before carrying out the drive installation and setup! It is imperative to implement the safety instructions listed hereunder.

This information is intended to protect you, the drive and the accompanying equipment during the product operation. Incorrect handling of the drive can lead to personal injury or material damage.

Only qualified personnel may install, set up, operate and maintain the drive. A “qualified person” has the knowledge and authorization to perform tasks such as transporting, assembling, installing, commissioning and operating drives.

The following safety symbols are used in this manual:



WARNING! *SIGNALS A DANGER THAT MIGHT CAUSE BODILY INJURY TO THE OPERATOR. MAY INCLUDE INSTRUCTIONS TO PREVENT THIS SITUATION*



CAUTION! *SIGNALS A DANGER FOR THE DRIVE, WHICH MIGHT DAMAGE THE PRODUCT OR OTHER EQUIPMENT. MAY INCLUDE INSTRUCTIONS TO AVOID THIS SITUATION*

1.1. Warnings



WARNING! *TO AVOID ELECTRIC ARCING AND HAZARDS, NEVER PLUG / UNPLUG CABLES INTO THE PRO-A08V48B-SA-CAT WHILE THE POWER SUPPLIES ARE ON!*



WARNING! THE DRIVE MAY HAVE HOT SURFACES DURING OPERATION.



WARNING! DURING DRIVE OPERATION, THE CONTROLLED MOTOR WILL MOVE. KEEP AWAY FROM ALL MOVING PARTS TO AVOID INJURY

1.2. Cautions



CAUTION! THE POWER SUPPLIES CONNECTED TO THE DRIVE MUST COMPLY WITH THE PARAMETERS SPECIFIED IN THIS DOCUMENT



CAUTION!

**TROUBLESHOOTING AND SERVICING ARE
PERMITTED ONLY FOR PERSONNEL AUTHORISED BY
ELECTROCRAFT**

2. Product Overview

2.1. Introduction

The **PRO-A08V48B-SA-CAT** is part of a family of fully digital programmable servo drives, based on the latest DSP technology and they offer unprecedented drive performance combined with an embedded motion controller.

Suitable for control of brushless DC, brushless AC (vector control), DC brushed motors and step motors, the PRO-A08V48B-SA-CAT drives accept as position feedback incremental encoders (quadrature or sine/cosine) and SSI encoders.

All drives perform position, speed or torque control and work in single, multi-axis or stand-alone configurations. Thanks to the embedded motion controller, the PRO-A08V48B-SA-CAT drives combine controller, drive and PLC functionality in a single compact unit and are capable to execute complex motions without requiring intervention of an external motion controller. Using the high-level ElectroCraft Motion Programming Language (**MPL**) the following operations can be executed directly at drive level:

- Setting various motion modes (profiles, PVT, PT, electronic gearing or camming, etc.)
- Changing the motion modes and/or the motion parameters
- Executing homing sequences
- Controlling the program flow through:
 - Conditional jumps and calls of MPL functions
 - MPL interrupts generated on pre-defined or programmable conditions (protections triggered, transitions on limit switch or capture inputs, etc.)
 - Waits for programmed events to occur
- Handling of digital I/O and analog input signals
- Executing arithmetic and logic operations
- Performing data transfers between axes¹
- Controlling motion of an axis from another one via motion commands sent between axes¹

By implementing motion sequences directly at drive level you can really distribute the intelligence between the master and the drives in complex multi-axis applications, reducing both the development time and the overall communication requirements. For example, instead of trying to command each movement of an axis, you can program the drives using MPL to execute complex motion tasks and inform the master when these tasks are done. Thus, for each axis control the master job may be reduced at: calling MPL functions stored in the drive EEPROM and waiting for a message, which confirms the MPL functions execution completion.

For PRO-A08V48 commissioning **PRO Config** or **MotionPRO Developer** PC applications may be used.

PRO Config is a subset of MotionPRO Developer, including only the drive setup part. The output of PRO Config is a set of setup data that can be downloaded into the drive EEPROM or saved on a PC file. At

¹ In preparation. Please contact ElectroCraft for availability

power-on, the drive is initialized with the setup data read from its EEPROM. With PRO Config it is also possible to retrieve the complete setup information from a drive previously programmed. PRO Config shall be used for drive setup in all cases where the motion commands are sent exclusively from a master. Hence neither the PRO-A08V48 MPL programming capability nor the drive camming mode, are used.

MotionPRO Developer platform includes PRO Config for the drive setup, and a **Motion Wizard** for the motion programming. The Motion Wizard provides a simple, graphical way of creating motion programs and automatically generates all the MPL instructions. *With MotionPRO Developer you can fully benefit from a key advantage of ElectroCraft drives – their capability to execute complex motions, thanks to their built-in motion controllers.* MotionPRO Developer, shall be used to program motion sequences in MPL. MotionPRO Developer can also be used with EtherCAT® protocol, if the user wants to call MPL functions stored in the drive EEPROM or to use the camming mode. With camming mode, MotionPRO Developer offers the possibility to quickly download and test a cam profile and also to create a **.sw** file (see par. 5.2.4) with the cam data. The **.sw** file can be afterwards stored in a master and downloaded to the drive, wherever needed.

2.2. Key Features

- Fully digital servo drive suitable for the control of rotary or linear brushless, DC brush, and step motors with EtherCAT® interface and built-in motion controller with high-level MPL motion language
- Very compact design
- Sinusoidal (FOC) or trapezoidal (Hall-based) control of brushless motors
- Open or closed-loop control of 2 and 3-phase steppers
- Various modes of operation, including: cyclic synchronous torque, velocity or position control; position or velocity profiles, external analog reference or sent via a communication bus
- ElectroCraft Motion Programming Language (MPL) instruction set for the definition and execution of motion sequences
- Standalone operation with stored motion sequences
- Communication:
 - RS-232 serial up to 115kbits/s
 - Dual 100Mbps RJ45 EtherCAT® interfaces, for use in daisy-chaining topologies
- Digital and analog I/Os:
 - 6 digital inputs: 12-36 V, programmable polarity: sourcing/NPN or sinking/PNP: 2 Limit switches and 4 general-purpose
 - 5 digital outputs: 5-36 V, with 0.5 A, sinking/NPN open-collector (Ready, Error and 3 general-purpose)
 - 2 analog inputs: 12 bit, 0-5V: Reference and Feedback or general purpose
 - NTC/PTC analog Motor Temperature sensor input
- Feedback devices (dual-loop support):
Feedback #1 devices supported:
 - Incremental encoder interface (single ended or differential¹)
 - Pulse & direction interface (single-ended) for external (master) digital reference

¹ Differential Feedback #1 is not available with the p/n P027.214.E721

-
- Analog sin/cos encoder interface (differential 1V_{PP})
 - Digital Hall sensor interface (single-ended and open collector)
 - Linear Hall sensors interface¹

Feedback #2 devices supported:

- Incremental encoder interface (differential)
- Pulse & direction interface (differential) for external (master) digital reference
- BiSS² / SSI encoder interface
- 127 h/w selectable addresses
- Various motion programming modes:
 - Position profiles with trapezoidal or S-curve speed shape
 - Position, Velocity, Time (PVT) 3rd order interpolation
 - Position, Time (PT) 1st order interpolation
 - Electronic gearing and camming
 - 35 Homing modes
- 16K × 16 internal SRAM memory for data acquisition
- 16K × 16 E²ROM to store MPL programs and data
- PWM switching frequency up to 100kHz
- Motor supply: 12-50V
- Logic supply: 9-36V. Separate supply is optional
- Output current: PRO-A08V48B-SA-CAT: 8A³ continuous; 20A peak
- Operating ambient temperature: 0-40°C (over 40°C with derating)
- Protections:
 - Short-circuit between motor phases
 - Short-circuit from motor phases to ground
 - Over-voltage
 - Under-voltage
 - Over-current
 - Over-temperature
 - Communication error
 - Control error

¹ Only available with the p/n P027.214.E721

² Currently in development

³ 8A cont. with DC, step and BLDC motors (trapezoidal), 8A amplitude (5.66A_{RMS}) for PMSM (sinusoidal)

2.3. Identifying the drive hardware revision

Figure 2.1 shows how to identify the *PRO-A08V48B-SA-CAT* version. This manual refers to *PRO-A08V48B-SA-CAT* version **B**.

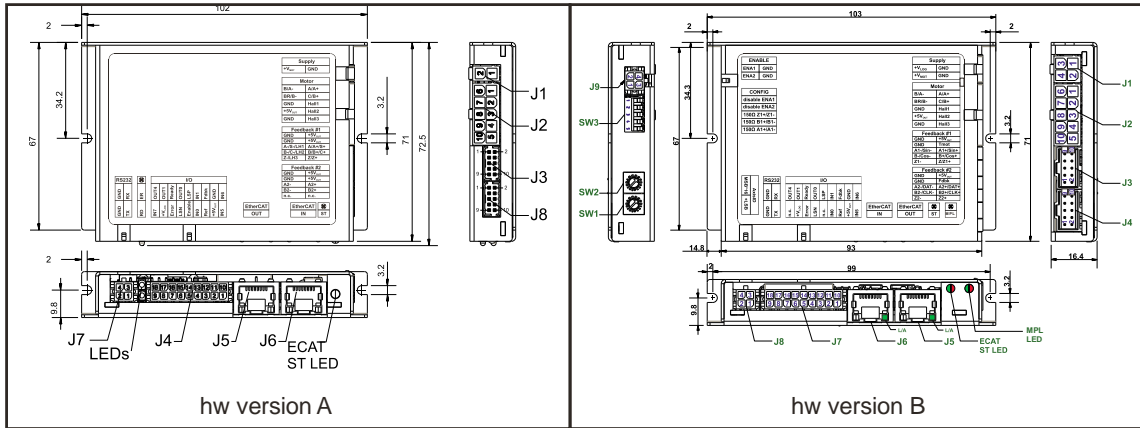


Figure 2.1. *PRO-A08V48B-SA-CAT* version A and version B comparison

Note 1: The hw version B has the p.n. P027.214.E221 or P027.214.E721
The hw version A has the p.n. P027.014.E221.

Note 2: Each p.n. has its own software template which is not compatible with the other.

2.4. Supported Motor-Sensor Configurations

PRO-A08V48B-SA-CAT supports the following configurations:

2.4.1. Single ended configurations

| Sensor \ Motor | PMSM | BLDC | DC BRUSH | STEP (2-ph) | STEP (3-ph) |
|------------------------|------|------|----------|-------------|-------------|
| Incr. Encoder | ● | | ● | ● | |
| Incr. Encoder + Hall | ● | ● | | | |
| Analog Sin/Cos encoder | ● | | ● | | |
| SSI | ● | | ● | | |
| BiSS-C* | ● | | | | |
| Linear Halls** | ● | | | | |
| Tacho | | | ● | | |
| Open-loop (no sensor) | | | | ● | ● |

*currently in development

**only with the p.n. P027.214.E721

2.4.2. Dual loop configurations

| Motor type | Feedback #1 | Feedback #2 |
|------------|--|--|
| PMSM | <ul style="list-style-type: none"> • Incremental encoder (single-ended or differential) • Analog Sin/Cos encoder | <ul style="list-style-type: none"> • Incremental encoder (differential) • SSI/BiSS encoder |
| DC Brush | <ul style="list-style-type: none"> • Incremental encoder (single-ended or differential) • Analog Sin/Cos encoder • Analog Tacho (only on motor) | <ul style="list-style-type: none"> • Incremental encoder (differential) • SSI/BiSS encoder |

Each defined motor type can have any combination of the supported feedbacks either on motor or on load.

Example:

-PMSM motor with Incremental encoder (from feedback #1) on motor and Incremental encoder (from feedback#2) on load

-DC brush motor with SSI encoder (from feedback #2) on motor and Sin/Cos encoder (from feedback #1) on load.

2.5. PRO-A08V48B-SA-CAT Drive Dimensions

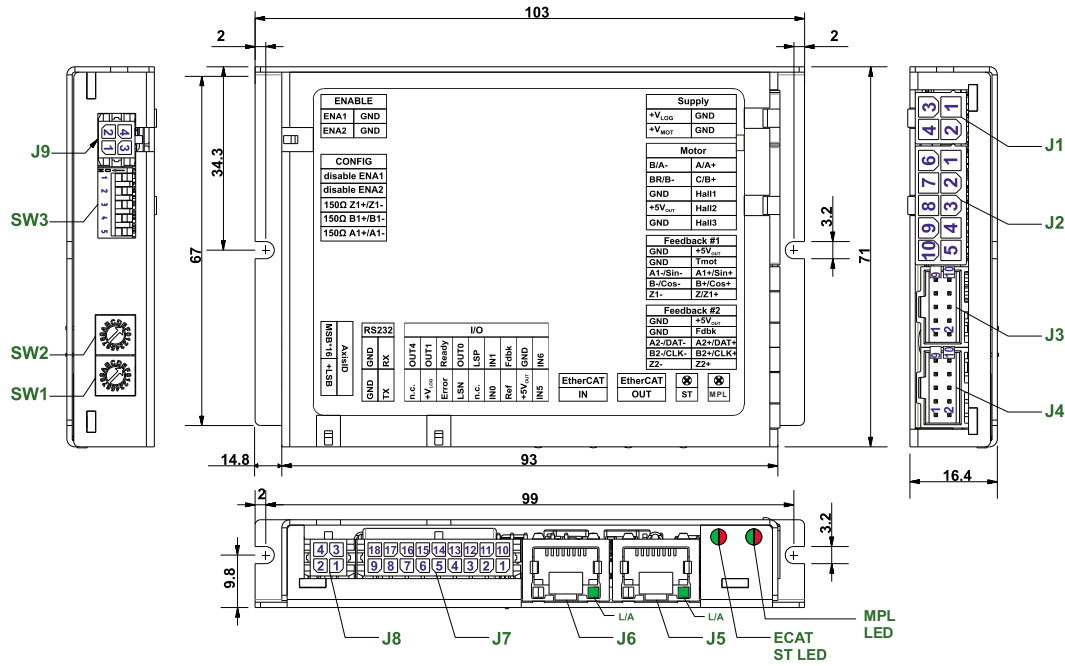


Figure 2.2. PRO-A08V48B-SA-CAT drive dimensions

All dimensions are in mm. The drawings are not to scale.

2.6. Identification Labels

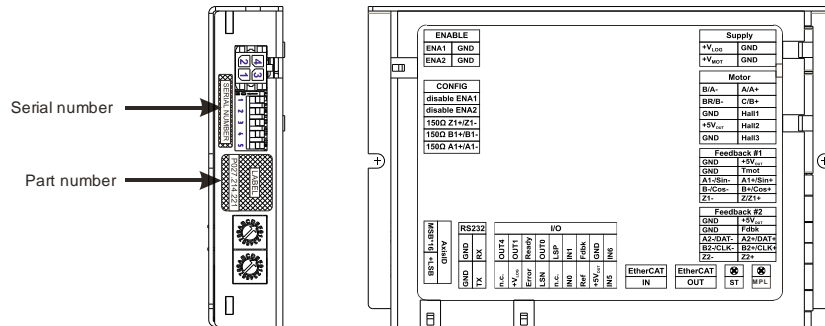


Figure 2.3. PRO-A08V48B-SA-CAT Identification Labels

The PRO-A08V48B-SA-CAT can have the following part numbers on the identification label:

- p.n. **P027.214.E221** – standard execution that supports a single ended and differential incremental encoder of Feedback #1.
- p.n. **P027.214.E721** – linear halls execution that supports a single ended encoder and linear halls on Feedback #1

2.7. Electrical Specifications

All parameters measured under the following conditions (unless otherwise specified):

$T_{amb} = 0 \dots 40^{\circ}\text{C}$, $V_{LOG} = 24 V_{DC}$; $V_{MOT} = 48V_{DC}$; Supplies start-up / shutdown sequence: *-any-*
Load current (sinusoidal amplitude / continuous BLDC, DC, stepper) = 8A

2.7.1. Operating Conditions

| | | Min. | Typ. | Max. | Units |
|----------------------------------|------------------------------------|----------------|----------|--------------|-------|
| Ambient temperature ¹ | | 0 | | +40 | °C |
| Ambient humidity | Non-condensing | 0 | | 90 | %Rh |
| Altitude / pressure ² | Altitude (referenced to sea level) | -0.1 | 0 ÷ 2.5 | ² | Km |
| | Ambient Pressure | 0 ² | 0.75 ÷ 1 | 10.0 | atm |

2.7.2. Storage Conditions

| | | Min. | Typ. | Max. | Units |
|--------------------------------------|---|------|------|------|-------|
| Ambient temperature | | -40 | | +105 | °C |
| Ambient humidity | Non-condensing | 0 | | 100 | %Rh |
| Ambient Pressure | | 0 | | 10.0 | atm |
| ESD capability (Human body model) | Not powered; applies to any accessible part | | | ±0.5 | kV |
| | Original packaging | | | ±15 | kV |

2.7.3. Mechanical Mounting

| | | |
|---------|--|--|
| Airflow | | natural convection ³ , closed box |
|---------|--|--|

2.7.4. Environmental Characteristics

| | | Min. | Typ. | Max. | Units |
|----------------------------------|-------------------------------------|-------------------------------|------|------|-------|
| Size (Length x Width x Height) | Without mating connector | 103 x 71 x 16.4 | | | mm |
| | | ~4.06 x 2.8 x 0.65 | | | inch |
| | With recommended mating connectors. | 109 x 79 x 19.5 | | | mm |
| | | ~4.3 x 3.1 x 0.77 | | | inch |
| Weight | Without mating connectors | 125 | | | g |
| Power dissipation | Idle (no load) | | 3.4 | | W |
| | Operating | | 8.5 | | |
| Efficiency | | | 98 | | % |
| Cleaning agents | Dry cleaning is recommended | Only Water- or Alcohol- based | | | |

¹ Operating temperature at higher temperatures is possible with reduced current and power ratings.

² PRO-A08V48 can be operated in vacuum (no altitude restriction), but at altitudes over 2,500m, current and power rating are reduced due to thermal dissipation efficiency.

³ In case of forced cooling (conduction or ventilation) the maximum ambient temperature can be increased substantially

| | | | |
|-------------------|------------------------------|------|---|
| Protection degree | According to IEC60529, UL508 | IP20 | - |
|-------------------|------------------------------|------|---|

2.7.5. Logic Supply Input (+V_{LOG})

| | | Min. | Typ. | Max. | Units |
|----------------|--|-------------------------|------|------|-----------------|
| Supply voltage | Nominal values | 9 | | 36 | V _{DC} |
| | Absolute maximum values, drive operating but outside guaranteed parameters | 8 | | 40 | V _{DC} |
| | Absolute maximum values, surge (duration ≤ 10ms) † | -1 | | +45 | V |
| Supply current | No Load on Digital Outputs | +V _{LOG} = 9V | | 400 | mA |
| | | +V _{LOG} = 12V | | 300 | |
| | | +V _{LOG} = 24V | | 150 | |
| | | +V _{LOG} = 40V | | 90 | |

2.7.6. Motor Supply Input (+V_{MOT})

| | | Min. | Typ. | Max. | Units |
|----------------|--|------|------|------|-----------------|
| Supply voltage | Nominal values | 11 | 48 | 50 | V _{DC} |
| | Absolute maximum values, drive operating but outside guaranteed parameters | 9 | | 52 | V _{DC} |
| | Absolute maximum values, surge (duration ≤ 10ms) † | -1 | | 57 | V |
| Supply current | Idle | | 1 | 5 | mA |
| | Operating | -20 | ±8 | +20 | A |
| | Absolute maximum value, short-circuit condition (duration ≤ 10ms) † | | | 26 | A |

2.7.7. Motor Outputs (A/A+, B/A-, C/B+, BR/B-)

| | | Min. | Typ. | Max. | Units |
|--------------------------------------|---|----------------------------|------|------|-------|
| Nominal output current, continuous | for DC brushed, steppers and BLDC motors with Hall-based trapezoidal control | | | 8 | A |
| | for PMSM motors with FOC sinusoidal control (sinusoidal amplitude value) | | | 8 | |
| | for PMSM motors with FOC sinusoidal control (sinusoidal effective value) | | | 5.66 | |
| Motor output current, peak | maximum 2.5s | -20 | | +20 | A |
| Short-circuit protection threshold | measurement range | ±22 | ±26 | ±30 | A |
| Short-circuit protection delay | | 5 | 10 | | µs |
| On-state voltage drop | for nominal output current; including typical mating connector contact resistance | | ±0.3 | ±0.5 | V |
| Off-state leakage current | | | ±0.5 | ±1 | mA |
| Motor inductance (phase-to-phase) | Recommended value, for ripple ±5% of measurement range; +V _{MOT} = 48 V | F _{PWM} = 20 kHz | 330 | | µH |
| | | F _{PWM} = 40 kHz | 150 | | |
| | | F _{PWM} = 60 kHz | 120 | | |
| | | F _{PWM} = 80 kHz | 80 | | |
| | | F _{PWM} = 100 kHz | 60 | | |
| | Absolute minimum value, limited by short-circuit protection; +V _{MOT} = 48 V | F _{PWM} = 20 kHz | 120 | | µH |
| | | F _{PWM} = 40 kHz | 40 | | |
| | | F _{PWM} = 60 kHz | 30 | | |
| | | F _{PWM} = 80 kHz | 15 | | |
| | | F _{PWM} = 100 kHz | 8 | | |
| Motor electrical time-constant (L/R) | Recommended value, for ±5% current measurement error due to ripple | F _{PWM} = 20 kHz | 250 | | µs |
| | | F _{PWM} = 40 kHz | 125 | | |
| | | F _{PWM} = 60 kHz | 100 | | |
| | | F _{PWM} = 80 kHz | 63 | | |
| | | F _{PWM} = 100 kHz | 50 | | |
| Current measurement accuracy | FS = Full Scale | | ±4 | ±8 | %FS |

2.7.8. Digital Inputs (IN0, IN1, IN2/LSP, IN3/LSN, IN5, IN6)¹

| | | Min. | Typ. | Max. | Units |
|---------------------|---|-----------|------|------|-------|
| Mode compliance | | PNP | | | |
| Default state | Input floating (wiring disconnected) | Logic LOW | | | |
| Input voltage | Logic "LOW" | -36 | 0 | 2.4 | V |
| | Logic "HIGH" | 7.5 | 24 | 36 | |
| | Floating voltage (not connected) | | 0 | | |
| | Absolute maximum, continuous | -36 | | +39 | |
| | Absolute maximum, surge (duration ≤ 1s) † | -50 | | +50 | |
| Input current | Logic "LOW"; Pulled to GND | | 0 | | mA |
| | Logic "HIGH" | | 9 | 10 | |
| Input frequency | | 0 | | 150 | kHz |
| Minimum pulse width | | 3.3 | | | µs |
| ESD protection | Human body model | ±2 | | | kV |

| | | Min. | Typ. | Max. | Units |
|---------------------|--|------------------------------------|------|------|-------|
| Mode compliance | | NPN / Open-collector / 24V outputs | | | |
| Default state | Input floating (wiring disconnected) | Logic HIGH | | | |
| Input voltage | Logic "LOW" | | 0 | 0.8 | V |
| | Logic "HIGH" | 2 | 5÷24 | | |
| | Floating voltage (not connected) | | 3 | | |
| | Absolute maximum, continuous | -10 | | +30 | |
| | Absolute maximum, surge (duration ≤ 1S) † | -20 | | +40 | |
| Input current | Logic "LOW"; Pulled to GND | | 0.6 | 1 | mA |
| | Logic "HIGH"; Internal 4.7KΩ pull-up to +3.3 | 0 | 0 | 0 | |
| | Logic "HIGH"; Pulled to +5V | | 0.15 | 0.2 | |
| | Logic "HIGH"; Pulled to +24V | | 2 | 2.5 | |
| Input frequency | | 0 | | 150 | kHz |
| Minimum pulse width | | 3.3 | | | µs |
| ESD protection | Human body model | ±2 | | | kV |

¹ The digital inputs are software selectable as PNP or NPN

2.7.9. Digital Outputs (OUT0, OUT1, OUT2/Error, OUT3/ Ready, OUT4)

| | | Min. | Typ. | Max. | Units | |
|---------------------|---|--------------------------------|------------------|-----------------------|-------|-----|
| Mode compliance | All outputs (OUT0, OUT1, OUT2/Error, OUT3/Ready, OUT4) | TTL / Open-collector / NPN 24V | | | | |
| Default state | Not supplied (+V _{LOG} floating or to GND) | High-Z (floating) | | | | |
| | Immediately after power-up | OUT0, OUT1, OUT4 | Logic "HIGH" | | | |
| | | OUT2/Error, OUT3/Ready | Logic "LOW" | | | |
| | Normal operation | OUT0, OUT1, OUT2/Error, OUT4 | Logic "HIGH" | | | |
| OUT3/Ready | | Logic "LOW" | | | | |
| Output voltage | Logic "LOW"; output current = 0.5A | | | 0.8 | V | |
| | Logic "HIGH"; output current = 0, no load | OUT2/Error, OUT3/Ready | 2.9 | 3 | | 3.3 |
| | | OUT0, OUT1, OUT4 | 4 | 4.5 | | 5 |
| | Logic "HIGH", external load to +V _{LOG} | | V _{LOG} | | | |
| | Absolute maximum, continuous | -0.5 | | V _{LOG} +0.5 | | |
| | Absolute maximum, surge (duration ≤ 1S) † | -1 | | V _{LOG} +1 | | |
| Output current | Logic "LOW", sink current, continuous | | | 0.5 | A | |
| | Logic "LOW", sink current, pulse ≤ 5 sec. | | | 1 | A | |
| | Logic "HIGH", source current; external load to GND; V _{OUT} ≥ 2.0V | OUT2/Error, OUT3/Ready | | | 2 | mA |
| | | OUT0, OUT1, OUT4 | | | 4 | mA |
| | Logic "HIGH", leakage current; external load to +V _{LOG} ; V _{OUT} = V _{LOG} max = 40V | | 0.1 | 0.2 | mA | |
| Minimum pulse width | | 2 | | | μs | |
| ESD protection | Human body model | ±15 | | | kV | |

2.7.10. Digital Hall Inputs (Hall1, Hall2, Hall3)

| | | Min. | Typ. | Max. | Units |
|---------------------|--|-----------------------------|------|------|-------|
| Mode compliance | | TTL / CMOS / Open-collector | | | |
| Default state | Input floating (wiring disconnected) | Logic HIGH | | | |
| Input voltage | Logic "LOW" | | 0 | 0.8 | V |
| | Logic "HIGH" | 2 | 5 | | |
| | Floating voltage (not connected) | | 4.4 | | |
| | Absolute maximum, surge (duration ≤ 1S) † | -10 | | +15 | |
| Input current | Logic "LOW"; Pull to GND | | | 1.2 | mA |
| | Logic "HIGH"; Internal 4.7KΩ pull-up to +5 | 0 | 0 | 0 | |
| Minimum pulse width | | 2 | | | μs |

| | | | | | |
|----------------|------------------|----|--|--|----|
| ESD protection | Human body model | ±5 | | | kV |
|----------------|------------------|----|--|--|----|

2.7.11. Encoder1 Inputs (A1/A1+, A1-, B1/B1+, B1-, Z1/Z1+, Z1-)

| | | Min. | Typ. | Max. | Units |
|--|--|-----------------------------|------|------|-------|
| Single-ended mode compliance | Leave negative inputs disconnected | TTL / CMOS / Open-collector | | | |
| Input voltage, single-ended mode A/A+, B/B+ | Logic "LOW" | | | 1.6 | V |
| | Logic "HIGH" | 1.8 | | | |
| | Floating voltage (not connected) | | 3.3 | | |
| Input voltage, single-ended mode Z/Z+ | Logic "LOW" | | | 1.2 | V |
| | Logic "HIGH" | 1.4 | | | |
| | Floating voltage (not connected) | | 4.7 | | |
| Input current, single-ended mode A/A+, B/B+, Z/Z+ | Logic "LOW"; Pull to GND | | 5.5 | 6 | mA |
| | Logic "HIGH"; Internal 2.2KΩ pull-up to +5 | 0 | 0 | 0 | |
| Differential mode compliance | For full RS422 compliance, see ¹ | TIA/EIA-422-A | | | |
| Input voltage, differential mode | Hysteresis | ±0.06 | ±0.1 | ±0.2 | V |
| | Common-mode range (A+ to GND, etc.) | -7 | | +7 | |
| Input impedance, differential | A1+ to A1-, B1+ to B1-, Z1+ to Z1- | | 1 | | kΩ |
| Input frequency | Single-ended mode, Open-collector / NPN | 0 | | 5 | kHz |
| | Differential mode, or Single-ended driven by push-pull (TTL / CMOS) | 0 | | 10 | MHz |
| Minimum pulse width | Single-ended mode, Open-collector / NPN | 1 | | | μs |
| | Differential mode, or Single-ended driven by push-pull (TTL / CMOS) | 50 | | | ns |
| Input voltage, any pin to GND | Absolute maximum values, continuous | -7 | | +7 | V |
| | Absolute maximum, surge (duration ≤ 1S) [†] | -11 | | +14 | |
| ESD protection | Human body model | ±1 | | | kV |

2.7.12. Encoder2 Inputs (A2+/Data+, A2-/Data-, B2+/Clk+, B2-/Clk-, Z2+, Z2-)²

| | | Min. | Typ. | Max. | Units |
|-------------------------------|--|---------------|------|------|-------|
| Differential mode compliance | | TIA/EIA-422-A | | | |
| Input voltage | Hysteresis | ±0.06 | ±0.1 | ±0.2 | V |
| | Differential mode | -14 | | +14 | |
| | Common-mode range (A+ to GND, etc.) | -11 | | +14 | |
| Input impedance, differential | A2+, B2+, Z2+ A2-, B2-, Z2- | | 150 | | Ω |
| Input frequency | Differential mode | 0 | | 10 | MHz |
| Minimum pulse width | Differential mode | 50 | | | ns |

¹ For full RS-422 compliance, 150Ω termination resistors must be connected across the differential pairs, set SW3 pins 3, 4 and 5 to ON; not available on the p/n P027.214.E721

² Encoder2 differential input pins have internal 150Ω termination resistors connected across

| | | | | | |
|----------------|------------------|----|--|--|----|
| ESD protection | Human body model | ±1 | | | kV |
|----------------|------------------|----|--|--|----|

2.7.13. Linear Hall Inputs (LH1, LH2, LH3)¹

| | | Min. | Typ. | Max. | Units |
|--------------------------|--|------|---------|------|-------|
| Input voltage | Operational range | 0 | 0.5÷4.5 | 4.9 | V |
| | Absolute maximum values, continuous | -7 | | +7 | |
| | Absolute maximum, surge (duration ≤ 1S) [†] | -11 | | +14 | |
| Input current | Input voltage 0...+5V | -1 | ±0.9 | +1 | mA |
| Interpolation Resolution | Depending on software settings | | | 11 | bits |
| Frequency | | 0 | | 1 | kHz |
| ESD protection | Human body model | ±1 | | | kV |

2.7.14. Sin-Cos Encoder Inputs (Sin+, Sin-, Cos+, Cos-)²

| | | Min. | Typ. | Max. | Units |
|-------------------------------|--|------|------|------|-----------------|
| Input voltage, differential | Sin+ to Sin-, Cos+ to Cos- | | 1 | 1.25 | V _{PP} |
| Input voltage, any pin to GND | Operational range | -1 | 2.5 | 4 | V |
| | Absolute maximum values, continuous | -7 | | +7 | |
| | Absolute maximum, surge (duration ≤ 1S) [†] | -11 | | +14 | |
| Input impedance | Differential, Sin+ to Sin-, Cos+ to Cos- | 4.2 | 4.7 | | kΩ |
| | With SW3 pins 2,3 to ON | | 150 | | Ω |
| | Common-mode, to GND | | 2.2 | | kΩ |
| Interpolation Resolution | Depending on software settings | | | 11 | bits |
| Frequency | Sin-Cos interpolation | 0 | | 450 | kHz |
| | Quadrature, no interpolation | 0 | | 10 | MHz |
| ESD protection | Human body model | ±1 | | | kV |

¹ Available only with the p/n P027.214.E721

² Available only with the p/n P027.214.E221

2.7.15. Analog 0...5V Inputs (REF, FDBK)

| | | Min. | Typ. | Max. | Units |
|--------------------|---|------|------|------|-------------------|
| Input voltage | Operational range | 0 | | 5 | V |
| | Absolute maximum values, continuous | -12 | | +18 | |
| | Absolute maximum, surge (duration ≤ 1S) † | | | ±36 | |
| Input impedance | To GND | | 28 | | kΩ |
| Resolution | | 12 | | | bits |
| Integral linearity | | | | ±2 | bits |
| Offset error | | | ±2 | ±10 | bits |
| Gain error | | | ±1% | ±3% | % FS ¹ |
| Bandwidth (-3dB) | Depending on software settings | 0 | | 1 | kHz |
| ESD protection | Human body model | ±5 | | | kV |

2.7.16. RS-232

| | | Min. | Typ. | Max. | Units |
|--------------------------|--------------------------------|---------------|------|--------|-------|
| Standards compliance | | TIA/EIA-232-C | | | |
| Bit rate | Depending on software settings | 9600 | | 115200 | Baud |
| Short-circuit protection | 232TX short to GND | Guaranteed | | | |
| ESD protection | Human body model | ±2 | | | kV |

2.7.17. EtherCAT®

| | | Min. | Typ. | Max. | Units |
|----------------------------------|---|--------------------------------|------|------|-------|
| Standards compliance | | IEEE802.3, IEC61158 | | | |
| Transmission line specification | According to TIA/EIA-568-5-A | Cat.5e.UTP | | | |
| J5, J6 pinout | EtherCAT® supports MDI/MDI-X auto-crossover | TIA/EIA-568-A or TIA/EIA-568-B | | | |
| Software protocols compatibility | | CoE, CiA402, IEC61800-7-301 | | | |
| Node addressing | By software, via PRO Config | 1 ÷ 255 | | | - |
| | By hardware via hex sw1 and sw2 | 1 ÷ 127 | | | - |
| MAC addressing | EtherCAT® uses no MAC address | none | | | - |
| ESD protection | Human body model | ±15 | | | kV |

¹ "FS" stands for "Full Scale"

2.7.18. Supply Output (+5V)

| | | Min. | Typ. | Max. | Units |
|--------------------------|-------------------------|---------------|------|------|-------|
| +5V output voltage | Current sourced = 250mA | 4.8 | 5 | 5.2 | V |
| +5V output current | | 200 | 250 | | mA |
| Short-circuit protection | | NOT protected | | | |
| Over-voltage protection | | NOT protected | | | |
| ESD protection | Human body model | ±1 | | | kV |

† Stresses beyond values listed under “absolute maximum ratings” may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

3. Step 1. Hardware Installation

3.1. Mechanical Mounting

The PRO-A08V48B-SA-CAT drive is intended to be mounted vertically on a metallic support using the provided mounting holes and the recommended mating connectors, as specified in chapter 3.2.

For thermal calculations, each PRO-A08V48 drive can be assumed to generate 3.4 Watt at idle, and up to 8.5 Watts (= 29 BTU/hour) worst case while driving a motor and using all digital outputs.

When the PRO-A08V48B-SA-CAT is mounted vertically, its overall envelope (size) including the recommended mating connectors is shown in *Figure 3.1*. Fixing the PRO-A08V48B-SA-CAT onto a support using the provided mounting holes is strongly recommended to avoid vibration and shock problems.

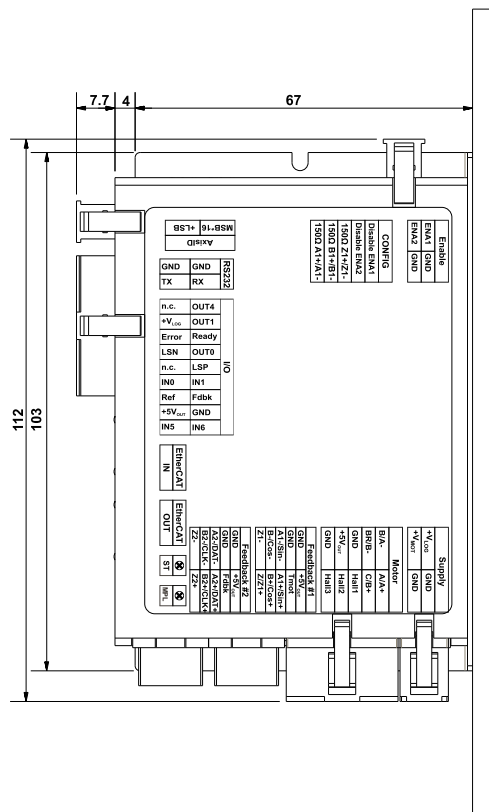


Figure 3.1 Overall dimensions using recommended mating connectors

The PRO-A08V48B-SA-CAT drive(s) can be cooled by natural convection. The support shall be thermally conductive (metallic), and shall be mounted vertically.

Figure 3.2 shows the minimum spacing to assure proper airflow by natural convection.

If closed completely in a box, ventilation openings shall be foreseen on the top and bottom sides.

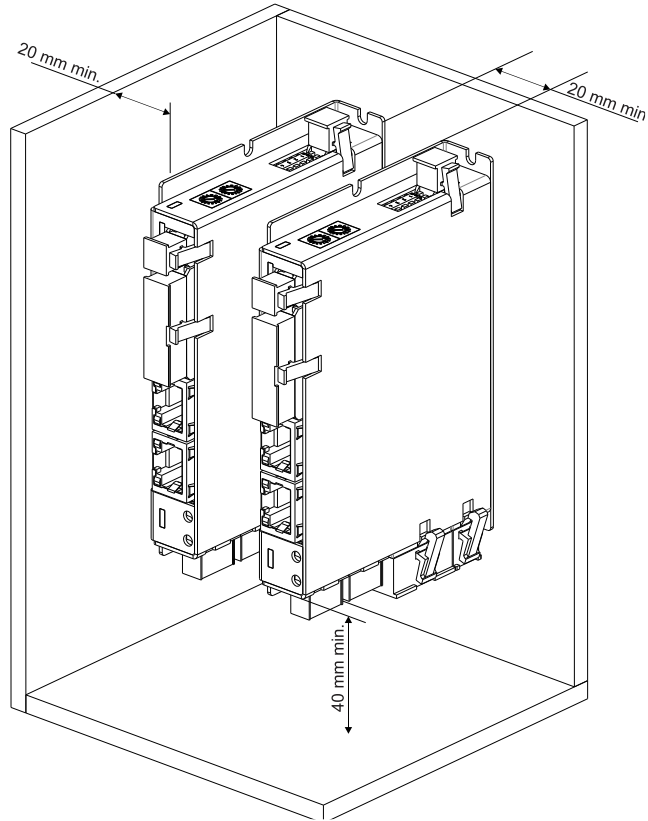


Figure 3.2 Minimum spacing for vertical mounting, metallic box

If ventilation driven by natural convection is not enough to maintain the temperature surrounding the PRO-A08V48B-SA-CAT drive(s), then alternate forced cooling methods must be applied.

3.2. Mating Connectors

| Connector | Description | Manufacturer | Part Number | Wire Gauge |
|------------|--|--------------|-------------|------------|
| J1 | MINIFIT JR. receptacle housing, 2x2 way | MOLEX | 39-03-9042 | AWG 18-20 |
| J2 | MINIFIT JR. receptacle housing, 2x5 way | MOLEX | 39-03-9102 | AWG 18-20 |
| J1,J2 | CRIMP PIN, MINIFIT JR., 13A | MOLEX | 45750-1111 | AWG 18-20 |
| J3, J4 | C-Grid III™ Crimp Housing Dual Row, 10 Circuits, with retention | MOLEX | 90142-0010 | AWG 22..24 |
| | C-Grid III™ Crimp Housing Dual Row, 10 Circuits, without retention | | 90143-0010 | |
| J3, J4 | C-Grid III™ Crimp Terminal | MOLEX | 90119-0109 | AWG 22..24 |
| J7 | MICROFIT RECEPTACLE HOUSING, 2x9 WAY | MOLEX | 43025-1800 | AWG 20..24 |
| J8, J9 | MICROFIT RECEPTACLE HOUSING, 2x2 WAY | MOLEX | 43025-0400 | AWG 20..24 |
| J7, J8, J9 | CRIMP PIN, MICROFIT, 5A | MOLEX | 43030-0007 | AWG 20..24 |
| J5, J6 | Standard 8P8C modular jack (RJ-45) male | - | - | - |

3.3. Connectors and Connection Diagrams

3.3.1. Connector Layout

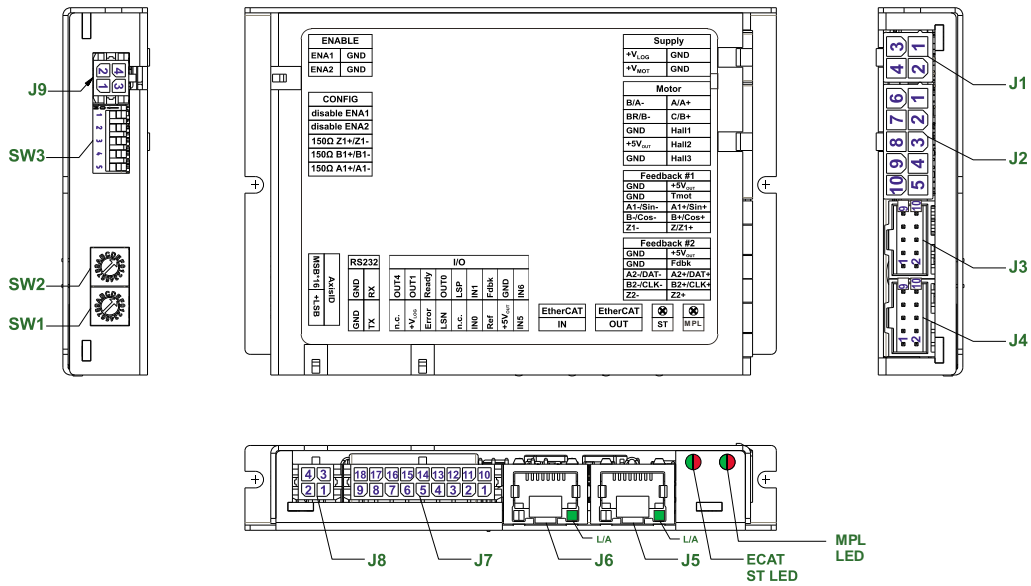


Figure 3.3. PRO-A08V48B-SA-CAT drive connectors

3.3.2. J1 Motor and logic supply input connector pinout

| Connector description | | | | |
|-----------------------|------|-------------------|-------------|--|
| Pin | Name | Type | Description | |
| J1 | 1 | GND | - | Negative return (ground) of the power supply |
| | 2 | GND | - | Negative return (ground) of the power supply |
| | 3 | +V _{LOG} | I | Positive terminal of the logic supply input: 9 to 36V _{DC} . Internally connected to J7 pin 8 |
| | 4 | +V _{MOT} | I | Positive terminal of the motor supply: 11 to 50V _{DC} . |

3.3.3. J2 Motor output and digital hall signals connector pinout

| Connector description | | | |
|-----------------------|------|--------------------|---|
| Pin | Name | Type | Description |
| J2 | 1 | A/A+ | O Phase A for 3-ph motors, A+ for 2-ph steppers, Motor+ for DC brush motors |
| | 2 | C/B+ | O Phase C for 3-ph motors, B+ for 2-ph steppers |
| | 3 | Hall 1 | I Digital input Hall 1 sensor |
| | 4 | Hall 2 | I Digital input Hall 2 sensor |
| | 5 | Hall 3 | I Digital input Hall 3 sensor |
| | 6 | B/A- | O Phase B for 3-ph motors, A- for 2-ph steppers, Motor- for DC brush motors |
| | 7 | BR/B- | O Brake resistor / Phase B- for step motors |
| | 8 | GND | - Negative return (ground) of the motor supply |
| | 9 | +5V _{OUT} | O 5V output supply - internally generated |
| | 10 | GND | - Negative return (ground) of the motor supply |

3.3.4. J3 Primary feedback connector pinout for the p.n. P027.214.E221

| Connector description | | | |
|-----------------------|------|--------------------|--|
| Pin | Name | Type | Description |
| J3 | 1 | Z1- | I Incr. encoder1 Z- diff. input |
| | 2 | Z1+ | I Incr. encoder1 Z single-ended, or Z+ diff. input |
| | 3 | B1-/Cos- | I Incr. encoder1 B- diff. input, or analog encoder Cos- diff. input |
| | 4 | B1+/Cos+ | I Incr. encoder1 B single-ended, or B+ diff. input, or analog encoder Cos+ diff. input |
| | 5 | A1-/Sin- | I Incr. encoder1 A- diff. input, or analog encoder Sin- diff. input |
| | 6 | A1+/Sin+ | I Incr. encoder1 A single-ended, or A+ diff. input, or analog encoder Sin+ diff. input |
| | 7 | GND | - Return ground for sensors supply |
| | 8 | Temp Mot | I NTC/PTC input. Used to read an analog temperature value |
| | 9 | GND | - Return ground for sensors supply |
| | 10 | +5V _{OUT} | O 5V output supply for I/O usage |

3.3.5. J3 Primary feedback connector pinout for the p.n. P027.214.E721

| Connector description | | | |
|-----------------------|------|--------------------|--|
| Pin | Name | Type | Description |
| J3 | 1 | LH3 / FDBK | I Linear Hall 3 input or Analog input, 12-bit, 0-5V. Used to read an analog position or speed feedback (as tacho), or used as general purpose analog input |
| | 2 | Z1 | I Incr. encoder1 Z single-ended |
| | 3 | LH2 | I Linear Hall 1 input |
| | 4 | B1 | I Incr. encoder1 B single-ended |
| | 5 | LH1 | I Linear Hall 1 input |
| | 6 | A1 | I Incr. encoder1 A single-ended |
| | 7 | GND | - Return ground for sensors supply |
| | 8 | Temp Mot | I NTC/PTC input. Used to read an analog temperature value |
| | 9 | GND | - Return ground for sensors supply |
| | 10 | +5V _{OUT} | O 5V output supply for I/O usage |

3.3.6. J4 Secondary feedback connector pinout

| Connector description | | | | |
|-----------------------|-----------------------|--------------------------|--|--|
| Pin | Name | Type | Description | |
| 1 | Z2- | I | Incr. encoder2 Z- diff. input; has 150Ω resistor between pins 1 and 2 | |
| 2 | Z2+ | I | Incr. encoder2 Z+ diff. input ; has 150Ω resistor between pins 1 and 2 | |
| 3 | B2-/Dir- /CLK-/MA- | I/O | Incr. encoder2 B- diff. input, or Dir-, or Clock- for SSI, or Master- for BiSS; has 150Ω resistor between pins 3 and 4 | |
| 4 | B2+/Dir+/CL K+/MA+ | I/O | Incr. encoder2 B+ diff. input, or Dir+, or Clock+ for SSI, or Master+ for BiSS; has 150Ω resistor between pins 3 and 4 | |
| J4 | 5 | A2-/Pulse-/ Data-/SL- | I | Incr. encoder2 A- diff. input, or Pulse-, or Data- for SSI, or Slave- for BiSS; has 150Ω resistor between pins 5 and 6 |
| | 6 | A2+/Pulse+/ Data+/SL+ | I | Incr. encoder2 A+ diff. input, or Pulse+, or Data+ for SSI, or Slave+ for BiSS; has 150Ω resistor between pins 5 and 6 |
| | 7 | GND | - | Return ground for sensors supply |
| | 8 | FDBK | I | Analog input, 12-bit, 0-5V. Used to read an analog position or speed feedback (as tacho), or used as general purpose analog input; Also connected to J7 pin12. |
| | 9 | GND | - | Return ground for sensors supply |
| | 10 | +5V _{OUT} | O | 5V output supply for sensors usage |

3.3.7. J5, J6 EtherCAT® connectors

J5 and J6 are standard RJ45 Ethernet connectors, compatible with IEEE802.3 100BASE-T (100Mbit/s). Accept STP/UTP wiring.

| Connector description | | | |
|-----------------------|----------|------|--|
| Port | Name | Type | Description |
| J5 | ECAT OUT | O | EtherCAT standard RJ45 Ethernet OUT port |
| J6 | ECAT IN | I | EtherCAT standard RJ45 Ethernet IN port |

3.3.8. J7 Digital, analog I/O and logic supply connector pinout

| Connector description | | | |
|-----------------------|--------------------|------|--|
| Pin | Name | Type | Description |
| 1 | IN5 | I | 12-36V general-purpose digital PNP/NPN input |
| 2 | +5V _{OUT} | O | 5V output supply for I/O usage |
| 3 | REF | I | Analog input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or used as general purpose analog input |
| 4 | IN0 | I | 12-36V general-purpose digital PNP/NPN input |
| 5 | n.c. | - | not connected |
| 6 | IN3/LSN | I | 12-36V digital PNP/NPN input. Negative limit switch input |
| 7 | OUT2/Error | O | 5-36V 0.5A, drive Error output, active low, NPN open-collector/TTL pull-up. Also drives the red Error LED. |
| 8 | +V _{LOG} | I | Positive terminal of the logic supply: 9 to 36V _{DC} ; Internally connected to J1 pin 3 |
| 9 | n.c. | - | not connected |
| 10 | IN6 | I | 12-36V general-purpose digital PNP/NPN input |
| 11 | GND | - | Return ground for I/O pins |
| 12 | FDBK | I | Analog input, 12-bit, 0-5V. Used to read an analog position or speed feedback (as tacho), or used as general purpose analog input; Connected also to J4 pin 8. |
| 13 | IN1 | I | 12-36V general-purpose digital PNP/NPN input |
| 14 | IN2/LSP | I | 12-36V digital PNP/NPN input. Positive limit switch input |
| 15 | OUT0 | O | 5-36V 0.5A, general-purpose digital output, NPN open-collector/TTL pull-up |
| 16 | OUT3/Ready | O | 5-36V 0.5A, drive Ready output, active low, NPN open-collector/TTL pull-up. Also drives the green Ready LED. |
| 17 | OUT1 | O | 5-36V 0.5A, general-purpose digital output, NPN open-collector/TTL pull-up |
| 18 | OUT4 | O | 5-36V 0.5A, general-purpose digital output, NPN open-collector/TTL pull-up |

3.3.9. J8 RS232 connector pinout

| Connector description | | | |
|-----------------------|-------|------|-------------------------------|
| Pin | Name | Type | Description |
| 1 | 232TX | O | RS-232 Data Transmission |
| 2 | GND | - | Return ground for RS-232 pins |
| 3 | 232RX | I | RS-232 Data Reception |
| 4 | GND | - | Return ground for RS-232 pins |

3.3.10. J9 Enable circuit connector pinout

| Connector description | | | |
|-----------------------|------|------|--|
| Pin | Name | Type | Description |
| 1 | ENA2 | I | Enable circuit input2; connect ENA1&ENA2 to +24V to activate motor operation |
| 2 | ENA1 | I | Enable circuit input1; connect ENA1&ENA2 to +24V to activate motor operation |
| 3 | GND | - | Return ground |
| 4 | GND | - | Return ground |

3.3.11. SW1 and SW2 Axis ID selection switches

| Switch description | | |
|--------------------|----------|--|
| Switch | Position | Description |
| SW1 | 0..F(15) | H/W Axis ID = SW2(MSB)*16 + SW1(LSB) |
| SW2 | 0..7 | Exception: SW2=0 and SW1=0 -->Axis ID = 255. Remark:SW2 should be set only between 0 and 7. |

3.3.12. SW3 Hardware Configuration selection DIP switch

| Switch description | | |
|--------------------|----------|---|
| Pin | Position | Description |
| 1 | down(ON) | Disable ENA1 functionality. Connects internally +V _{LOG} to ENA1 |
| 2 | down(ON) | Disable ENA2 functionality. Connects internally +V _{LOG} to ENA2 |
| 3 | down(ON) | Connect an 150Ω resistor between Z1+ and Z1- feedback pins |
| 4 | down(ON) | Connect an 150Ω resistor between B1+ and B1- feedback pins |
| 5 | down(ON) | Connect an 150Ω resistor between A1+ and A1- feedback pins |

3.3.13. 24V Digital I/O Connection

3.3.13.1 PNP inputs

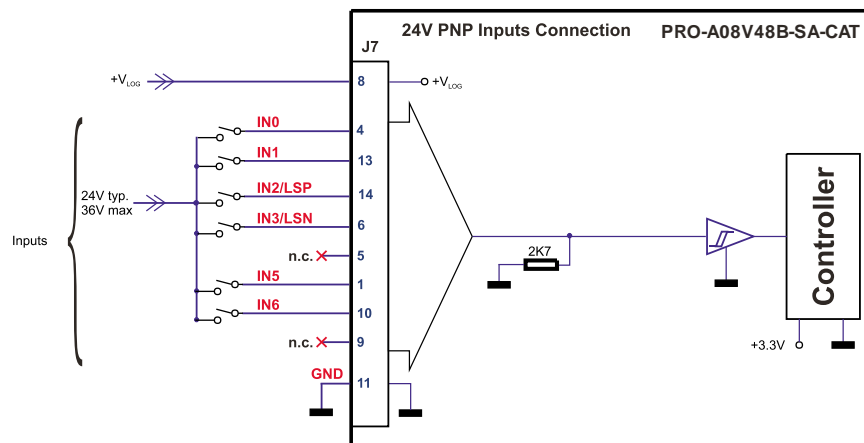


Figure 3.4. 24V Digital PNP Inputs connection

Remarks:

1. The inputs are selectable as PNP/ NPN by software.
2. The inputs are compatible with PNP type outputs (input must receive a positive voltage value (12-36V) to change its default state)

3.3.13.2 NPN inputs

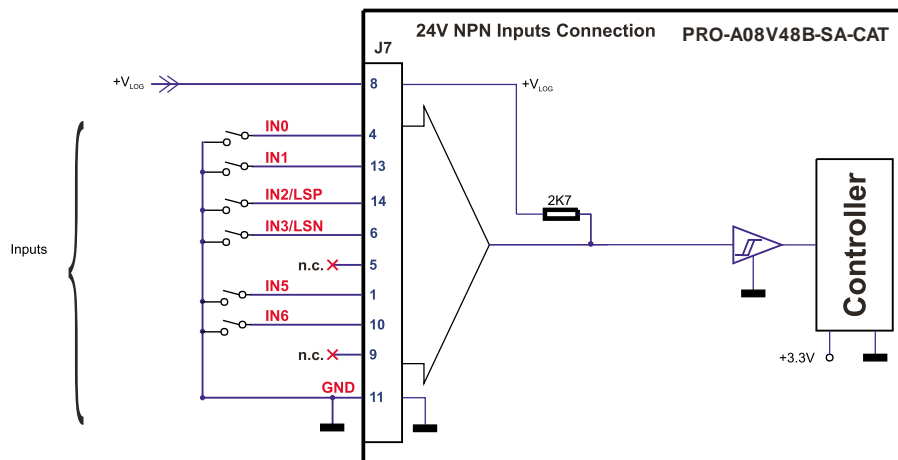


Figure 3.5. 24V Digital NPN Inputs connection

Remarks:

1. The inputs are selectable as PNP/ NPN by software.
2. The inputs are compatible with NPN type outputs (input must be pulled to GND to change its default state)

3.3.13.3 NPN outputs

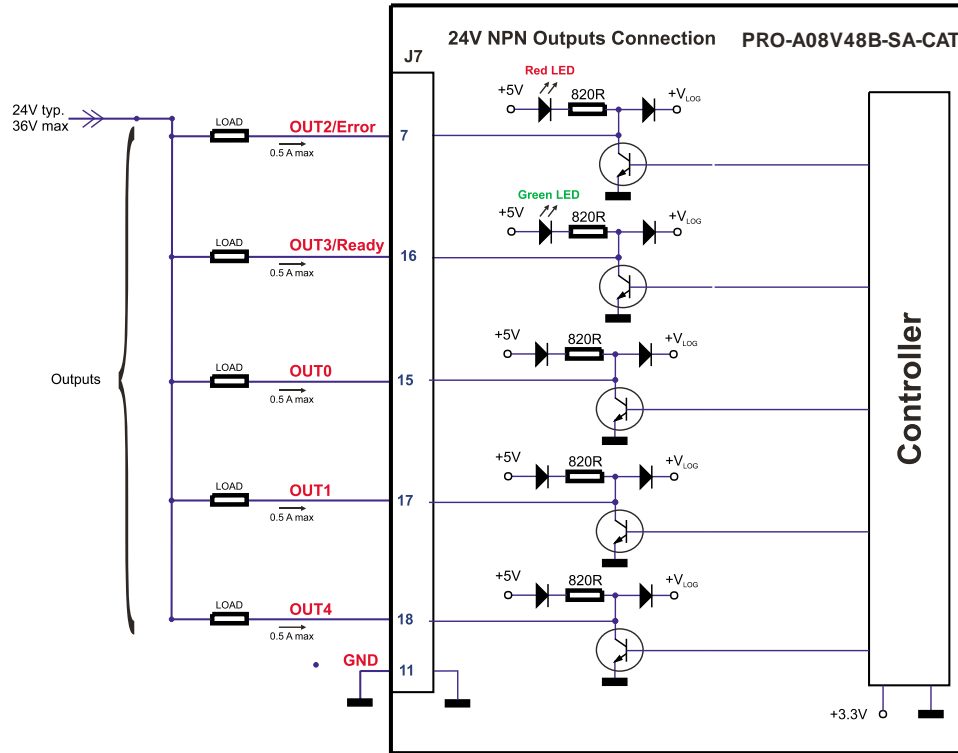


Figure 3.6. 24V Digital NPN Inputs connection

Remarks:

1. The outputs are compatible with NPN type inputs (load is tied to common +V_{LOG}, output pulls to GND when active and is floating when inactive)

3.3.14. Analog Inputs Connection

3.3.14.1 0-5V Input Range

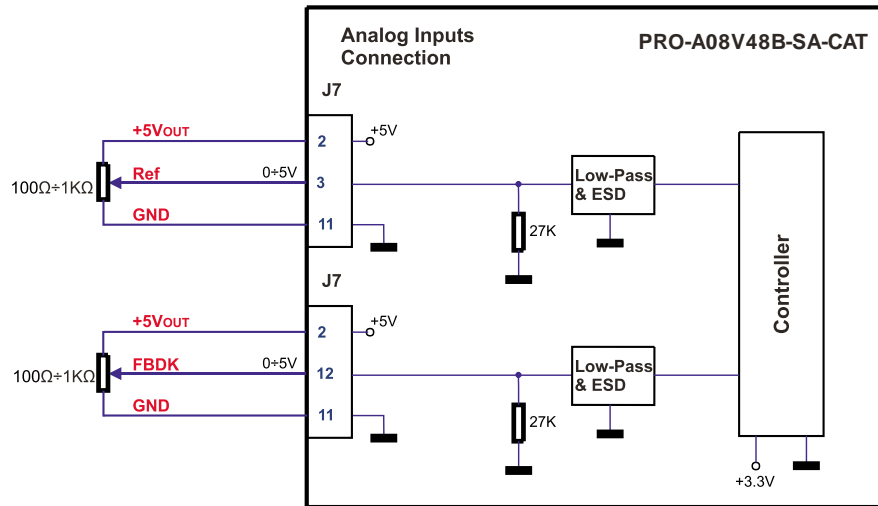


Figure 3.7. Analog inputs connection

Remark: Default input range for analog inputs is 0÷5 V for REF and FBDK. For a +/-10 V range, see Figure 3.8.

3.3.14.2 +/- 10V to 0-5V Input Range Adapter

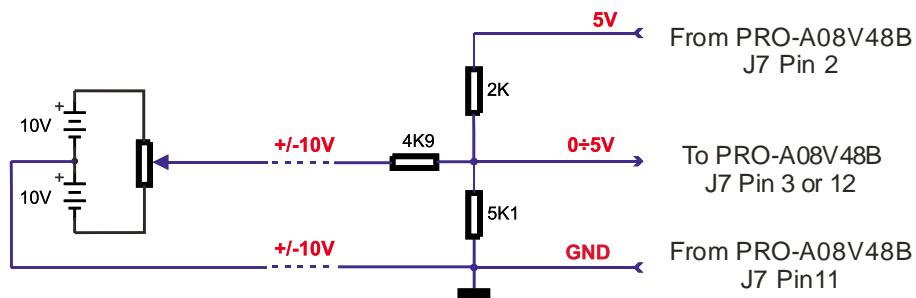


Figure 3.8. +/-10V to 0-5V adapter

3.3.14.3 Recommendations for Analog Signals Wiring

- a) If the analog signal source is single-ended, use a 2-wire shielded cable as follows: 1st wire connects the live signal to the drive positive input (+); 2nd wire connects the signal ground to the drive negative input(-).
- b) If the analog signal source is differential and the signal source ground is isolated from the drive GND, use a 3-wire shielded cable as follows: 1st wire connects the signal plus to the drive positive input (+); 2nd wire connects the signal minus to the drive negative input (-) and 3rd wire connects the source ground to the drive GND
- c) If the analog signal source is differential and the signal source ground is common with the drive GND, use a 2-wire shielded cable as follows: 1st wire connects the signal plus to the drive positive input (+); 2nd wire connects the signal minus to the drive negative input (-)
- d) For all of the above cases, connect the cable shield to the drive GND and leave the other shield end unconnected to the signal source. To further increase the noise protection, use a double shielded cable with inner shield connected to drive GND and outer shield connected to the motor chassis (earth).

3.3.15. Motor connections

3.3.15.1 Brushless Motor connection

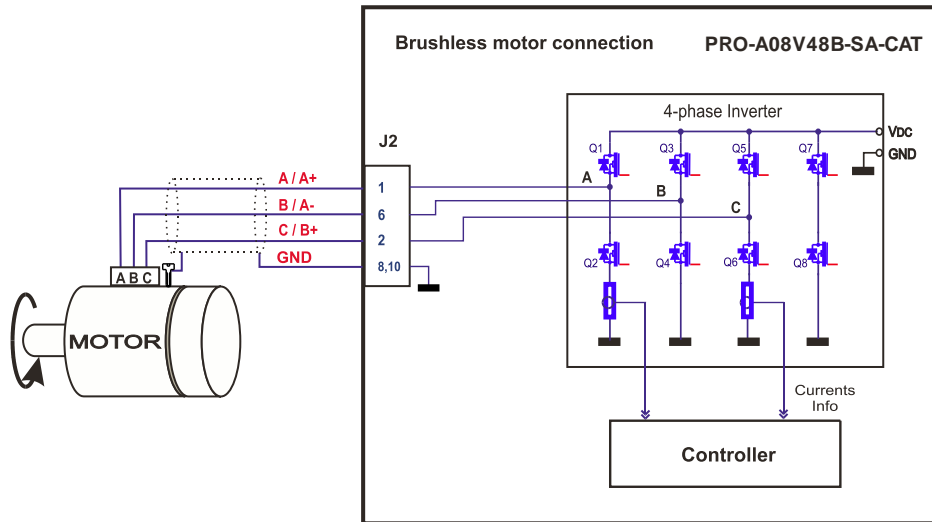


Figure 3.9. Brushless motor connection

3.3.15.2 2-phase Step Motor connection

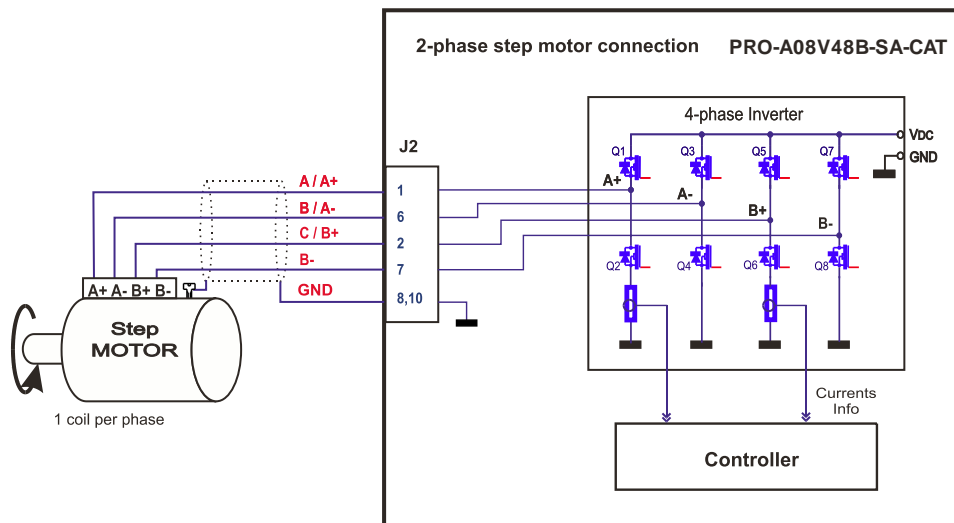


Figure 3.10. 2-phase step motor connection, one coil per phase

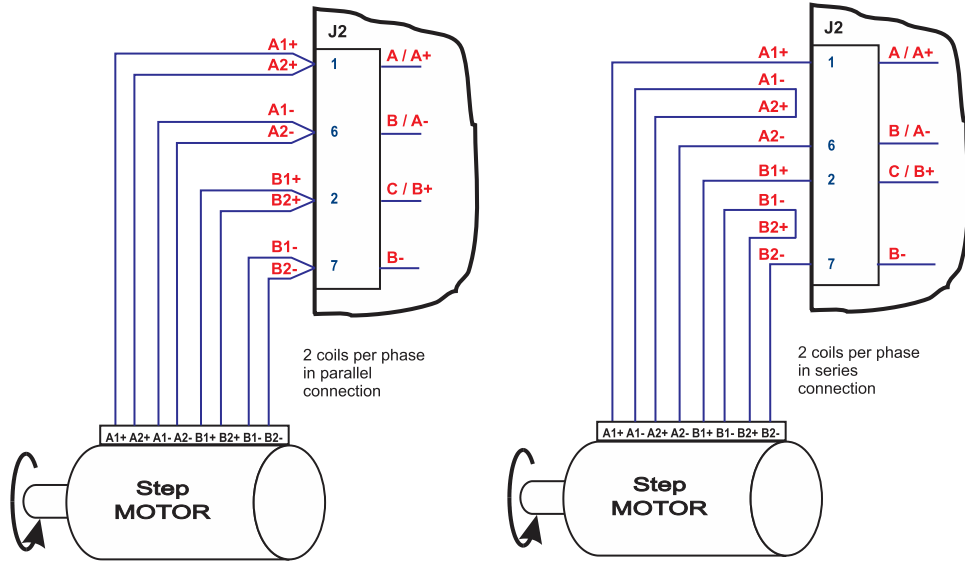


Figure 3.11. 2-phase step motor connection, two coils per phase

3.3.15.3 3-Phase Step Motor connection

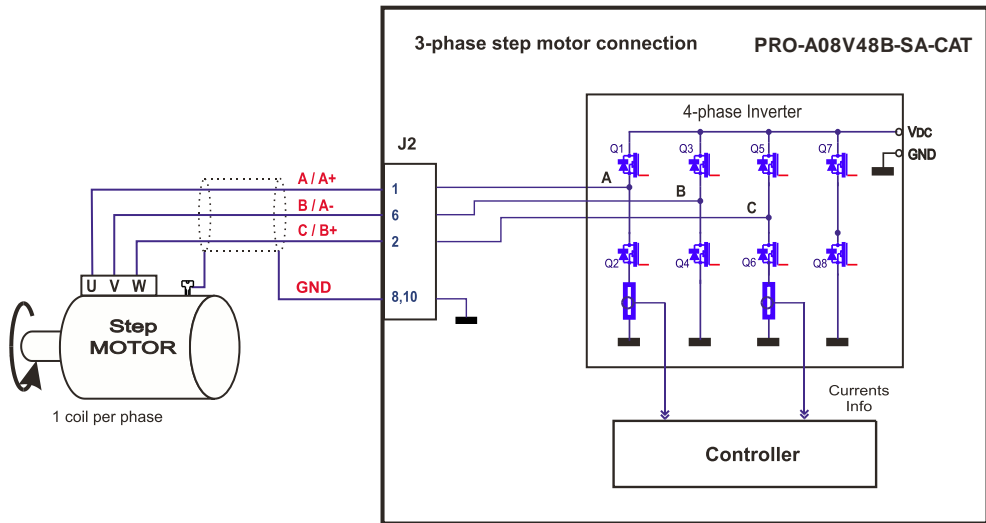


Figure 3.12. 3-phase step motor connection

3.3.15.4 DC Motor connection

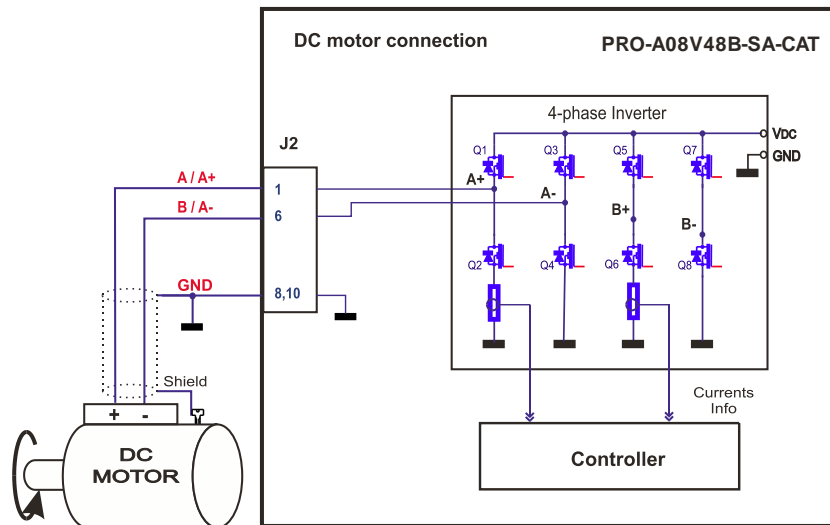


Figure 3.13. DC Motor connection

3.3.15.5 Recommendations for motor wiring

- Avoid running the motor wires in parallel with other wires for a distance longer than 2 meters. If this situation cannot be avoided, use a shielded cable for the motor wires. Connect the cable shield to the PRO-A08V48 GND pin. Leave the other end disconnected.
- The parasitic capacitance between the motor wires must not bypass 10nF. If very long cables (tens of meters) are used, this condition may not be met. In this case, add series inductors between the PRO-A08V48 outputs and the cable. The inductors must be magnetically shielded (toroidal, for example), and must be rated for the motor surge current. Typically the necessary values are around 100 μ H.
- A good shielding can be obtained if the motor wires are running inside a metallic cable guide.

3.3.16. Feedback connections

3.3.16.1 Single-ended Incremental Encoder Feedback #1 Connection

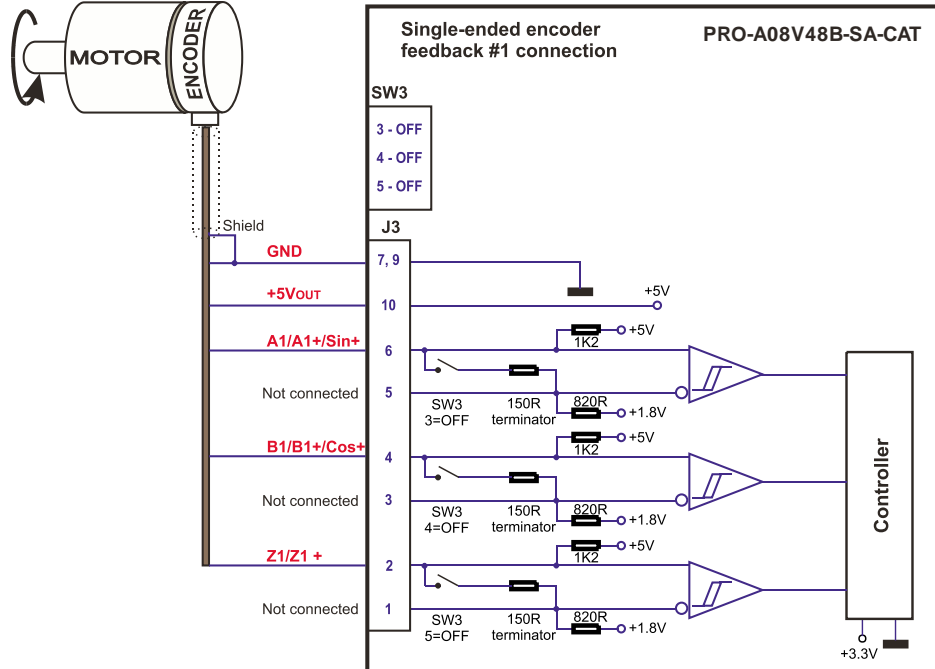


Figure 3.14. Single-ended incremental encoder Feedback #1 connection



CAUTION! DO NOT CONNECT UNTERMINATED WIRES. THEY MIGHT PICK UP UNWANTED NOISE AND GIVE FALSE ENCODER READINGS.

3.3.16.2 Differential Incremental Encoder Feedback #1 Connection¹

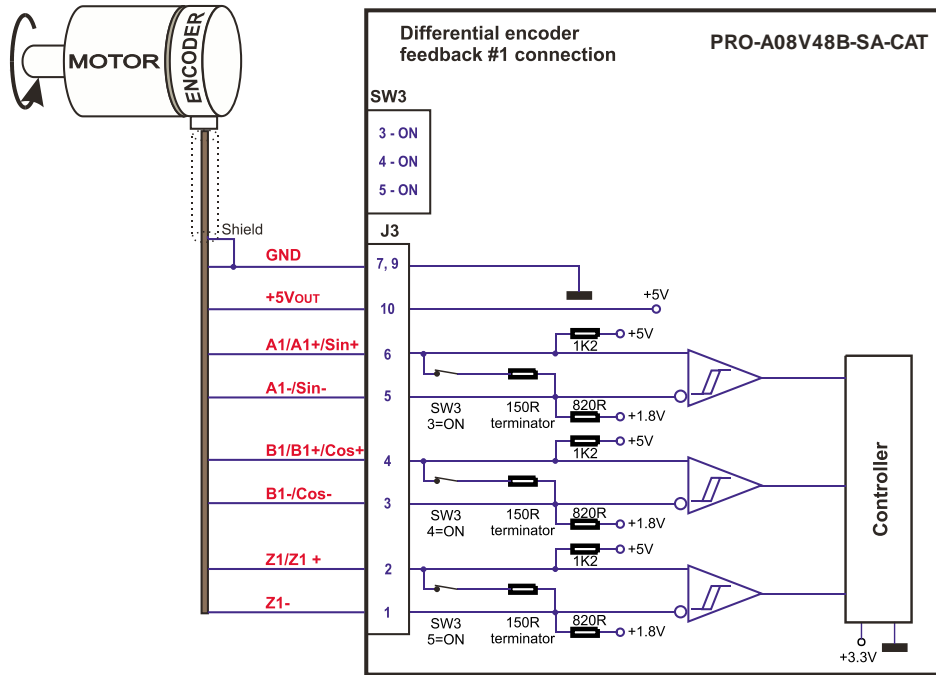


Figure 3.15. Differential incremental encoder feedback #1 connection

Remark: 150Ω terminators are required for long encoder cables, or noisy environments. They are available through the SW3 DIP switch.

¹ Differential Feedback #1 is not available with the p/n P027.214.E721

3.3.16.3 Differential Incremental Encoder Feedback #2 Connection

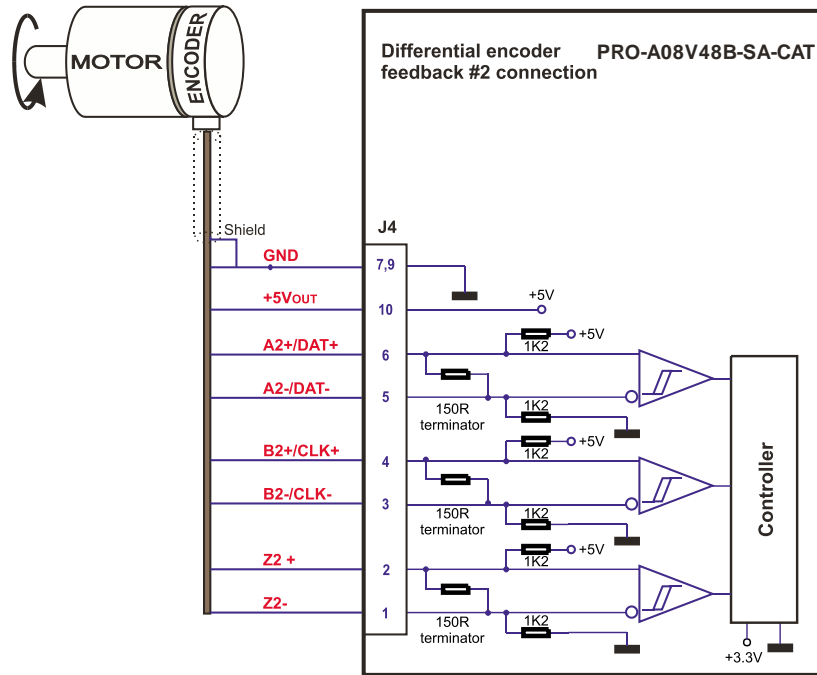


Figure 3.16. Differential incremental encoder feedback #2 connection

Remark: The Feedback #2 input has internal 150Ω terminators present in the drive. Single-ended connections are not supported

3.3.16.4 Master – Slave connection using the second incremental encoder input

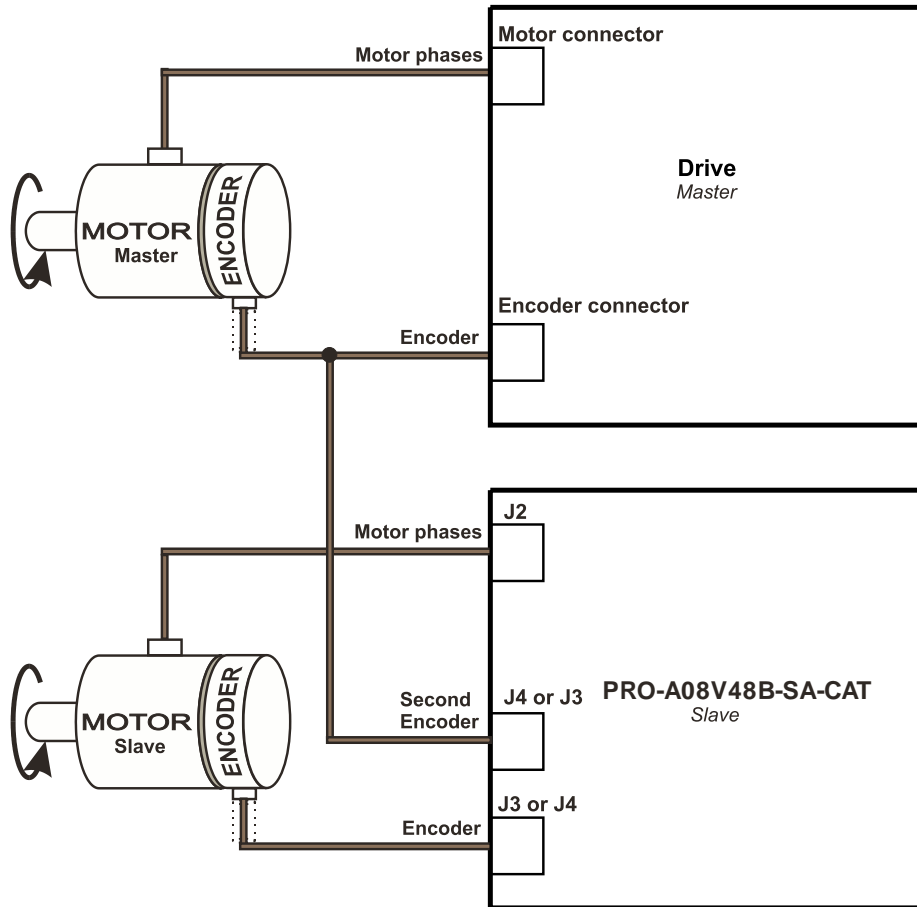


Figure 3.17. Master – Slave connection using second encoder input

This type of hardware connection is useful when executing an Electronic Gearing or Camming motion, to not send the feedback data over the communication bus.

3.3.16.5 Digital Hall Connection

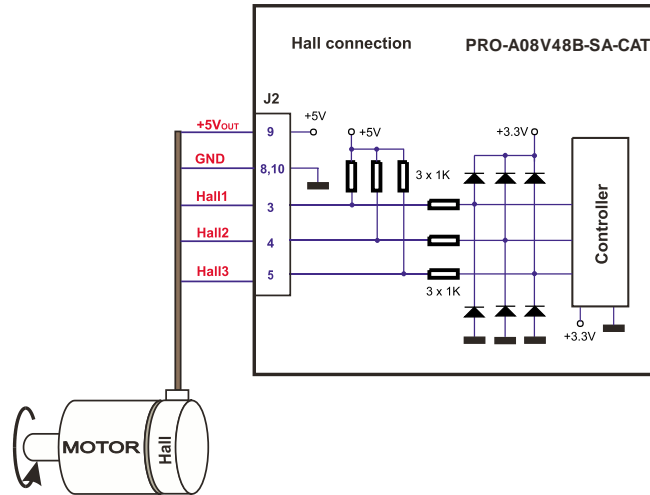


Figure 3.18. Digital Hall connection

3.3.16.6 Pulse and direction connection

See 4.2.4 to select Feedback #1 or #2 as the Pulse & Direction source in the software setup.

3.3.16.6.1 Single and connection on Feedback #1

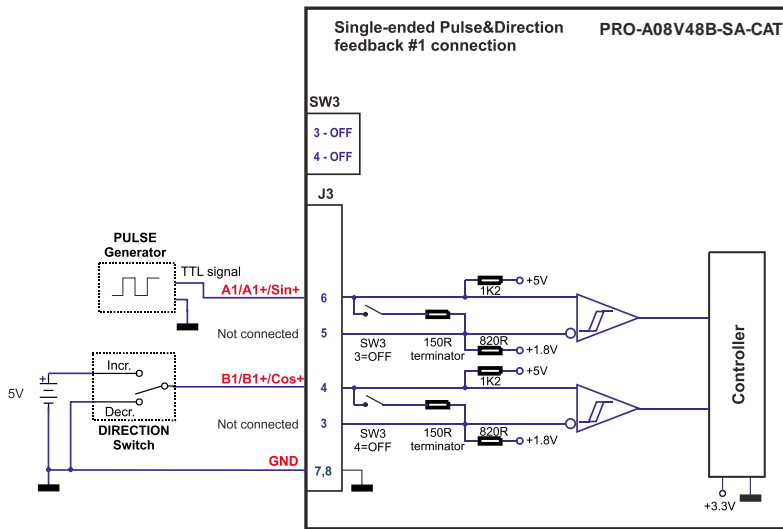


Figure 3.19. Single ended 5V Pulse & Direction Feedback #1 connection

3.3.16.6.2 Differential connection of Feedback #2

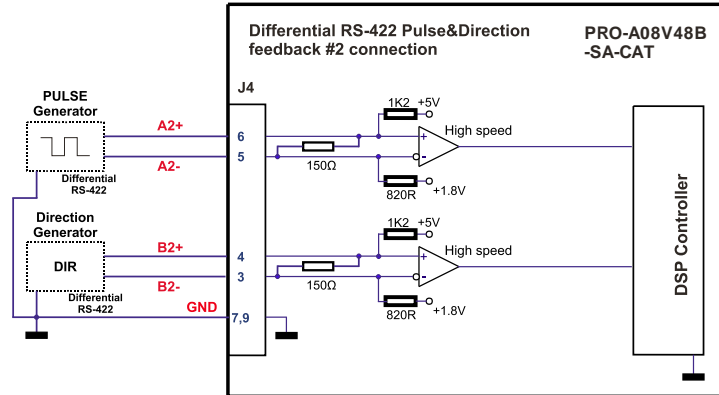


Figure 3.20. Differential (RS-422) Pulse & Direction Feedback #2 connection

3.3.16.7 SSI Feedback #2 Connection

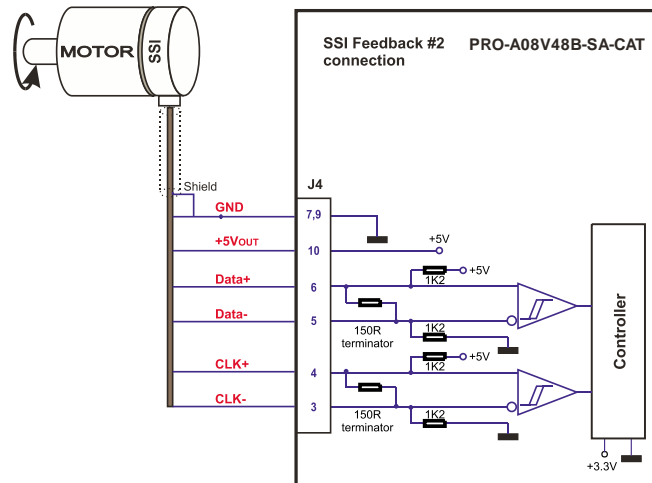


Figure 3.21. SSI Feedback #2 connection

Remark: The Feedback #2 input has internal 150Ω terminators present in the drive

3.3.16.8 BiSS Feedback #2 Connection¹

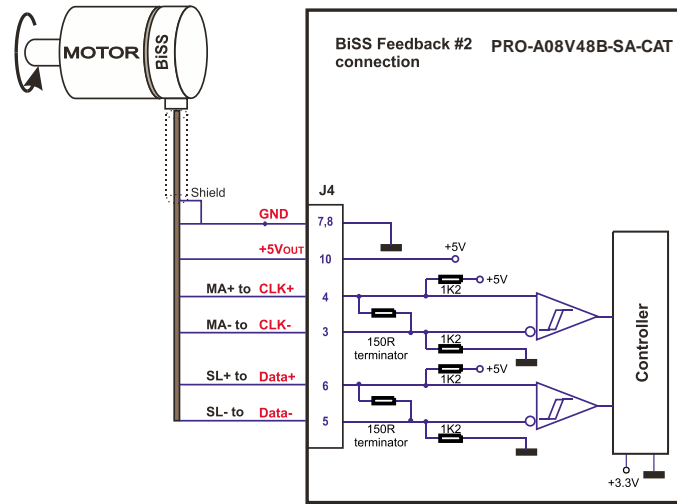


Figure 3.22. SSI Feedback #2 connection

Remark: The Feedback #2 input has internal 150Ω terminators present in the drive

3.3.16.9 Linear Hall Feedback #1 Connection

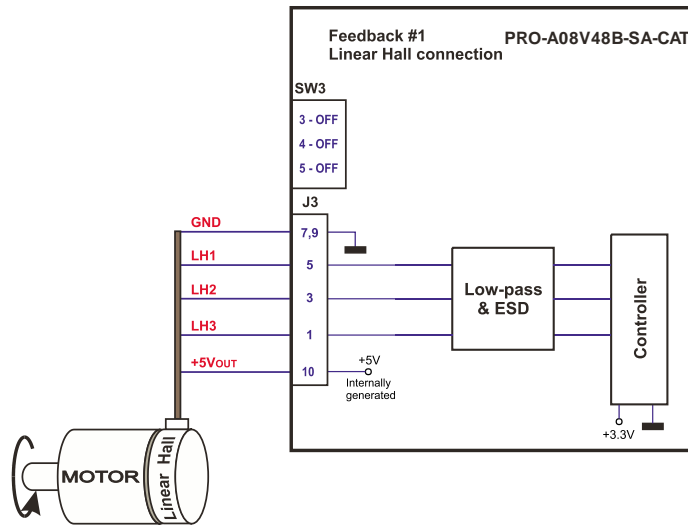


Figure 3.23. Linear Hall connection

Remark: The linear hall connection is available only on the PRO-A08V48B-SA-CAT having the part number P027.214.E721.

¹ Currently in development

3.3.16.10 Sine-Cosine Analog Encoder Feedback #1 Connection

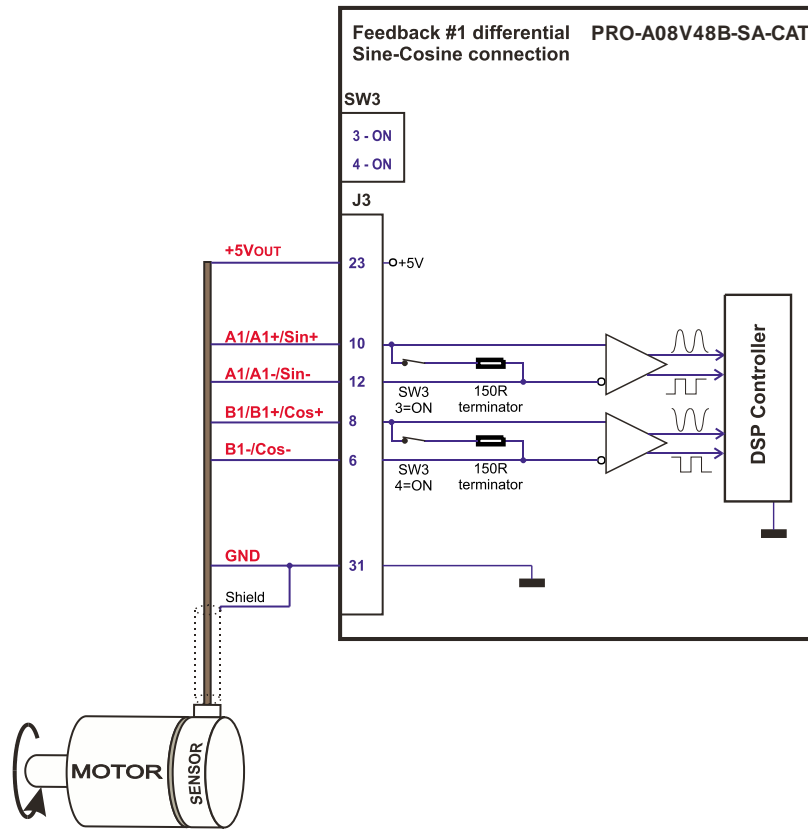


Figure 3.24. Sine-Cosine analog encoder Feedback #1 connection

3.3.16.11 Recommendations for wiring

- Always connect both positive and negative signals when the position sensor is differential and provides them. Use one twisted pair for each differential group of signals as follows: A+/Sin+ with A-/Sin-/LH1, B+/Cos+ with B-/Cos-/LH2, Z+ with Z-/LH3. Use another twisted pair for the 5V supply and GND.
- Always use shielded cables to avoid capacitive-coupled noise when using single-ended encoders or Hall sensors with cable lengths over 1 meter. Connect the cable shield to the GND, at only one end. This point could be either the PRO-A08V48 (using the GND pin) or the encoder / motor. Do not connect the shield at both ends.
- If the PRO-A08V48 5V supply output is used by another device (like for example an encoder) and the connection cable is longer than 5 meters, add a decoupling capacitor near the supplied device, between the +5V and GND lines. The capacitor value can be 1...10 μF , rated at 6.3V.

3.3.17. Power Supply Connection

3.3.17.1 Supply Connection

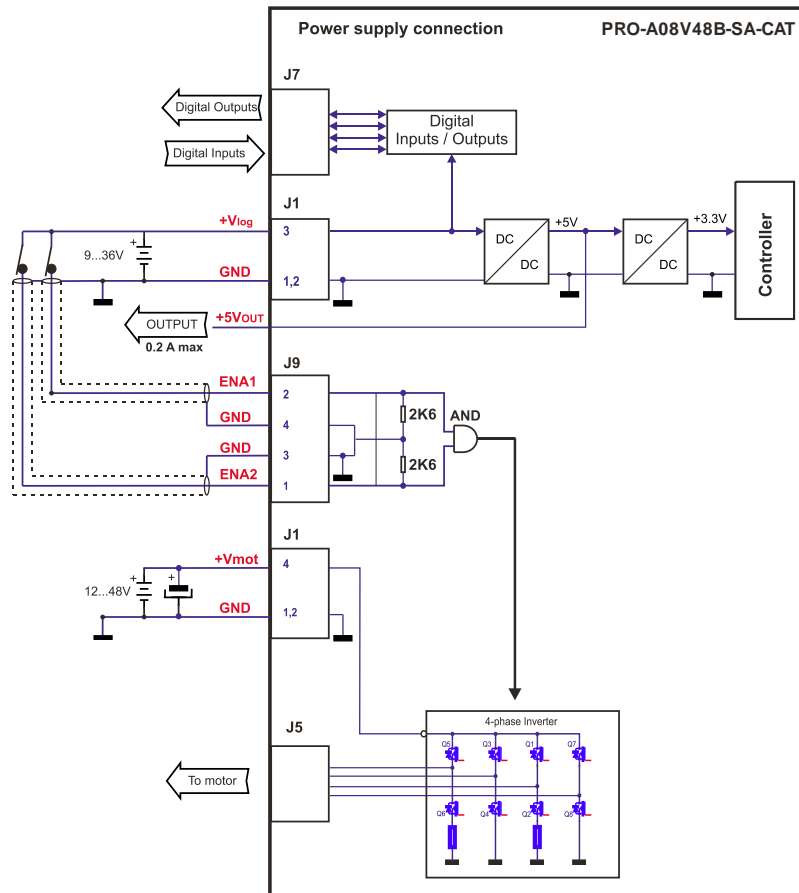


Figure 3.25. Supply connection

3.3.17.2 Recommendations for Supply Wiring

The PRO-A08V48B-SA-CAT always requires two supply voltages: V_{log} and V_{mot} .

Use short, thick wires between the PRO-A08V48 and the motor power supply. Connect power supply wires to all the indicated pins. If the wires are longer than 2 meters, use twisted wires for the supply and ground return. For wires longer than 20 meters, add a capacitor of at least $4,700\mu F$ (rated at an appropriate voltage) right on the terminals of the PRO-A08V48.

It is recommended to connect the negative motor supply return (GND) to the Earth protection near the power supply terminals.

3.3.17.3 Recommendations to limit over-voltage during braking

During abrupt motion brakes or reversals the regenerative energy is injected into the motor power supply. This may cause an increase of the motor supply voltage (depending on the power supply characteristics). If the voltage bypasses 53V, the drive over-voltage protection is triggered and the drive power stage is disabled. In order to avoid this situation you have 2 options:

Option 1. Add a capacitor on the motor supply big enough to absorb the overall energy flowing back to the supply. The capacitor must be rated to a voltage equal or bigger than the maximum expected over-voltage and can be sized with the formula:

$$C \geq \frac{2 \times E_M}{U_{MAX}^2 - U_{NOM}^2}$$

where:

U_{MAX} = 53V is the over-voltage protection limit

U_{NOM} is the nominal motor supply voltage

E_M = the overall energy flowing back to the supply in Joules. In case of a rotary motor and load, E_M can be computed with the formula:

$$E_M = \underbrace{\frac{1}{2}(J_M + J_L)\omega_M^2}_{\text{Kinetic energy}} + \underbrace{(m_M + m_L)g(h_{\text{initial}} - h_{\text{final}})}_{\text{Potential energy}} - \underbrace{3I_M^2 R_{Ph} t_d}_{\text{Copper losses}} - \underbrace{\frac{t_d \omega_M}{2} T_F}_{\text{Friction losses}}$$

where:

J_M – total rotor inertia [kgm²]

J_L – total load inertia as seen at motor shaft after transmission [kgm²]

ω_M – motor angular speed before deceleration [rad/s]

m_M – motor mass [kg] – when motor is moving in a non-horizontal plane

m_L – load mass [kg] – when load is moving in a non-horizontal plane

g – gravitational acceleration i.e. 9.8 [m/s²]

h_{initial} – initial system altitude [m]

h_{final} – final system altitude [m]

I_M – motor current during deceleration [A_{RMS}/phase]

R_{Ph} – motor phase resistance [Ω]

t_d – time to decelerate [s]

T_F – total friction torque as seen at motor shaft [Nm] – includes load and transmission

In case of a linear motor and load, the motor inertia J_M and the load inertia J_L will be replaced by the motor mass and the load mass measured in [kg], the angular speed ω_M will become linear speed measured in [m/s] and the friction torque T_F will become friction force measured in [N].

Option 2. Connect a brake resistor R_{BR} between phase BR/B- (J2/ pin 7) and ground (J2/ pins 8,10), and activate the software option of dynamic braking.

This option is not available when the drive is used with a step motor.

The dynamic braking option can be found in the Drive Setup dialogue within MotionPRO Developer / PRO Config. The braking will occur when DC bus voltage increases over U_{BRAKE} . This parameter (U_{BRAKE}) should be adjusted depending on the nominal motor supply. Optimally (from a braking point of view), U_{BRAKE} should be a few volts above the maximum nominal supply voltage. This setting will activate the brake resistor earlier, before reaching dangerous voltages – when the over-voltage protection will stop the drive. Of course, U_{BRAKE} must always be less than U_{MAX} – the over-voltage protection threshold.

Remark: This option can be combined with an external capacitor whose value is not enough to absorb the entire regenerative energy E_M but can help reducing the brake resistor size.

Brake resistor selection

The brake resistor value must be chosen to respect the following conditions:

1. to limit the maximum current below the drive peak current $I_{PEAK} = 20A$

$$R_{BR} > \frac{U_{MAX}}{I_{PEAK}}$$

2. to sustain the required *braking power*:

$$P_{BR} = \frac{E_M - \frac{1}{2}C(U_{MAX}^2 - U_{brake}^2)}{t_d}$$

where C is the capacitance on the motor supply (external), i.e:

$$R_{BR} < \frac{U_{BRAKE}^2}{2 \times P_{BR}}$$

3. to limit the average current below the drive nominal current $I_{NOM}=8A$

$$R_{BR} > \frac{P_{BR} \times t_d}{t_{CYCLE} \times I_{NOM}^2}$$

where t_{CYCLE} is the time interval between 2 brakes in case of repetitive moves.

4. to be rated for an average power $P_{AV} = \frac{P_{BR} \times t_d}{t_{CYCLE}}$ and a peak power $P_{PEAK} = \frac{U_{MAX}^2}{R_{BR}}$

Remarks:

1. If $\frac{U_{MAX}}{I_{PEAK}} > \frac{U_{BRAKE}^2}{2 \times P_{BR}}$ the braking power P_{BR} must be reduced by increasing either t_d – the time to decelerate or C – the external capacitor on the motor supply
2. If $\frac{P_{BR} \times t_d}{t_{CYCLE} \times I_{NOM}^2} > \frac{U_{BRAKE}^2}{2 \times P_{BR}}$ either the braking power must be reduced (see Remark 1) or t_{CYCLE} – the time interval between braking cycles must be increased



WARNING!

THE BRAKE RESISTOR MAY HAVE HOT SURFACES DURING OPERATION.

3.3.18. Serial RS-232 connection

3.3.18.1 Serial RS-232 connection

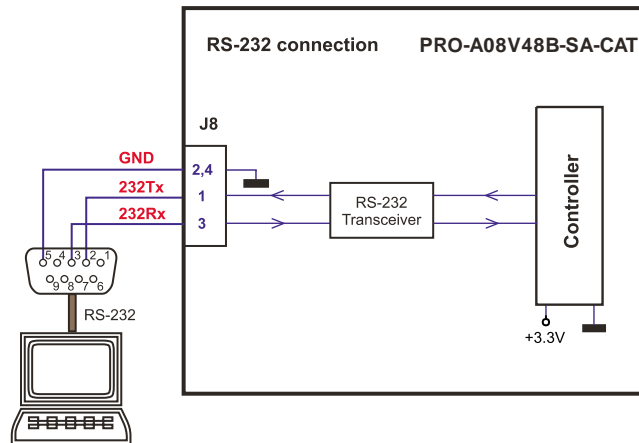


Figure 3.26. Serial RS-232 connection

3.3.18.2 Recommendation for wiring

- If the serial cable is built separately, use a 3-wire shielded cable with the shield connected to BOTH ends. Do not use the shield as GND. The ground wire (pin 2 or 4 of J8) must be included inside the shield, like the 232Rx and 232Tx signals
- Always power-off all the PRO-A08V48B-SA-CAT supplies before inserting/removing the RS-232 serial connector
- Do not rely on an earthed PC to provide the PRO-A08V48 GND connection! The drive must be earthed through a separate circuit. Most communication problems are caused by the lack of such connection



CAUTION! DO NOT CONNECT/DISCONNECT THE RS-232 CABLE WHILE THE DRIVE IS POWERED ON. THIS OPERATION CAN DAMAGE THE DRIVE

3.3.19. Recommendations for EtherCAT® Wiring

- a) Build EtherCAT® network using UTP (unshielded twisted pair) cables rated CAT5E or higher (CAT6, etc.). Cables with this rating must have multiple characteristics, as described in TIA/EIA-568-B. Among these are: impedance, frequency attenuation, cross-talk, return loss, etc.
- b) It is acceptable to use STP (shielded twisted pair) or FTP (foil twisted pair) cables, rated CAT5E or higher (CAT6, etc.). The added shielding is beneficial in reducing the RF (radio-frequency) emissions, improving the EMC emissions of the application.
- c) The maximum length of each network segment must be less than 100 meters.
- d) The network topology is daisy-chain. All connections are done using point-to-point cables. The global topology can be one of the two:
 - Linear, when the J5 / OUT port of the last drive in the chain remains not connected. Master is connected to J6 / IN port of the first drive; J5 / OUT of the first drive is connected to J6 / IN of the following drive; J5 / OUT of the last drive remains unconnected.
See *Figure 3.28* for a visual representation of the linear topology.
 - Ring, when the J5 / OUT port of the last drive in the chain is connected back to the master controller, on the 2nd port of the master. This topology consists of the linear topology described above, plus an extra connection between the master, which has two RJ45 ports, to J5 / OUT of the last drive.
See *Figure 3.29* for a visual representation of the ring topology.
- e) Ring topology is preferred for its added security, since it is insensitive to one broken cable / connection along the ring (re-routing of communication is done automatically, so that to avoid the broken cable / connection)
- f) It is highly recommended to use qualified cables, assembled by a specialized manufacturer. When using CAT5E UTP cables that are manufactured / commissioned / prepared on-site, it is highly recommended to check the cables. The check should be performed using a dedicated Ethernet cable tester, which verifies more parameters than simple galvanic continuity (such as cross-talk, attenuation, etc.). The activation of “Link” indicators will NOT guarantee a stable and reliable connection! This can only be guaranteed by proper quality of cables used, according to TIA/EIA-568-B specifications.

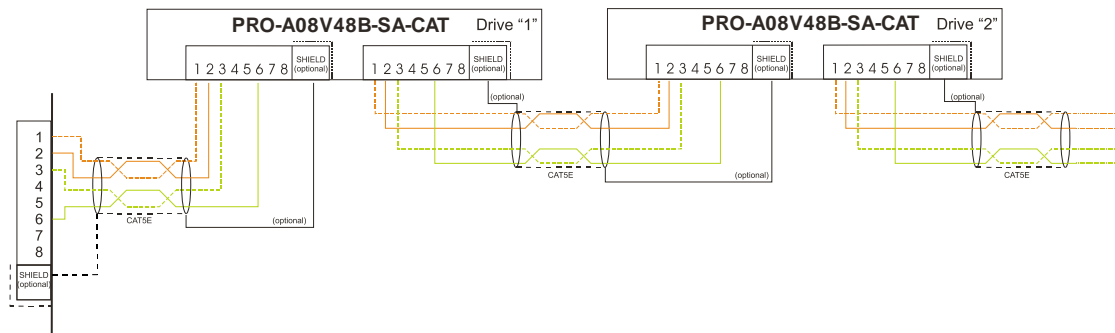


Figure 3.27. EtherCAT® Wiring

Linear Topology

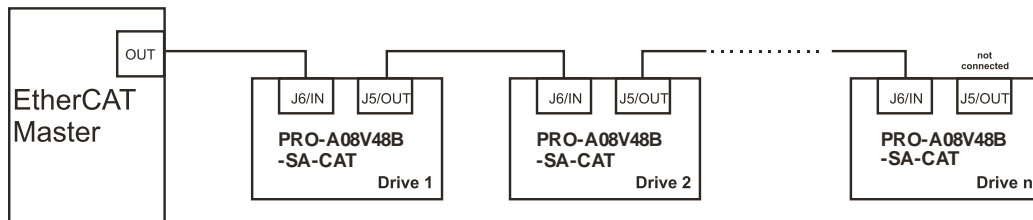


Figure 3.28. EtherCAT® Network - Linear Topology

Ring Topology

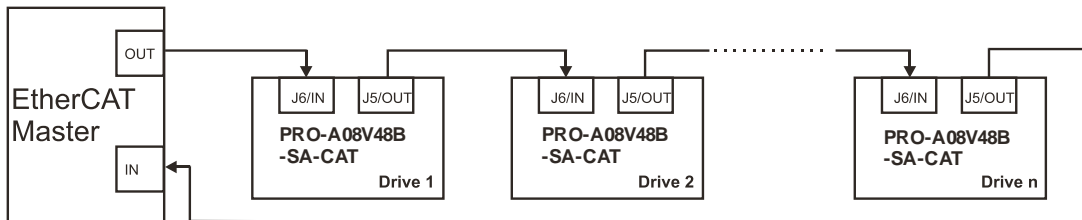


Figure 3.29. EtherCAT® Network - Ring Topology

3.3.20. Disabling the setup table at startup

In some very rare cases, the setup table might be corrupted, leading to a loop where the drive resets continuously. This behavior can be noticed by seeing both the Ready and Error LED blinking for short periods of time continuously.

To recover from this behavior, the setup table can be invalidated by connecting all digital Hall inputs to GND, as shown in *Figure 3.30*.

On the next power on, the drive will load setup default settings and the Motion Error Register (MER) bit 2 will be 1. After a new valid setup table is loaded onto the drive, disconnect the hall sensors from GND and execute a new power off/ power on cycle.

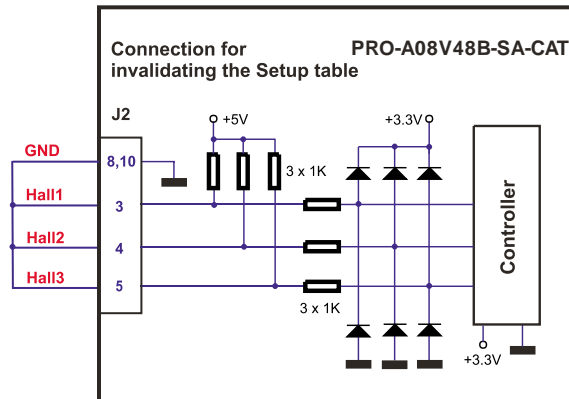


Figure 3.30. Temporary connection during power-on to disable the setup table

3.4. Axis ID Selection for PRO-A08V48B-SA-CAT drives with EtherCAT

The PRO-A08V48B-SA-CAT drives support all EtherCAT standard addressing modes. In case of device addressing mode based on node address, the PRO-A08V48B-SA-CAT drive sets the *configured station alias* address with its AxisID value. The drive AxisID value is set after power on by:

- Software, setting via PRO Config a specific AxisID value in the range 1-255.
- Hardware, by setting h/w in PRO Config and selecting a value between 1-127 from the Axis ID selection switches SW1 and SW2

3.4.1. LED Indicators

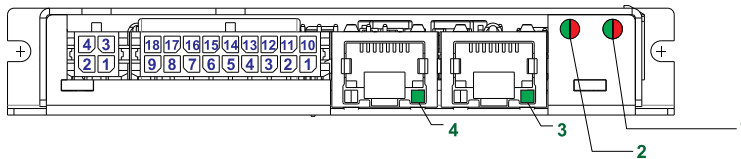


Figure 3.31. LED locations

Table 3.1 – LED Indicators

| LED no. | LED name | LED color | Function |
|---------|-----------------------------|---------------|---|
| 1 | Drive Ready/ Error | green | Lit after power-on when the drive initialization ends. Turned off when an error occurs. |
| | | red | Turned on when the drive detects an error condition or when OUT2/Error is set to +Vlog with OUT(2)=0 MPL instruction. |
| 2 | EtherCAT® ST | red and green | EtherCAT® ERROR and RUN indicators combined. Shows the state of the EtherCAT® Status Machine |
| 3 | EtherCAT® OUT Link/Activity | green | Shows the state of the physical link and activity. |
| 4 | EtherCAT® IN Link/Activity | green | Shows the state of the physical link and activity. |

3.4.2. EtherCAT® Status indicator

The STATUS indicator displays the RUN states with a 180 degree phase shift to the ERROR states. An example is noted in **Figure 3.32**.

In case of a conflict between turning the indicator on green versus red, the indicator shall be turned to red. Apart from this situation, the bi-color STATUS indicator combines the behavior of the RUN indicator specified in **Table 3.2** and the behavior of the ERROR indicator specified in **Table 3.3**.

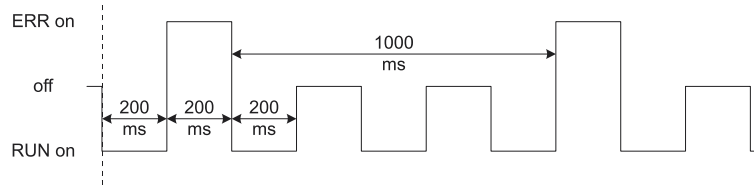


Figure 3.32. STATUS indicator Example

Table 3.2 – RUN Indicator States

| Indicator states | Slave State | Description |
|------------------|------------------|--|
| Off | INITIALISATION | The drive is in state INIT |
| Blinking | PRE-OPERATIONAL | The drive is in state PRE-OEPRATIONAL |
| Single Flash | SAFE-OPERATIONAL | The drive is in state SAFE-OPERATIONAL |
| On | OPERATIONAL | The drive is in state OPERATIONAL |

Table 3.3 – ERROR Indicator States

| ERR state | Error name | Description |
|--------------|---|---|
| On | Application controller failure | An critical communication or application controller error has occurred |
| Double Flash | Process Data Watchdog Timeout/ EtherCAT Watchdog Timeout | An application watchdog timeout has occurred. |
| Single Flash | Local Error | Slave device application has changed the EtherCAT state autonomously, due to local error (see ETG.1000 part 6 EtherCAT State Machine). Error Indicator bit is set to 1 in AL Status register. |
| Blinking | Invalid Configuration | General Configuration Error |
| Flickering | Booting Error | Booting Error was detected. INIT state reached, but Error Indicator bit is set to 1 in AL Status register |
| Off | No error | The EtherCAT communication of the device is in working condition |

For a more detailed description of EtherCAT® LED functionalities please read ETG.1300 S (R) V1.0.1 available at www.EtherCAT.org .

4. Step 2. Drive Setup

4.1. Installing PRO Config

PRO Config is a PC software platform for the setup of the ElectroCraft drives. PRO Config comes with an **Update via Internet tool** through which you can check if your software version is up-to-date, and when necessary download and install the latest updates.

You will need MotionPRO Developer only if you plan to use the advanced features presented in Section 5.3 Combining CoE with MPL.

4.2. Getting Started with PRO Config

Using PRO Config you can quickly setup a drive for your application. The drive can be directly connected with your PC via a serial RS 232 link.

The output of PRO Config is a set of *setup data*, which can be downloaded into the drive EEPROM or saved on your PC for later use.

PRO Config includes a set of evaluation tools like the Data Logger, the Control Panel and the Command Interpreter which help you to quickly measure, check and analyze your drive commissioning.

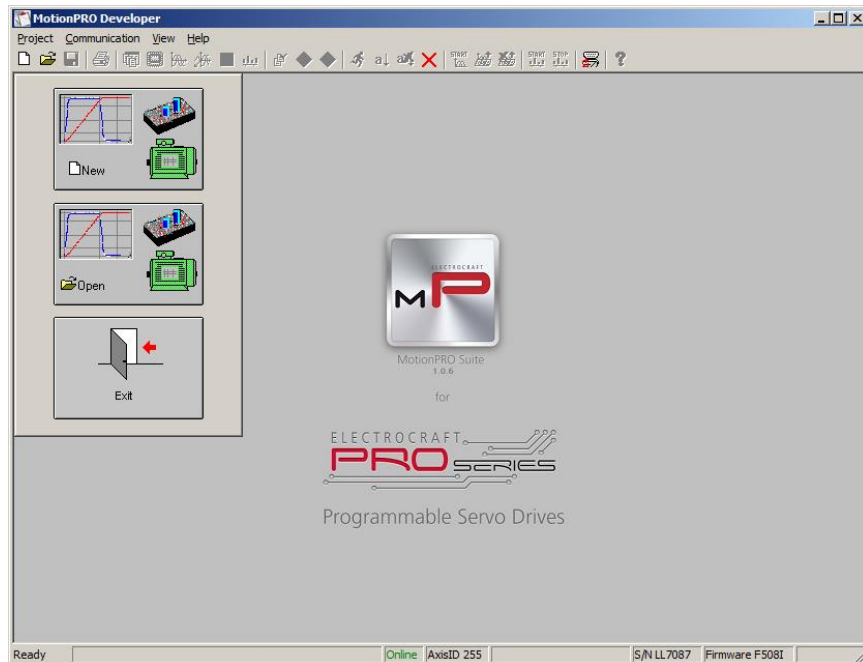
PRO Config works with **setup** data. A **setup** contains all the information needed to configure and parameterize a ElectroCraft drive. This information is preserved in the drive EEPROM in the *setup table*. The setup table is copied at power-on into the RAM memory of the drive and is used during runtime. With PRO Config it is also possible to retrieve the complete setup information from a drive previously programmed.

Note that with PRO Config you do only your drive/motor commissioning. For motion programming you have the following options:

- Use a **EtherCAT® master**
- Use **MotionPRO Developer** to create and download a **MPL** program into the drive/motor memory
- **Implement** on your master the MPL commands you need to send to the drives using one of the supported communication channels. The implementation must be done according with ElectroCraft communication protocols.
- **Combine** MPL programming at drive level with one of the other options (see Section 5.3)

4.2.1. Establish communication

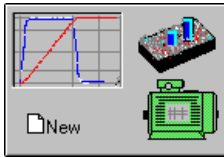
PRO Config starts with an empty window from where you can create a **New** setup, **Open** a previously created setup which was saved on your PC, or **Upload** the setup from the drive/motor.



Before selecting one of the above options, you need to establish the communication with the drive you want to commission. Use menu command **Communication | Setup** to check/change your PC communication settings. Press the **Help** button of the dialogue opened. Here you can find detailed information about how to setup your drive and do the connections. Power on the drive, then close the Communication | Setup dialogue with OK. If the communication is established, PRO Config displays in the status bar (the bottom line) the text **“Online”** plus the axis ID of your drive/motor and its firmware version. Otherwise the text displayed is **“Offline”** and a communication error message tells you the error type. In this case, return to the Communication | Setup dialogue, press the Help button and check troubleshoots

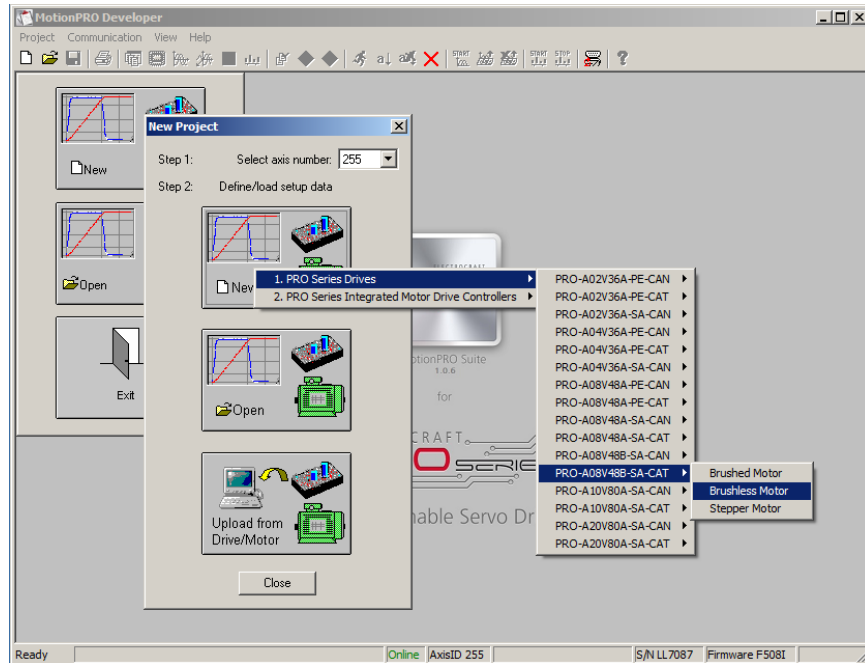
Remark: When first started, PRO Config tries to communicate via RS-232 and COM1 with a drive having axis ID=255 (default communication settings). If your drive is powered and it is connected to your PC port COM1 via an RS-232 cable, the communication shall establish automatically. If the drive has a different axis ID and you don't know it, select in the Communication | Setup dialogue at “Axis ID of drive/motor connected to PC” the option **Autodetected**.

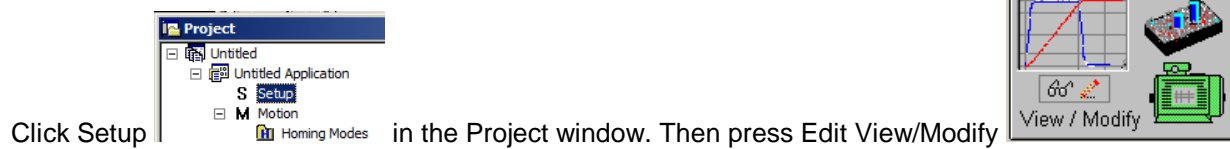
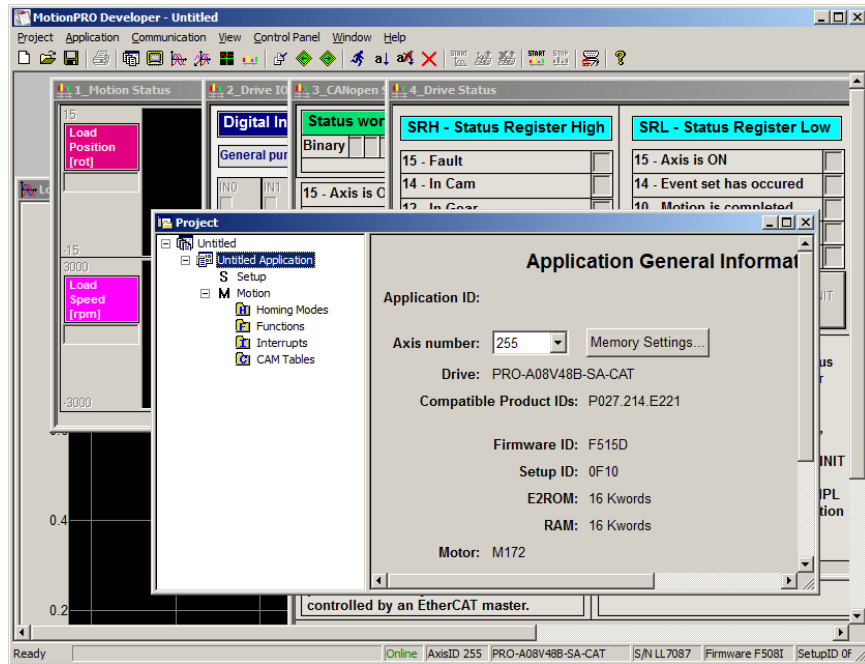
4.2.2. Setup drive/motor



Press **New** button and select your drive type.

The selection continues with the motor technology (for example: brushless or brushed).





The selection opens 2 setup dialogues: for **Motor Setup** and for **Drive setup** through which you can configure and parameterize an ElectroCraft drive, plus several predefined control panels customized for the product selected.

Brushless Motor Setup

Guideline assistant
 Step 1. Select your motor from a database. If your motor does not exist in any database, proceed through all the next steps in order to define your motor and sensors data. In either case, use the tests from the next steps to verify/detect the motor and sensors parameters and operation.

Previous Next

Motor data

Nominal current: 3.52 A
 Peak current: 10.6 A
 Pole pairs: 4
 Torque constant: 0.0355 Nm/A
 Phase resistance (motor + drive): 1.2 Ohms
 Phase inductance (motor + drive): 1.8 mH
 Motor inertia: 48 kgm²E-7
 Phase connection: Star Delta
 Motor inertia is unknown

Test Phase Connections
 Detect Number of Pole Pairs
 Identify Resistance and Inductance

Motor sensors

Type: Incremental Encoder Connector: Feedback 1
 No. of lines/rev: 500 lines
 Hall sensors: Hall configuration: 0
 Filter encoder inputs to: 1/3 of maximum bandwidth (only for single-ended encoders)
 Reverse encoder counting:

Sensor type: NTC PTC
 Temperature:

Load sensors: Type: None

Database
 Motor:
 Save to User Database Delete Help Cancel

Motor brake

Motor brake on output line:
 OUT0

Motor brake is applied when NPN (sink) output is connected to GND.

Drive not active Drive active
 Brake applied Brake released

Brake release delay: 0 ms Brake apply delay: 0 ms

Transmission to load

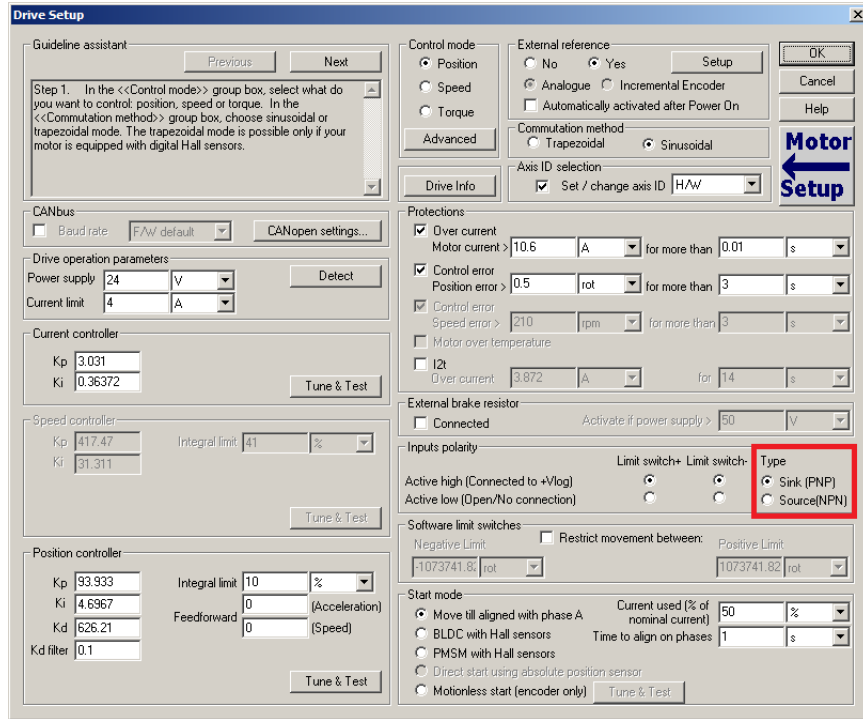
Transmission type: Rotary to rotary
 Rotary to linear
 Linear to rotary
 Linear to linear

Motor displacement of: 1 rot
 corresponds on load to: 1 rot

Drive Setup

In the **Motor setup** dialogue you can introduce the data of your motor and the associated sensors. Data introduction is accompanied by a series of tests having as goal to check the connections to the drive and/or to determine or validate a part of the motor and sensors parameters. In the **Drive setup** dialogue you can configure and parameterize the drive for your application. In each dialogue you will find a **Guideline Assistant**, which will guide you through the whole process of introducing and/or checking your data. Close the Drive setup dialogue with **OK** to keep all the changes regarding the motor and the drive setup.

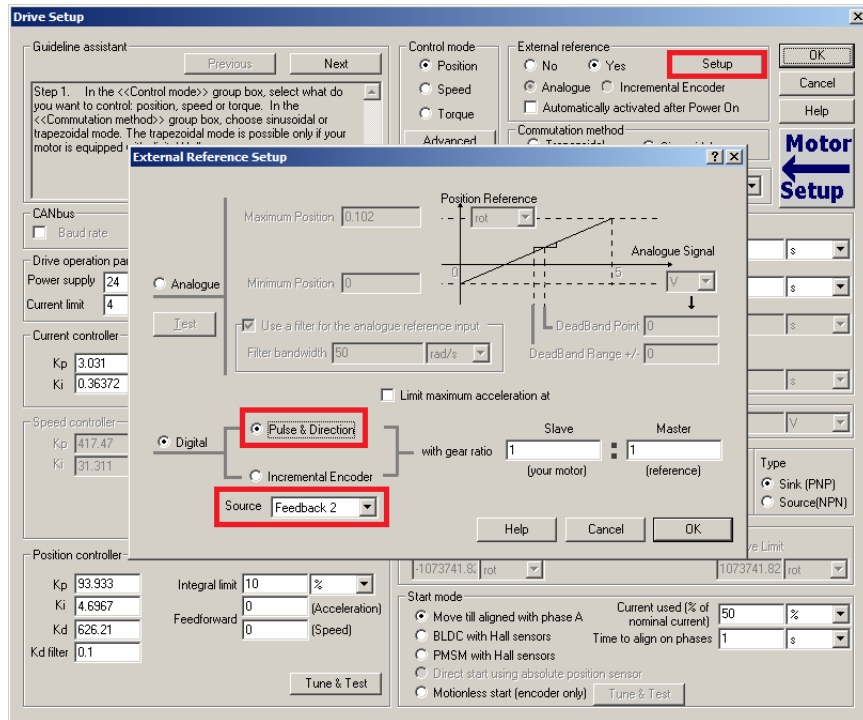
4.2.3. Selecting NPN/PNP inputs type in Setup



In Drive Setup, choose the inputs type PNP or NPN.

4.2.4. Selecting the feedback source for Pulse and Direction

The Pulse and Direction feedback source can be chosen in Setup/ Drive Setup/ External reference Setup button.




Feedback #1 or Feedback #2 will be available for Pulse and Direction only if they are not already selected as primary feedback for the motor.

4.2.5. Download setup data to drive/motor



Press the **Download to Drive/Motor** button to download your setup data in the drive/motor EEPROM memory in the *setup table*. From now on, at each power-on, the setup data is copied into the

drive/motor RAM memory which is used during runtime. It is also possible to **Save**  the setup data on your PC and use it in other applications.

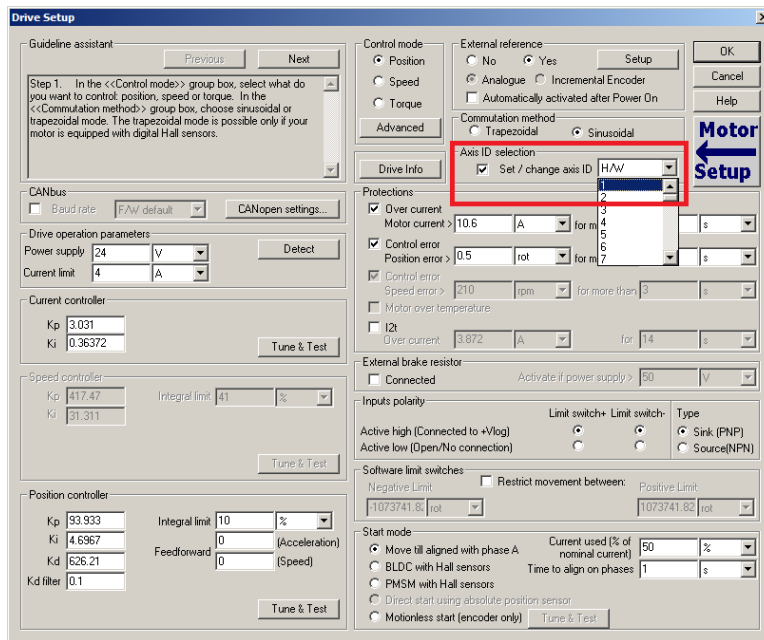
To summarize, you can define or change the setup data in the following ways:

- create a new setup data by going through the motor and drive dialogues
- use setup data previously saved in the PC
- upload setup data from a drive/motor EEPROM memory

4.2.6. Evaluate drive/motor behavior (optional)

You can use the **Data Logger** or the **Control Panel** evaluation tools to quickly measure and analyze your application behavior. In case of errors like protections triggered, use the Drive Status control panel to find the cause.

4.3. Changing the drive Axis ID



The axis ID of a PRO-A08V48 drive can be set by software (via Setup) – any value between 1 and 255, stored in the setup table.

The axis ID is initialized at power on, using the following algorithm:

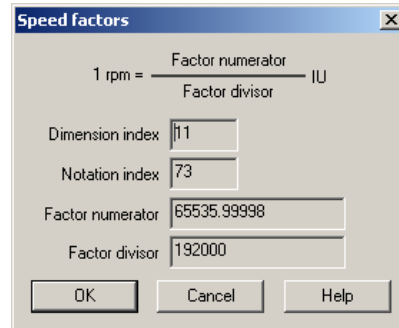
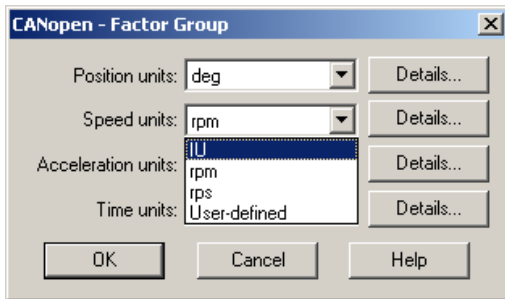
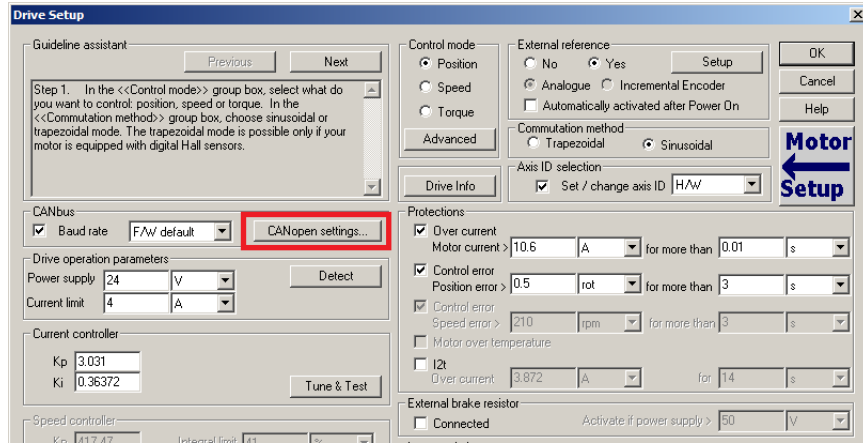
- If a valid setup table exists, and this setup table was created with the *Axis ID Selection* checkbox checked in the Drive Setup dialogue (see above) – with the value read from the setup table. This value can be an axis number 1 to 255.
- If a valid the setup table exists, and this was created with the *Axis ID Selection* checkbox unchecked in the Drive Setup dialogue (see above) – with the last value set from a valid setup table. This value can be an axis number 1 to 255.
- If the setup table is invalid, with the last value set from a valid setup table.
- If the setup table is invalid, there is no previous axis ID set from a valid setup table, will be set as 255.

Remark: If you don't know the axis ID set in a drive, you can find it in the following way:

- Connect the drive via a serial RS232 link to a PC where PRO Config or MotionPRO Developer are installed
- With the drive powered, open PRO Config or MotionPRO Developer and check the status bar. If communication with the drive is established, the status bar displays **Online** in green and nearby the drive's Axis ID. If the status bar displays **Offline** in red, execute menu command "Communication|Setup..." and in the dialogue opened select at "Channel Type" **RS232** and at "Axis ID of drive/motor connected to PC" the option **Autodetected**. After closing the dialogue with OK, communication with the drive shall be established and the status bar shall display the drive's Axis ID

4.4. Setting factor group scaling factors

By pressing the CANopen Settings button, you can choose the initial values after power on for the CANopen factor group settings. The factor group settings describe the scaling factors for position, speed, acceleration and time objects. In the factor group dialogue you can select the units to use when writing to these objects or reading them. You can either choose one of the standard units defined in the CiA 402 standard or define your own unit.



In the last case, it is your responsibility to set the factor numerator and divisor as well as its dimension and notation index. The factor group settings are stored in the setup table. By default the drive uses its internal units. The correspondence between the drive internal units and the SI units is presented in chapter 6 **Scaling Factors**.

4.5. Creating an Image File with the Setup Data

Once you have validated your setup, you can create with the menu command **Setup | Create EEPROM Programmer File** a software file (with extension **.sw**) which contains all the setup data to write in the EEPROM of your drive.

A software file is a text file that can be read with any text editor. It contains blocks of data separated by an empty row. Each block of data starts with the block start address, followed by data values to place in ascending order at consecutive addresses: first data – to write at start address, second data – to write at start address + 1, etc. All the data are hexadecimal 16-bit values (maximum 4 hexadecimal digits). Each row contains a single data value. When less than 4 hexadecimal digits are shown, the value must be right justified. For example 92 represents 0x0092.

The **.sw** file can be programmed into a drive:

- from an EtherCAT master, using the communication objects for writing data into the drive EEPROM
- using the EEPROM Programmer tool, which comes with PRO Config but may also be installed separately. The EEPROM Programmer was specifically designed for repetitive fast and easy programming of **.sw** files into the ElectroCraft drives during production.

5. Step 3. Motion Programming

5.1. Using an EtherCAT® master

5.1.1. Modes of Operation

The PRO-A08V48B-SA-CAT drive supports CAN application protocol over EtherCAT® (CoE) protocol with the following CiA 402 modes of operation:

- Profile position mode
- Profile velocity mode
- Homing mode
- Interpolated position mode
- Cyclic synchronous position mode
- Cyclic synchronous speed mode
- Cyclic synchronous torque mode

Additional to these modes, there are also several manufacturer specific modes defined:

- Electronic gearing position mode
- Electronic camming position mode

For details see the EtherCAT Programming manual (part no. P091.064.UM.xxxx)

5.1.2. Checking Setup Data Consistency

During the configuration phase, an EtherCAT® master can quickly verify using the checksum objects and a reference **.sw** file (see 4.5 and 5.2.4 for details) whether the non-volatile EEPROM memory of an PRO-A08V48 drive contains the right information. If the checksum reported by the drive doesn't match with that computed from the **.sw** file, the CANopen master can download the entire **.sw** file into the drive EEPROM using the communication objects for writing data into the drive EEPROM.

5.2. Using the built-in Motion Controller and MPL

One of the key advantages of the ElectroCraft drives is their capability to execute complex motions without requiring an external motion controller. This is possible because ElectroCraft drives offer in a single compact package both a state of art digital drive and a powerful motion controller.

5.2.1. ElectroCraft Motion Programming Language Overview

Programming motion directly on a ElectroCraft drive requires creating and downloading a MPL (ElectroCraft Motion Programming Language) program into the drive memory. The MPL allows you to:

- Set various motion modes (profiles, PVT, PT, electronic gearing or camming, etc.)
- Change the motion modes and/or the motion parameters
- Execute homing sequences
- Control the program flow through:
 - Conditional jumps and calls of MPL functions
 - MPL interrupts generated on pre-defined or programmable conditions (protections triggered, transitions on limit switch or capture inputs, etc.)
 - Waits for programmed events to occur
- Handle digital I/O and analog input signals
- Execute arithmetic and logic operations

In order to program a motion using MPL you need MotionPRO Developer software platform.

5.2.2. Installing MotionPRO Developer

MotionPRO Developer is an integrated development environment for the setup and motion programming of ElectroCraft programmable drives. It comes with an **Update via Internet tool** through which you can check if your software version is up-to-date, and when necessary download and install the latest updates.

A **demo version of MotionPRO Developer** including the **fully functional version of PRO Config** can be downloaded free of charge from ElectroCraft web page.

MotionPRO Developer is delivered on a CD. Once you have started the installation package, follow its indications. After installation, use the update via internet tool to check for the latest updates. Alternately, you can first install the demo version and then purchase a license. By introducing the license serial number in the menu command **Help | Enter registration info...**, you can transform the demo version into a fully functional version.

5.2.3. Getting Started with MotionPRO Developer

Using MotionPRO Developer you can quickly do the setup and the motion programming of a ElectroCraft a drive according with your application needs. The drive can be directly connected with your PC via a serial RS 232 link.

The output of the MotionPRO Developer is a set of setup data and a motion program, which can be downloaded to the drive/motor EEPROM or saved on your PC for later use.

MotionPRO Developer includes a set of evaluation tools like the Data Logger, the Control Panel and the Command Interpreter which help you to quickly develop, test, measure and analyze your motion application.

MotionPRO Developer works with **projects**. A project contains one or several **Applications**.

Each application describes a motion system for one axis. It has 2 components: the **Setup** data and the **Motion** program and an associated axis number: an integer value between 1 and 255. An application may be used either to describe:

1. One axis in a multiple-axis system
2. An alternate configuration (set of parameters) for the same axis.

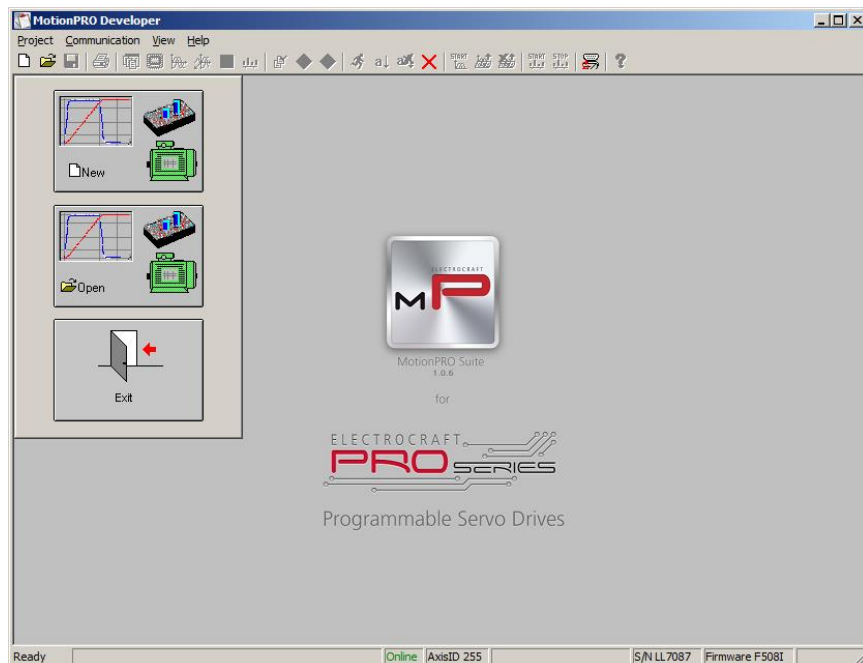
In the first case, each application has a different axis number corresponding to the axis ID of the drives/motors from the network. All data exchanges are done with the drive/motor having the same address as the selected application. In the second case, all the applications have the same axis number.

The setup component contains all the information needed to configure and parameterize a ElectroCraft drive. This information is preserved in the drive/motor EEPROM in the *setup table*. The setup table is copied at power-on into the RAM memory of the drive/motor and is used during runtime.

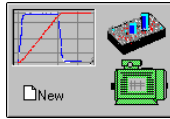
The motion component contains the motion sequences to do. These are described via a MPL (ElectroCraft Motion Programming Language) program, which is executed by the drives/motors built-in motion controller.

5.2.3.1 Create a new project

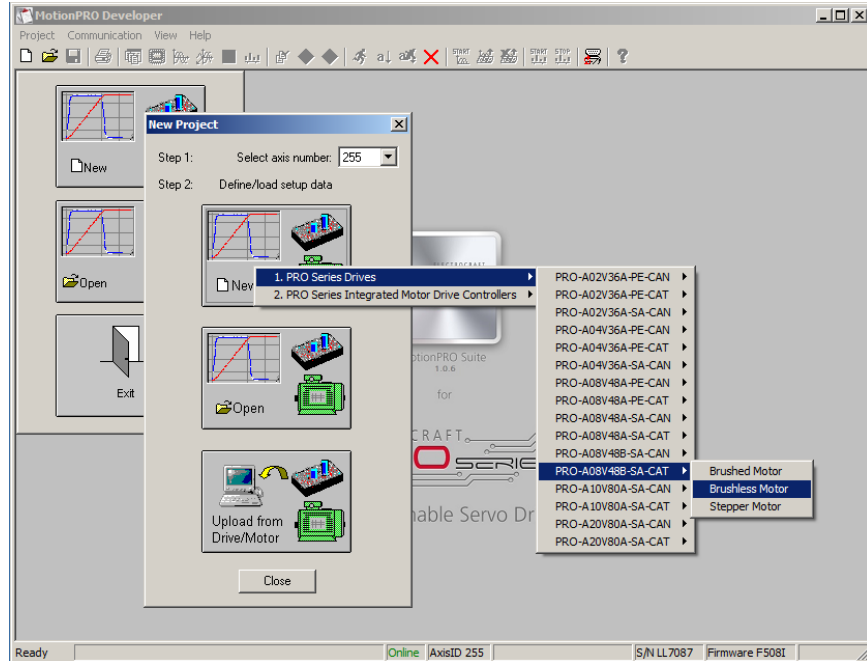
MotionPRO Developer starts with an empty window from where you can create a new project or open a previously created one.



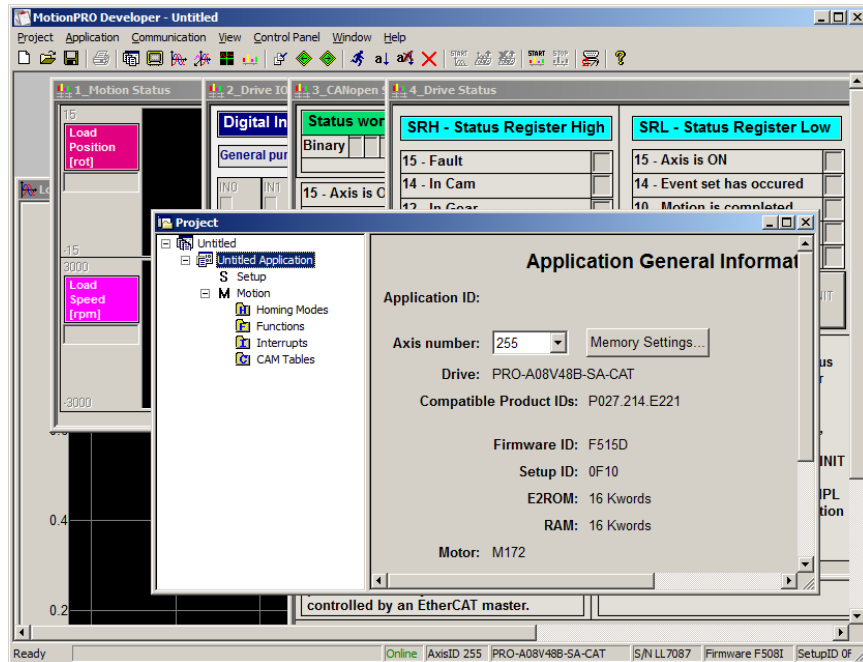
When you start a new project, MotionPRO Developer automatically creates a first application. Additional applications can be added later. You can duplicate an application or insert one defined in another project.



Press **New** button to open the “New Project” dialogue. Set the axis number for your first application equal with your drive/motor axis ID. The initial value proposed is 255 which is the default axis ID of the drives. Press **New** button and select your drive type. Depending on the product chosen, the selection may continue with the motor technology (for example: brushless or brushed) and the type of feedback device (for example: incremental encoder).



Click on your selection. MotionPRO Developer opens the Project window where on the left side you can see the structure of a project. At beginning both the new project and its first application are named “Untitled”. The application has 2 components: **S** Setup and **M** Motion (program).



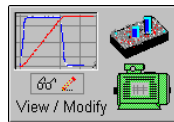
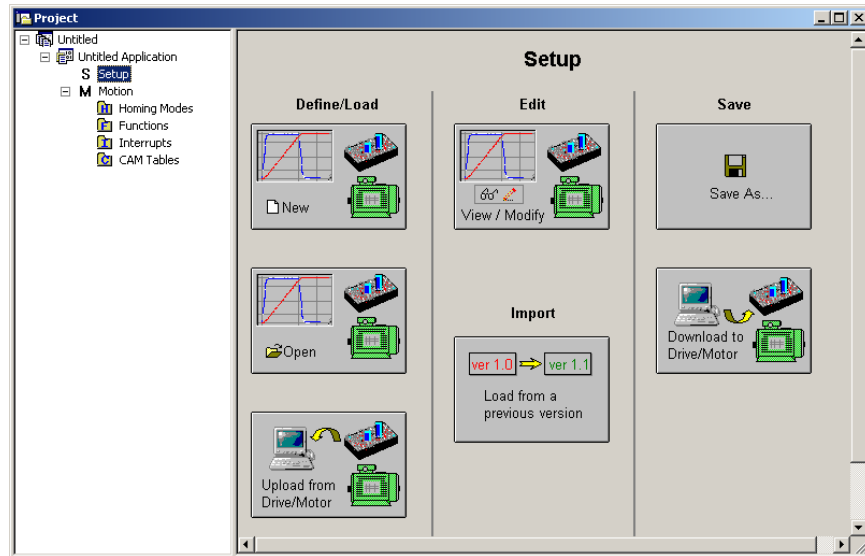
5.2.3.2 Step 2 Establish communication

If you have a drive/motor connected with your PC, now its time to check the communication. Use menu command **Communication | Setup** to check/change your PC communication settings. Press the **Help** button of the dialogue opened. Here you can find detailed information about how to setup your drive/motor and the connections. Power on the drive, then close the Communication | Setup dialogue with OK. If the communication is established, MotionPRO Developer displays in the status bar (the bottom line) the text “**Online**” plus the axis ID of your drive/motor and its firmware version. Otherwise the text displayed is “**Offline**” and a communication error message tells you the error type. In this case, return to the Communication | Setup dialogue, press the Help button and check troubleshoots.

Remark: When first started, MotionPRO Developer tries to communicate via RS-232 and COM1 with a drive having axis ID=255 (default communication settings). If your drive is powered and it is connected to your PC port COM1 via an RS-232 cable, the communication shall establish automatically.

5.2.3.3 Setup drive/motor

In the project window left side, select “S Setup”, to access the setup data for your application.



Press **View/Modify** button. This opens 2 setup dialogues: for **Motor Setup** and for **Drive Setup** (same like on PRO Config) through which you can configure and parameterize a ElectroCraft drive. In the **Motor setup** dialogue you can introduce the data of your motor and the associated sensors. Data introduction is accompanied by a series of tests having as goal to check the connections to the drive and/or to determine or validate a part of the motor and sensors parameters. In the **Drive setup** dialogue you can configure and parameterize the drive for your application. In each dialogue you will find a **Guideline Assistant**, which will guide you through the whole process of introducing and/or checking your data.



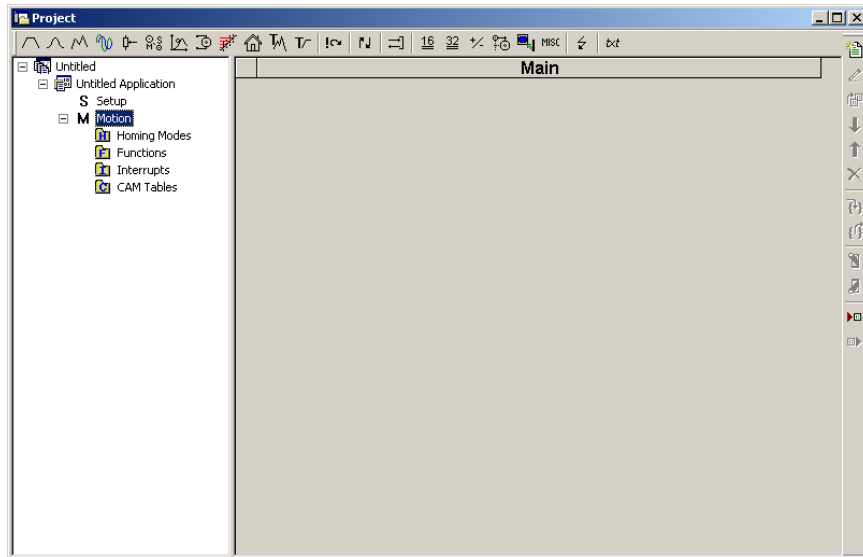
Press the **Download to Drive/Motor** button to download your setup data in the drive/motor EEPROM memory in the *setup table*. From now on, at each power-on, the setup data is copied into the drive/motor RAM memory which is used during runtime. It is also possible to save the setup data on your PC and use it in other applications. Note that you can upload the complete setup data from a drive/motor.

To summarize, you can define or change the setup data of an application in the following ways:

- create a new setup data by going through the motor and drive dialogues
- use setup data previously saved in the PC
- upload setup data from a drive/motor EEPROM memory

5.2.3.4 Program motion

In the project window left side, select “M Motion”, for motion programming. This automatically activates the **Motion Wizard**.



The Motion Wizard offers you the possibility to program all the motion sequences using high level graphical dialogues which automatically generate the corresponding MPL instructions. Therefore with Motion Wizard you can develop motion programs using almost all the MPL instructions without needing to learn them. A MPL program includes a main section, followed by the subroutines used: functions, interrupt service routines and homing procedures. The MPL program may also include cam tables used for electronic camming applications.

When activated, Motion Wizard adds a set of toolbar buttons in the project window just below the title. Each button opens a programming dialogue. When a programming dialogue is closed, the associated MPL instructions are automatically generated. Note that, the MPL instructions generated are not a simple text included in a file, but a motion object. Therefore with Motion Wizard you define your motion program as a collection of motion objects.

The major advantage of encapsulating programming instructions in motion objects is that you can very easily manipulate them. For example, you can:

- Save and reuse a complete motion program or parts of it in other applications
- Add, delete, move, copy, insert, enable or disable one or more motion objects
- Group several motion objects and work with bigger objects that perform more complex functions

As a starting point, push for example the leftmost Motion Wizard button – Trapezoidal profiles, and set a position or speed profile. Then press the **Run** button. At this point the following operations are done automatically:

- A MPL program is created by inserting your motion objects into a predefined template
- The MPL program is compiled and downloaded to the drive/motor
- The MPL program execution is started

For learning how to send MPL commands from your host/master, using one of the communication channels and protocols supported by the drives use menu command **Application | Binary Code Viewer...** Using this tool, you can get the exact contents of the messages to send and of those expected to be received as answers.

5.2.3.5 Evaluate motion application performances

MotionPRO Developer includes a set of evaluation tools like the **Data Logger**, the **Control Panel** and the **Command Interpreter** which help you to quickly measure and analyze your motion application.

5.2.4. Creating an Image File with the Setup Data and the MPL Program

Once you have validated your application, you can create with the menu command **Application | Create EEPROM Programmer File** a software file (with extension **.sw**) which contains all the data to write in the EEPROM of your drive. This includes both the setup data and the motion program. For details regarding the **.sw** file format and how it can be programmed into a drive, see paragraph 0

5.3. Combining CoE with MPL

Due to its embedded motion controller, an PRO-A08V48B-SA-CAT offers many programming solutions that may simplify a lot the task of a EtherCAT® master. This paragraph overviews a set of advanced programming features which arise when combining MPL programming at drive level with EtherCAT® master control. A detailed description of these advanced programming features is included in the ***EtherCAT Programming (part no. P091.064.UM.xxxx)*** manual. All features presented below require usage of MotionPRO Developer as MPL programming tool

Remark: *If you don't use the advanced features presented below, you don't need MotionPRO Developer. In this case the PRO-A08V48B-SA-CAT is treated like a standard EtherCAT® drive, whose setup is done using PRO Config.*

5.3.1. Using MPL Functions to Split Motion between Master and Drives

With ElectroCraft programmable drives you can really distribute the intelligence between an EtherCAT® master and the drives in complex multi-axis applications. Instead of trying to command each step of an axis movement, you can program the drives using MPL to execute complex tasks and inform the master when these are done. Thus for each axis, the master task may be reduced at: calling MPL functions (with possibility to abort their execution) stored in the drives EEPROM and waiting for a message, which confirms the finalization of the MPL functions execution.

5.3.2. Executing MPL programs

The distributed control concept can go one step further. You may prepare and download into a drive a complete MPL program including functions, homing procedures¹, etc. The MPL program execution can be started by simply writing a value in a dedicated object,

5.3.3. Loading Automatically Cam Tables Defined in MotionPRO Developer

Apart from the standard modes of operation of CiA 402, the PRO-A08V48B-SA-CAT offers others like: electronic gearing, electronic camming, external modes with analog or digital reference etc. When electronic camming is used, the cam tables can be loaded in the following ways:

- a) The master downloads the cam points into the drive active RAM memory after each power on;
- b) The cam points are stored in the drive EEPROM and the master commands their copy into the active RAM memory
- c) The cam points are stored in the drive EEPROM and during the drive initialization (transition to Ready to Switch ON status) are automatically copied from EEPROM to the active RAM

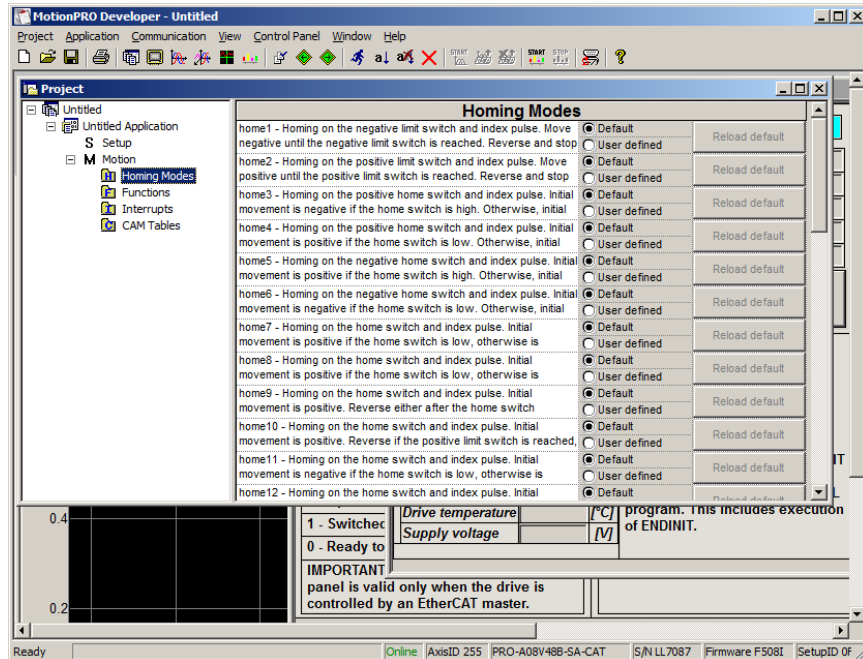
For the last 2 options the cam table(s) are defined in MotionPRO Developer and are included in the information stored in the EEPROM together with the setup data and the MPL programs/functions.

Remark: The cam tables are included in the **.sw** file generated with MotionPRO Developer. Therefore, the drives can check the cam presence in the drive EEPROM using the same procedure as for testing of the setup data.

¹ The customization of the interrupt service routines and homing routines is available only for PRO-A08V48 CAN executions

5.3.4. Customizing the Homing Procedures

The PRO-A08V48 supports all homing modes defined in CiA402 device profile, plus 4 custom based on hard stop. If needed, any of these homing modes can be customized. In order to do this you need to select the Homing Modes from your MotionPRO Developer application and in the right side to set as “User defined” one of the Homing procedures. Following this operation the selected procedure will occur under Homing Modes in a subtree, with the name *HomeX* where X is the number of the selected homing.



If you click on the *HomeX* procedure, on the right side you’ll see the MPL function implementing it. The homing routine can be customized according to your application needs. Its calling name and method remain unchanged.

5.3.5. Customizing the Drive Reaction to Fault Conditions

Similarly to the homing modes, the default service routines for the MPL interrupts can be customized according to your application needs. However, as most of these routines handle the drive reaction to fault conditions, it is mandatory to keep the existent functionality while adding your application needs, in order to preserve the correct protection level of the drive. The procedure for modifying the MPL interrupts is similar with that for the homing modes.

6. Scaling factors

ElectroCraft drives work with parameters and variables represented in the drive internal units (IU). These correspond to various signal types: position, speed, current, voltage, etc. Each type of signal has its own internal representation in IU and a specific scaling factor. This chapter presents the drive internal units and their relation with the international standard units (SI).

In order to easily identify them, each internal unit has been named after its associated signal. For example the **position units** are the internal units for position, the **speed units** are the internal units for speed, etc.

6.1. Position units

6.1.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal position units are encoder counts. The correspondence with the load **position in SI units**¹ is:

$$\text{Load_Position[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr}} \times \text{Motor_Position[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

6.1.2. DC brushed motor with quadrature encoder on load and tacho on motor

The internal position units are encoder counts. The motor is rotary and the transmission is rotary-to-rotary. The correspondence with the load position in SI units is:

$$\text{Load_Position[rad]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines}} \times \text{Load_Position[IU]}$$

where:

No_encoder_lines – is the encoder number of lines per revolution

¹SI units for position are: [rad] for a rotary movement, [m] for a linear movement

6.1.3. Step motor open-loop control. No feedback device

The internal position units are motor μ steps. The correspondence with the load **position in SI units** is:

$$\text{Load_Position[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps} \times \text{Tr}} \times \text{Motor_Position[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_μsteps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

Step motor closed-loop control. Incremental encoder on motor

The internal position units are motor encoder counts. The correspondence with the load **position in SI units**¹ is:

$$\text{Load_Position[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr}} \times \text{Motor_Position[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

6.1.4. Step motor open-loop control. Incremental encoder on load

The internal position units are load encoder counts. The transmission is rotary-to-rotary. The correspondence with the load position in SI units is:

$$\text{Load_Position[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines}} \times \text{Load_Position[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

¹ SI units for position are [rad] for a rotary movement , [m] for a linear movement

6.1.5. Brushless motor with sine/cosine encoder on motor

The internal position units are interpolated encoder counts. The correspondence with the load position in SI units is:

For rotary motors:

$$\text{Load_Position[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation} \times \text{Tr}} \times \text{Motor_Position[IU]}$$

For linear motors:

$$\text{Load_Position[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation} \times \text{Tr}} \times \text{Motor_Position[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 and 256. 1 means no interpolation

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

6.2. Speed units

The internal speed units are internal position units / (slow loop sampling period) i.e. the position variation over one slow loop sampling period

6.2.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal speed units are encoder counts / (slow loop sampling period). The correspondence with the load **speed in SI units** is:

$$\text{Load_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times \text{T}} \times \text{Motor_Speed[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.2.2. DC brushed motor with quadrature encoder on load and tacho on motor

The internal speed units are encoder counts / (slow loop sampling period). The motor is rotary and the transmission is rotary-to-rotary. The correspondence with the load speed in SI units is:

$$\text{Load_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{T}} \times \text{Load_Speed[IU]}$$

where:

No_encoder_lines – is the encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.2.3. DC brushed motor with tacho on motor

When only a tachometer is mounted on the motor shaft, the internal speed units are A/D converter bits. The correspondence with the load **speed in SI units**¹ is:

$$\text{Load_Speed[SI]} = \frac{\text{Analogue_Input_Range}}{4096 \times \text{Tacho_gain} \times \text{Tr}} \times \text{Motor_Speed[IU]}$$

where:

Analog_Input_Range – is the range of the drive analog input for feedback, expressed in [V]. You can read this value in the “Drive Info” dialogue, which can be opened from the “Drive Setup”

Tacho_gain – is the tachometer gain expressed in [V/rad/s]

6.2.4. Step motor open-loop control. No feedback device

¹ SI units for speed are [rad/s] for a rotary movement, [m/s] for a linear movement

The internal speed units are motor μ steps / (slow loop sampling period). The correspondence with the load **speed in SI units** is:

$$\text{Load_Speed[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps} \times \text{Tr} \times \text{T}} \times \text{Motor_Speed[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_μsteps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

Step motor open-loop control. Incremental encoder on load

The internal speed units are load encoder counts / (slow loop sampling period). The transmission is rotary-to-rotary. The correspondence with the load speed in SI units is:

$$\text{Load_Speed[rad/s]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{T}} \times \text{Load_Speed[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in [rad] and load displacement in [rad] or [m]

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

6.2.5. Step motor closed-loop control. Incremental encoder on motor

The internal speed units are motor encoder counts / (slow loop sampling period). The correspondence with the load **speed in SI units**¹ is:

$$\text{Load_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times \text{T}} \times \text{Motor_Speed[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

¹ SI units for speed are [rad/s] for a rotary movement , [m/s] for a linear movement

6.2.6. Brushless motor with sine/cosine encoder on motor

The internal speed units are interpolated encoder counts / (slow loop sampling period). The correspondence with the load speed in SI units is:

For rotary motors:

$$\text{Load_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation} \times \text{Tr} \times \text{T}} \times \text{Motor_Speed[IU]}$$

For linear motors:

$$\text{Load_Speed[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation} \times \text{Tr} \times \text{T}} \times \text{Motor_Speed[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 an 256. 1 means no interpolation

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.3. Acceleration units

The internal acceleration units are internal position units / (slow loop sampling period)² i.e. the speed variation over one slow loop sampling period.

6.3.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal acceleration units are encoder counts / (slow loop sampling period)². The correspondence with the load **acceleration in SI units** is:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times \text{T}^2} \times \text{Motor_Acceleration[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.3.2. DC brushed motor with quadrature encoder on load and tacho on motor

The internal acceleration units are encoder counts / (slow loop sampling period)². The motor is rotary and the transmission is rotary-to-rotary. The correspondence with the load acceleration in SI units is:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{T}^2} \times \text{Load_Acceleration[IU]}$$

where:

No_encoder_lines – is the encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.3.3. Step motor open-loop control. No feedback device

The internal acceleration units are motor μ steps / (slow loop sampling period)². The correspondence with the load **acceleration in SI units** is:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps} \times \text{Tr} \times \text{T}^2} \times \text{Motor_Acceleration[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_μsteps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.3.4. Step motor open-loop control. Incremental encoder on load

The internal acceleration units are load encoder counts / (slow loop sampling period)². The correspondence with the load acceleration in SI units is:

For rotary-to-rotary transmission:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times T^2} \times \text{Load_Acceleration[IU]}$$

For rotary-to-linear transmission:

$$\text{Load_Acceleration[m/s}^2] = \frac{\text{Encoder_accuracy}}{T^2} \times \text{Load_Acceleration[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Encoder_accuracy – is the linear encoder accuracy i.e. distance in [m] between 2 pulses

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

6.3.5. Step motor closed-loop control. Incremental encoder on motor

The internal acceleration units are motor encoder counts / (slow loop sampling period)². The transmission is rotary-to-rotary. The correspondence with the load **acceleration in SI units** is:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times T^2} \times \text{Motor_Acceleration[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.3.6. Brushless motor with sine/cosine encoder on motor

The internal acceleration units are interpolated encoder counts / (slow loop sampling period)². The correspondence with the load **acceleration in SI units**¹ is:

For rotary motors:

$$\text{Load_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation} \times \text{Tr} \times \text{T}^2} \times \text{Motor_Acceleration[IU]}$$

For linear motors:

$$\text{Load_Acceleration[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation} \times \text{Tr} \times \text{T}^2} \times \text{Motor_Acceleration[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 and 256. 1 means no interpolation

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

¹ SI units for acceleration are [rad/s²] for a rotary movement, [m/s²] for a linear movement

6.4. Jerk units

The internal jerk units are internal position units / (slow loop sampling period)³ i.e. the acceleration variation over one slow loop sampling period.

6.4.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal jerk units are encoder counts / (slow loop sampling period)³. The correspondence with the load **jerk in SI units**¹ is:

$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times \text{T}^3} \times \text{Motor_Jerk[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.4.2. DC brushed motor with quadrature encoder on load and tacho on motor

The internal jerk units are encoder counts / (slow loop sampling period)³. The motor is rotary and the transmission is rotary-to-rotary. The correspondence with the load jerk in SI units is:

$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{T}^3} \times \text{Load_Jerk[IU]}$$

where:

No_encoder_lines – is the encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

¹ SI units for jerk are [rad/s³] for a rotary movement, [m/s³] for a linear movement

6.4.3. Step motor open-loop control. No feedback device

The internal jerk units are motor μ steps / (slow loop sampling period)³. The correspondence with the load jerk in SI units¹ is:

$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps} \times \text{Tr} \times \text{T}^3} \times \text{Motor_Jerk[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_μsteps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.4.4. Step motor open-loop control. Incremental encoder on load

The internal jerk units are load encoder counts / (slow loop sampling period)³. The transmission is rotary-to-rotary. The correspondence with the load jerk in SI units is:

$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{T}^3} \times \text{Load_Jerk[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

6.4.5. Step motor closed-loop control. Incremental encoder on motor

The internal jerk units are motor encoder counts / (slow loop sampling period)³. The correspondence with the load jerk in SI units is:

$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times \text{Tr} \times \text{T}^3} \times \text{Motor_Jerk[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

6.4.6. Brushless motor with sine/cosine encoder on motor

¹ SI units for jerk are [rad/s³] for a rotary movement, [m/s³] for a linear movement

The internal jerk units are interpolated encoder counts / (slow loop sampling period)³. The correspondence with the load jerk in SI units is:

For rotary motors:
$$\text{Load_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation} \times \text{Tr} \times T^3} \times \text{Motor_Jerk[IU]}$$

For linear motors:
$$\text{Load_Jerk[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation} \times \text{Tr} \times T^3} \times \text{Motor_Jerk[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 and 256. 1 means no interpolation

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.5. Current units

The internal current units refer to the motor phase currents. The correspondence with the motor currents in [A] is:

$$\text{Current[A]} = \frac{2 \times I_{\text{peak}}}{65520} \times \text{Current[IU]}$$

where I_{peak} – is the drive peak current expressed in [A]. You can read this value in the “Drive Info” dialogue, which can be opened from the “Drive Setup”.

6.6. Voltage command units

The internal voltage command units refer to the voltages applied on the motor. The significance of the voltage commands as well as the scaling factors, depend on the motor type and control method used.

In case of **brushless motors** driven in **sinusoidal** mode, a field oriented vector control is performed. The voltage command is the amplitude of the sinusoidal phase voltages. In this case, the correspondence with the motor phase voltages in SI units i.e. [V] is:

$$\text{Voltage command[V]} = \frac{1.1 \times V_{\text{dc}}}{65534} \times \text{Voltage command[IU]}$$

where V_{dc} – is the drive power supply voltage expressed in [V].

In case of **brushless** motors driven in **trapezoidal** mode, the voltage command is the voltage to apply between 2 of the motor phases, according with Hall signals values. In this case, the correspondence with the voltage applied in SI units i.e. [V] is:

$$\text{Voltage command[V]} = \frac{V_{\text{dc}}}{32767} \times \text{Voltage command[IU]}$$

This correspondence is also available for **DC brushed** motors which have the voltage command internal units as the brushless motors driven in trapezoidal mode.

6.7. Voltage measurement units

The internal voltage measurement units refer to the drive V_{MOT} supply voltage. The correspondence with the supply voltage in [V] is:

$$\text{Voltage_measured[V]} = \frac{V_{\text{dcMaxMeasurable}}}{65520} \times \text{Voltage_measured[IU]}$$

where $V_{\text{dcMaxMeasurable}}$ – is the maximum measurable DC voltage expressed in [V]. You can read this value in the “Drive Info” dialogue, which can be opened from the “Drive Setup”.

Remark: the voltage measurement units occur in the scaling of the over voltage and under voltage protections and the supply voltage measurement

6.8. Time units

The internal time units are expressed in slow loop sampling periods. The correspondence with the time in [s] is:

$$\text{Time[s]} = T \times \text{Time[IU]}$$

where T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”. For example, if $T = 1\text{ms}$, one second = 1000 IU.

6.9. Master position units

When the master position is sent via a communication channel, the master position units depend on the type of position sensor present on the master axis.

6.10. Master speed units

The master speed is computed in internal units (IU) as master position units / slow loop sampling period i.e. the master position variation over one position/speed loop sampling period.

6.11. Motor position units

6.11.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal motor position units are encoder counts. The correspondence with the motor **position in SI units**¹ is:

$$\text{Motor_Position[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines}} \times \text{Motor_Position[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

6.11.2. DC brushed motor with quadrature encoder on load and tacho on motor

The motor position is not computed.

¹SI units for motor position are: [rad] for a rotary motor, [m] for a linear motor

6.11.3. Step motor open-loop control. No feedback device

The internal motor position units are motor μ steps. The correspondence with the motor **position in SI units**¹ is:

$$\text{Motor_Position[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps}} \times \text{Motor_Position[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_μsteps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

6.11.4. Step motor open-loop control. Incremental encoder on load

In open-loop control configurations with incremental encoder on load, the motor position is not computed.

6.11.5. Step motor closed-loop control. Incremental encoder on motor

The internal motor position units are motor encoder counts. The correspondence with the motor position in SI units is:

$$\text{Motor_Position[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines}} \times \text{Motor_Position[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

6.11.6. Brushless motor with sine/cosine encoder on motor

The internal motor position units are interpolated encoder counts. The correspondence with the motor position in SI units is:

For rotary motors:

$$\text{Motor_Position[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation}} \times \text{Motor_Position[IU]}$$

For linear motors:

$$\text{Motor_Position[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation}} \times \text{Motor_Position[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 and 256. 1 means no interpolation

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

6.12. Motor speed units

6.12.1. Brushless / DC brushed motor with quadrature encoder on motor

The internal motor speed units are encoder counts / (slow loop sampling period). The correspondence with the motor **speed in SI units** is:

$$\text{For rotary motors: } \text{Motor_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times T} \times \text{Motor_Speed[IU]}$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.12.2. DC brushed motor with quadrature encoder on load and tacho on motor

The internal motor speed units are A/D converter bits. The correspondence with the motor **speed in SI units**¹ is:

$$\text{Motor_Speed[SI]} = \frac{\text{Analogue_Input_Range}}{4096 \times \text{Tacho_gain}} \times \text{Motor_Speed[IU]}$$

where:

Analog_Input_Range – is the range of the drive analog input for feedback, expressed in [V]. You can read this value in the “Drive Info” dialogue, which can be opened from the “Drive Setup”

Tacho_gain – is the tachometer gain expressed in [V/rad/s]

6.12.3. DC brushed motor with tacho on motor

The internal motor speed units are A/D converter bits. The correspondence with the motor speed in SI units is:

$$\text{Motor_Speed[SI]} = \frac{\text{Analogue_Input_Range}}{4096 \times \text{Tacho_gain}} \times \text{Motor_Speed[IU]}$$

where:

Analog_Input_Range – is the range of the drive analog input for feedback, expressed in [V]. You can read this value in the “Drive Info” dialogue, which can be opened from the “Drive Setup”

Tacho_gain – is the tachometer gain expressed in [V/rad/s]

¹ SI units for motor speed are [rad/s] for a rotary motor, [m/s] for a linear motor

6.12.4. Step motor open-loop control. No feedback device or incremental encoder on load

The internal motor speed units are motor μ steps / (slow loop sampling period). The correspondence with the motor **speed in SI units** is:

$$\text{Motor_Speed[SI]} = \frac{2 \times \pi}{\text{No_}\mu\text{steps} \times \text{No_steps} \times T} \times \text{Motor_Speed[IU]}$$

where:

No_steps – is the number of motor steps per revolution

No_ μ steps – is the number of microsteps per step. You can read/change this value in the “Drive Setup” dialogue from PRO Config.

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

6.12.5. Step motor closed-loop control. Incremental encoder on motor

The internal motor speed units are motor encoder counts / (slow loop sampling period). The correspondence with the load speed in SI units is:

$$\text{Motor_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{No_encoder_lines} \times T} \times \text{Motor_Speed[IU]}$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”.

6.12.6. Brushless motor with sine/cosine encoder on motor

The internal motor speed units are interpolated encoder counts / (slow loop sampling period). The correspondence with the motor speed in SI units is:

For rotary motors:

$$\text{Motor_Speed[SI]} = \frac{2 \times \pi}{4 \times \text{Enc_periods} \times \text{Interpolation} \times T} \times \text{Motor_Speed[IU]}$$

For linear motors:

$$\text{Motor_Speed[SI]} = \frac{\text{Encoder_accuracy}}{\text{Interpolation} \times T} \times \text{Motor_Speed[IU]}$$

where:

Enc_periods – is the rotary encoder number of sine/cosine periods or lines per revolution

Encoder_accuracy – is the linear encoder accuracy in [m] for one sine/cosine period

Interpolation – is the interpolation level inside an encoder period. Its a number power of 2 between 1 and 256. 1 means no interpolation

Tr – transmission ratio between the motor displacement in SI units and load displacement in SI units

T – is the slow loop sampling period expressed in [s]. You can read this value in the “Advanced” dialogue, which can be opened from the “Drive Setup”

7. Memory Map

PRO-A08V48B-SA-CAT has 2 types of memory available for user applications: 16K×16 SRAM and 16K×16 serial E²ROM.

The SRAM memory is mapped in the address range: C000h to FFFFh. It can be used to download and run a MPL program, to save real-time data acquisitions and to keep the cam tables during run-time.

The E²ROM is mapped in the address range: 4000h to 7FFFh. It is used to keep in a non-volatile memory the MPL programs, the cam tables and the drive setup information.

Remark: MotionPRO Developer handles automatically the memory allocation for each motion application. The memory map can be accessed and modified from the main folder of each application

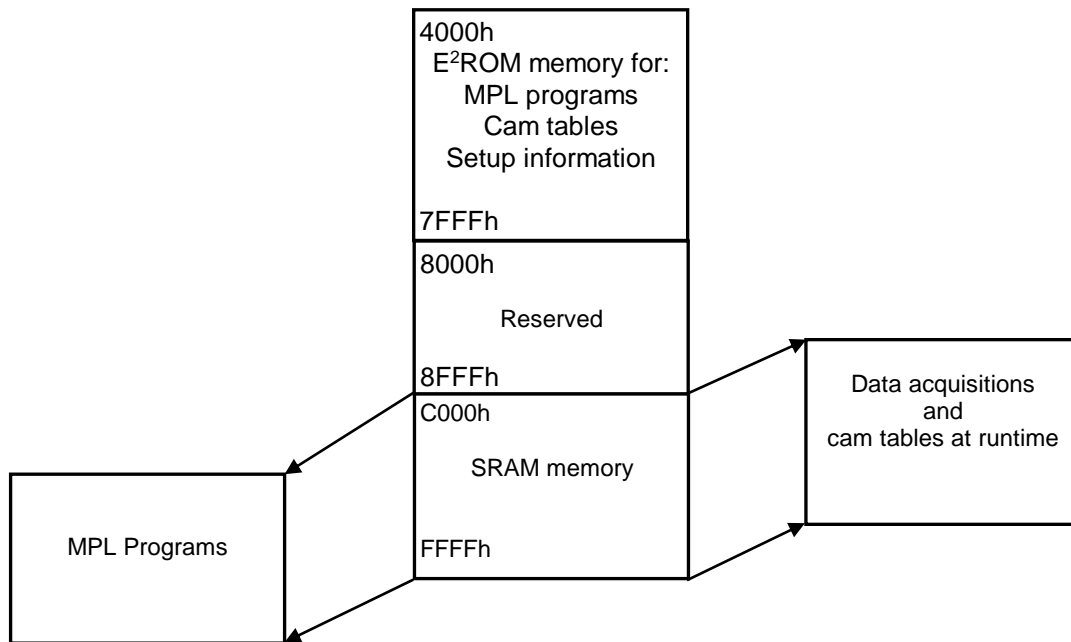


Figure 7.1. PRO-A08V48B-SA-CAT Memory Map

