ElectroCraft

PRO-A08V48B-SA-CAN

Programmable Servo Drive
for Step, DC, Brushless DC
and AC Motors

Programmable Servo Drive

ElectroCraft Document Number
A11225 Rev 2

Technical Reference

ELECTROCRAFT

PRO-A08V48B-SA-CAN

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Read This First

About This Manual

This book is a technical reference manual for:

- **PRO-A08V48B-SA-CAN** 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 **CANopen master**[1]
  - ☐ The drive's **built-in motion controller** executing an ElectroCraft Motion PROgramming Language (**MPL**) program developed using ElectroCraft **MotionPRO Suite** software
  - ☐ A **MPL_LIB motion library for PCs** (Windows or Linux)
  - ☐ A **MPL_LIB motion library for PLCs**
  - ☐ 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-CAN** 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.

[1] when PRO-A08V48 is set in CANopen mode

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** – Electrocraft Motion Program Language
- **MPLCAN** – Electrocraft protocol for exchanging MPL commands via CAN-bus

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.

PRO Series CANOpen Programming Manual (Document No. A11226) – explains how to program the PRO Series family of programmable drives using **CANopen** protocol and describes the associated object dictionary for **CiA 301 v.4.2** application layer and communication profile, **CiA WD 305 v.2.2.13** layer settings services and protocols and **CiA DSP 402 v3.0** device profile for drives and motion control now included in IEC 61800-7-1 Annex A, IEC 61800-7-201 and IEC 61800-7-301 standards.

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.

MPL_LIB v2.0 **(Document No. A11230)** – explains how to program in **C, C++,C#, Visual Basic or Delphi Pascal** a motion application for the ElectroCraft programmable drives using ElectroCraft Document Number A11230 motion control library for PCs. The MPL_LIB includes ready-to-run examples that can be executed on **Windows** or **Linux** (x86 and x64).

PRO Series and MPL_LIB_LabVIEW Compatibility **(Document No. A11231)** – explains how to program in **LabVIEW** a motion application for the ElectroCraft programmable drives using MPL_LIB_Labview v2.0 motion control library for PCs. The MPL_LIB_LabVIEW includes over 40 ready-to-run examples.

***PRO Series and PLC Siemens Series S7-300 or S7-400* (Document No. A11232)** – explains how to program in a PLC **Siemens series S7-300 or S7-400** a motion application for the ElectroCraft programmable drives using MPL_LIB_S7 motion control library. The MPL_LIB_S7 library is **IEC61131-3 compatible**.

***PRO Series and PLC Omron Series MPL_LIB_CJ1* (Document No. A11233)** – explains how to program in a PLC **Omron series CJ1** a motion application for the ElectroCraft programmable drives using MPL_LIB_CJ1 motion control library for PLCs. The MPL_LIB_CJ1 library is **IEC61131-3 compatible**.

***MPL_LIB_X20* (Document No. A11234)** – explains how to program in a PLC **B&R series X20** a motion application for the ElectroCraft programmable drives using MPL_LIB_X20 motion control library for PLCs. The MPL_LIB_X20 library is **IEC61131-3 compatible**.

***ElectroCAN* (Document No. A11235)** – presents ElectroCAN protocol – an extension of the CANopen communication profile used for MPL commands

***QS-PRO-A0xV36* (Document No. 11235)** – describes the PRO-A08V48 Quick Start board included in the **PRO-A08V48** Evaluation Kits

If you Need Assistance …

If you want to …	Contact ElectroCraft at …
Visit ElectroCraft online	World Wide Web: www.electrocraft.com
Receive general information or assistance (see Note)	World Wide Web: www.electrocraft.com Email: drivesupport@electrocraft.com
Ask questions about product operation or report suspected problems (see Note)	Tel.: +1 734-662-7771 Email: drivesupport@electrocraft.com
Make suggestions about, or report errors in documentation (see Note)	Mail: ElectroCraft 1 Progress Drive Dover, NH 03820 USA

Contents

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 THE PRO-A08V48B-SA-CAN FROM IT'S SOCKET 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-CAN** is part of a family of fully digital intelligent 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-CAN drives accept as position feedback incremental encoders (quadrature or sine/cosine) and linear Halls signals.

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-CAN 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 Program 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 analogue input signals
- Executing arithmetic and logic operations
- Performing data transfers between axes
- Controlling motion of an axis from another one via motion commands sent between axes
- Sending commands to a group of axes (multicast). This includes the possibility to start simultaneously motion sequences on all the axes from the group
- Synchronizing all the axes from a network

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.

All PRO-A08V48B-SA-CAN drives are equipped with a serial RS232 and a CAN 2.0B interface and can be set (hardware, via a DIP switch) to operate in 2 modes:

- **CANopen**
- **MPLCAN**

When **CANopen** mode is selected, the PRO-A08V48 conforms to **CiA 301 v4.2** application layer and communication profile, **CiA WD 305 v2.2.13** and **CiA DSP 402 v3.0** device profile for drives and motion control, now included in IEC 61800-7-1 Annex A, IEC 61800-7-201 and IEC 61800-7-301 standards. In this mode, the PRO-A08V48 may be controlled via a CANopen master. As a bonus, PRO-A08V48 offers a CANopen master the option to call motion sequences, written in MPL and stored in the drive EEPROM, using manufacturer specific objects (see for details par. 5.3).

When **MPLCAN** mode is selected, the PRO-A08V48 behaves as standard Electrocraft intelligent drive and conforms to Electrocraft protocol for exchanging MPL commands via CAN-bus. When MPLCAN protocol is used, it is not mandatory to have a master. Any PRO-A08V48 can be set to operate standalone, and may play the role of a master to coordinate both network communication/ synchronization and the motion application via MPL commands sent directly to the other drives.

When higher level coordination is needed, apart from a CANopen master, the PRO-A08V48 drives can also be controlled via a PC or a PLC using one of the **MPL_LIB** motion libraries.

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 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 is 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 without requiring an external motion controller, thanks to their built-in motion controllers*. MotionPRO Developer, shall be used to program motion sequences in MPL. This is the PRO-A08V48 typical operation mode when MPLCAN protocol is selected. MotionPRO Developer shall also be used with CANopen 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
- 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 position; torque, speed or position control; position or speed profiles, external analogue reference or sent via a communication bus
- Electrocraft Motion Program 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
  - CAN-Bus up to 1Mbit/s
- 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 analogue inputs: 12 bit, 0-5V: Reference and Feedback or general purpose
  - NTC/PTC analogue Motor Temperature sensor input
- Feedback devices (dual-loop support):

  Feedback #1 devices supported:
  - Incremental encoder interface (single ended or differential[1])
  - Pulse & direction interface (single-ended) for external (master) digital reference
  - Analog sin/cos encoder interface (differential $1V_{PP}$)
  - Digital Hall sensor interface (single-ended and open collector)
  - Linear Hall sensors interface[2]

  Feedback #2 devices supported:
  - Incremental encoder interface (differential)
  - Pulse & direction interface (differential) for external (master) digital reference
  - BiSS[3] / SSI encoder interface
- 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
- 127 h/w selectable addresses

[1] Differential Feedback #1 is available with the standard hardware configuration
[2] Only available with the optional Linear Halls hardware configuration
[3] Currently in development

- Two operation modes selectable by DIP switch:
  - **CANopen** – conforming with **CiA 301 v4.2, CiA WD 305 v2.2.13** and **CiA DSP 402 v3.0**
  - **MPLCAN** – intelligent drive conforming with Electrocraft protocol for exchanging MPL commands via CAN-bus
- 16K × 16 internal SRAM memory for data acquisition
- 16K × 16 E^2ROM 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-CAN: 8A[1] 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] 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-CAN* version.
This manual refers to *PRO-A08V48**B**-SA-CAN* (**version 'B'**). If your hardware version is 'A', please refer to the *PRO-A08V48x-SA-CAN* Technical Reference Manual with revision 1.

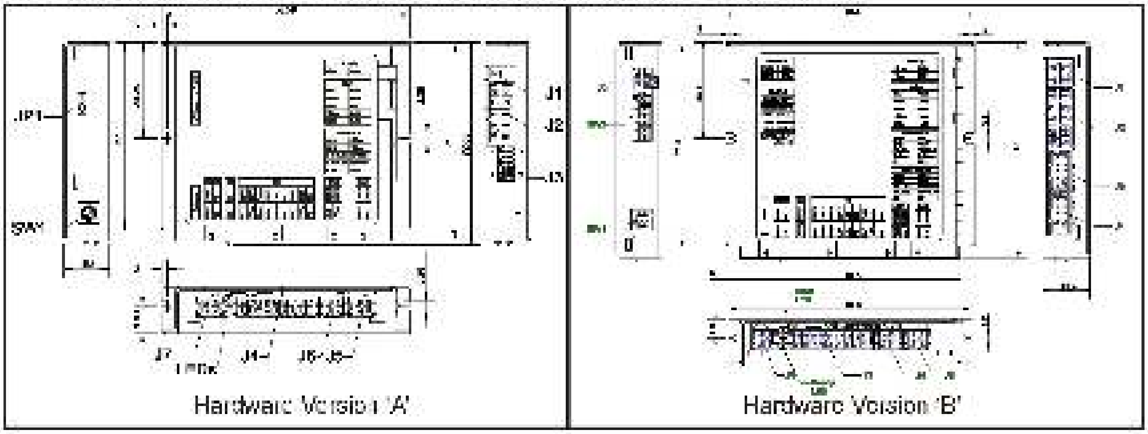


Figure 2.1. PRO-A08V48x-SA-CAN v 'A' and v 'B' comparison

Note 1: The hw ver. 'A' has the p.n. PRO-A08V48A-SA-CAN
The hw ver. 'B' has the p.n. PRO-A08V48B-SA-CAN
Note 2: Each p.n. has its own MotorPRO software template which is not compatible with the other.

2.4. Supported Motor-Sensor Configurations

The PRO-A08V48B-SA-CAN 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.E701

2.4.2. Dual loop configurations

Motor type	Feedback #1	Feedback #2
PMSM	• Incremental encoder (single-ended or differential) • Analogue Sin/Cos encoder	• Incremental encoder (differential) • SSI/BiSS encoder
DC Brush	• Incremental encoder (single-ended or differential) • Analogue Sin/Cos encoder • Analogue Tacho (only on motor)	• 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-CAN Drive Dimensions

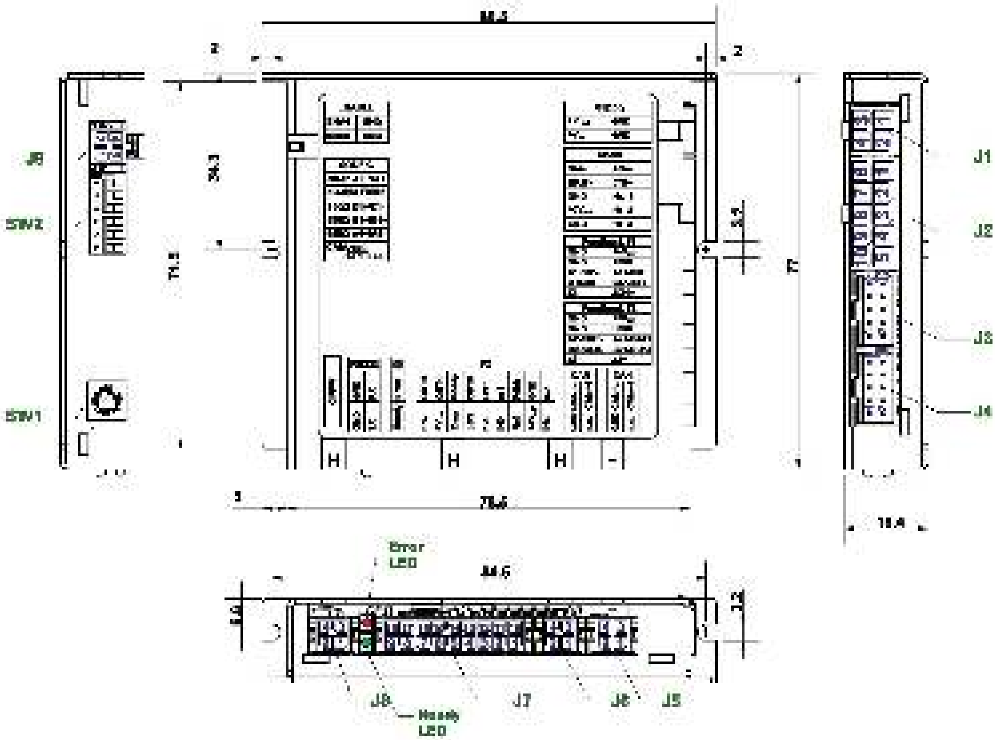


Figure 2.2. PRO-A08V48B-SA-CAN drive dimensions

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

2.6. Identification Labels

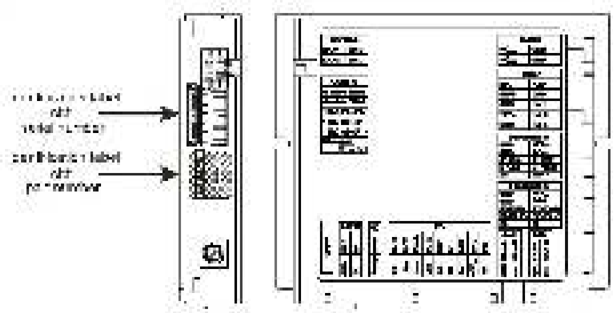


Figure 2.3. PRO-A08V48B-SA-CAN Identification Labels

2.7. Electrical Specifications

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

T_{amb} = 0…40°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	Not powered; applies to any accessible part			±0.5	kV
(Human body model)	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	98.5 x 77 x 16.4			mm
		~3.46 x 3.03 x 0.65			inch
	With recommended mating connectors.	98 x 85 x 19.5			mm
		~3.86 x 3.35 x 0.77			inch
Weight	Without mating connectors	104			g
Power dissipation	Idle (no load)		TBD		W
	Operating		TBD		W
Efficiency			98		%
Cleaning agents	Dry cleaning is recommended	Only Water- or Alcohol- based			
Protection degree	According to IEC60529, UL508	IP20			-

[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 air ventilation) the maximum ambient temperature can be increased substantially.

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	±6	+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	20			
		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	V
		OUT0, OUT1, OUT4	4	4.5	5	V
	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		V
	Floating voltage (not connected)		4.4		V
	Absolute maximum, surge (duration ≤ 1S) †	-10		+15	V
Input current	Logic "LOW"; Pull to GND			1.2	mA
	Logic "HIGH"; Internal 4.7KΩ pull-up to +5	0	0	0	mA
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 driver by push-pull (TTL / CMOS)	0		10	MHz
Minimum pulse width	Single-ended mode, Open-collector / NPN	1			µs
	Differential mode, or Single-ended driver 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
ESD protection	Human body model	±1			kV

[1] For full RS-422 compliance 150Ω termination resistors must be connected across the differential pairs: set SW2 pins 3, 4 and 5 to ON

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

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 SW2 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

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[3]
Bandwidth (-3dB)	Depending on software settings	0		1	kHz
ESD protection	Human body model	±5			kV

[1] Available only with the Linear Halls hardware configuration

[2] Available only with the Standard hardware configuration

[3] "FS" stands for "Full Scale"

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. CAN-Bus

		Min.	Typ.	Max.	Units
Standards compliance		ISO11898, CiA-301v4.2, CiA WD 305 v2.2.13, CiA DSP402v3.0			
Bit rate	Depending on software settings	125		1000	Kbps
Bus length	1Mbps			25	m
	500Kbps			100	
	≤ 250Kbps			250	
Number of CAN nodes/drives				125	-
Termination resistor	Between CAN-Hi, CAN-Lo	none on-board			
Node addressing	Hardware: by Hex switch (SW1)	1 - 15 & LSS non-configured (CANopen); 1-15 & 255 (MPLCAN)			
	Software	1 - 127 (CANopen); 1- 255 (MPLCAN)			
Voltage, CAN-Hi or CAN-Lo to GND		-26		+26	V
ESD protection	Human body model	±15			KV

2.7.18. Supply Output (+5V)

		Min.	Typ.	Max.	Units
+5V output voltage	Current sourced = 500mA	4.8	5	5.2	V
+5V output current		500	550		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-CAN drive is intended to be mounted vertically or horizontally 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 1 Watt at idle, and up to 5 Watts (= 17 BTU/hour) worst case while driving a motor and using all digital outputs.

3.1.1. Vertical Mounting

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

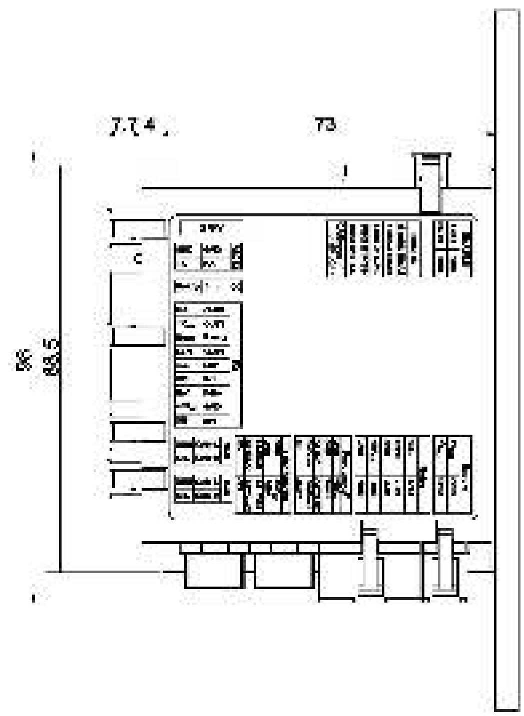


Figure 3.1 *Overall dimensions using recommended mating connectors*

The PRO-A08V48B-SA-CAN drive(s) can be cooled by natural convection. The support can be mounted horizontally or vertically.

Figure 3.2. shows the recommended spacing to assure proper airflow by natural convection, *__in the worst case__* – closed box done from a plastic (non-metallic) material with no ventilation openings.

Whenever possible, ventilation openings shall be foreseen on the top side wall of the box and at the bottom of the lateral walls. When using a horizontal support considerably larger than the size of the hosted PRO-A08V48B-SA-CAN drives, it is recommended to provide ventilation holes in the support also.

Remark: *In case of using a metallic box, with ventilation openings, all spacing values may be reduced substantially. With proper ventilation, keeping the air surrounding the PRO-A08V48B-SA-CAN inside the limits indicated, the spacing values may be reduced down to zero.*

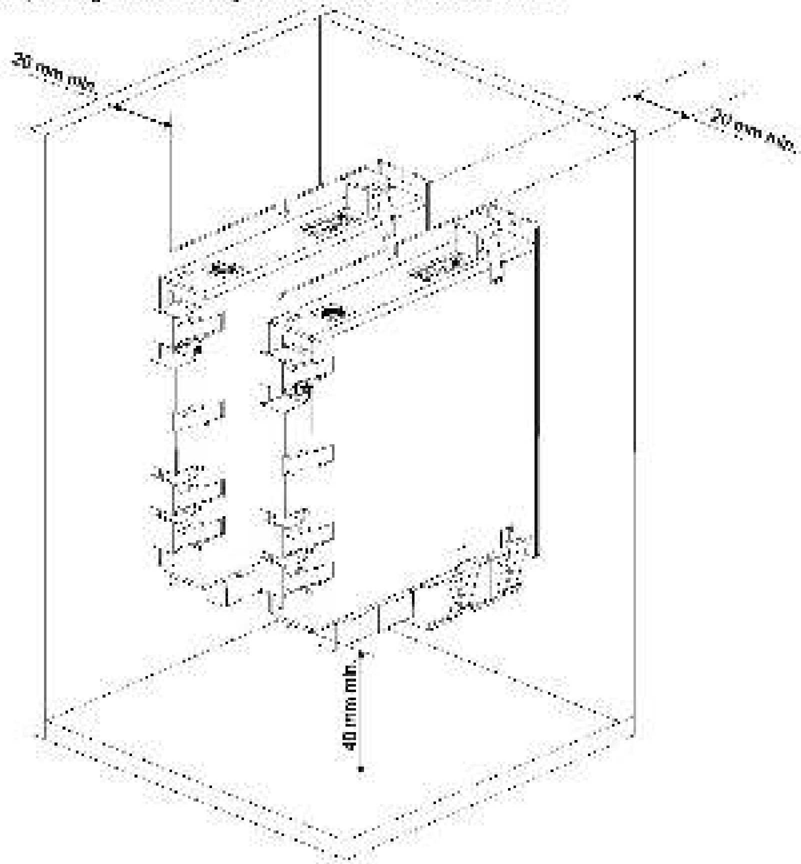


***Figure** 3.2 Recommended spacing for vertical mounting, worst case: non-metallic, closed box*

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

3.1.2. Horizontal Mounting

Figure 3.3 shows the recommended spacing to assure proper airflow by natural convection, *in the worst case* – closed box done from a plastic (non metallic) material with no ventilation openings.

Whenever possible, ventilation openings shall be foreseen.

Remark: *In case of using a metallic box, with ventilation openings, all spacing values may be reduced substantially. With proper ventilation, keeping the air surrounding the PRO A08V48B SA CAN inside the limits indicated, the spacing values may be reduced down to the mechanical tolerance limits of Figure 3.1.*

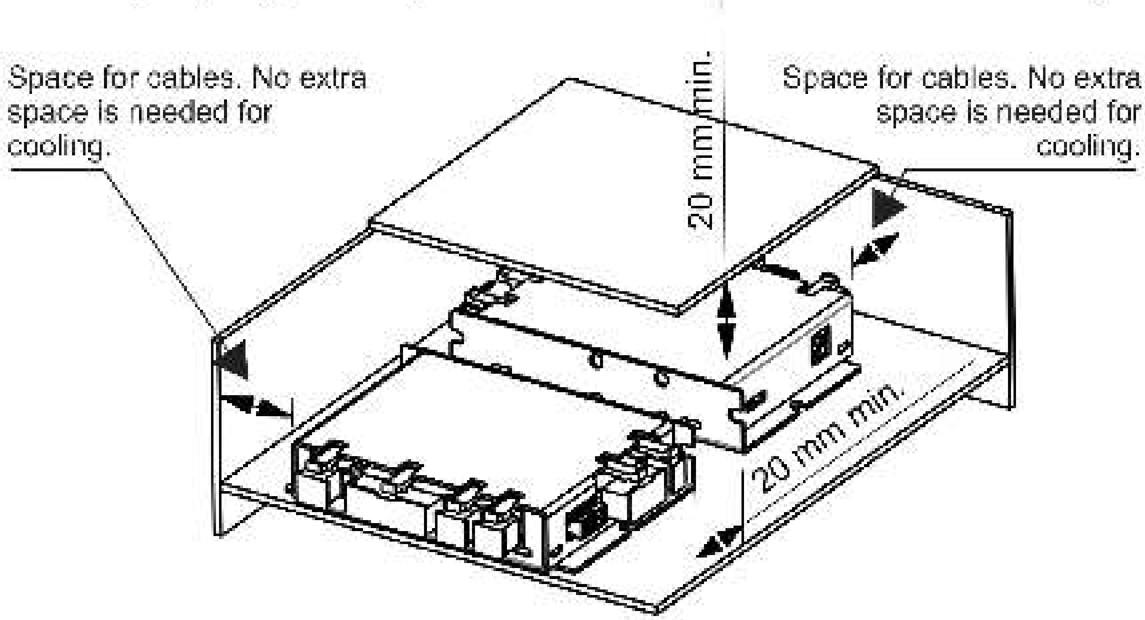


Figure 3.3 *Recommended spacing for horizontal mounting, worst case: non-metallic, closed box*

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
J5,J6,J8,J9	MICROFIT RECEPTACLE HOUSING, 2x2 WAY	MOLEX	43025-0400	AWG 20..24
J5,J6,J7, J8, J9	CRIMP PIN, MICROFIT, 5A	MOLEX	43030-0007	AWG 20..24

3.3. Connectors and Connection Diagrams

3.3.1. Connector Layout

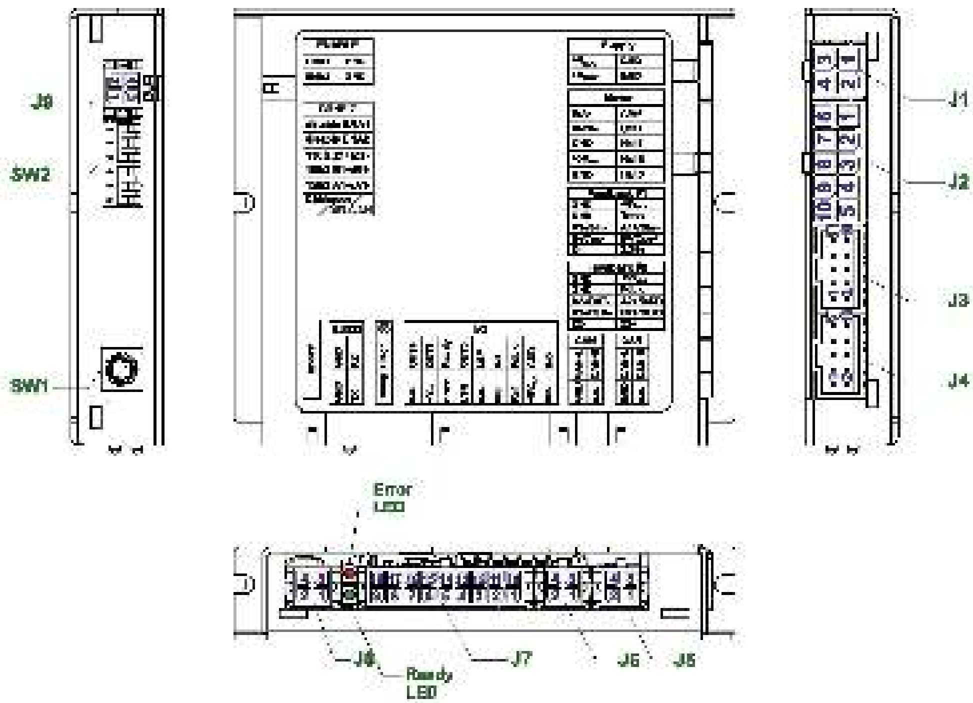


Figure 3.4. PRO-A08V48B-SA-CAN drive connectors

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 6
	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.E201

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 analogue encoder Cos- diff. input
	4	B1+/Cos+	I	Incr. encoder1 B single-ended, or B+ diff. input, or analogue encoder Cos+ diff. input
	5	A1- /Sin-	I	Incr. encoder1 A- diff. input, or analogue encoder Sin- diff. input
	6	A1+/Sin+	I	Incr. encoder1 A single-ended, or A+ diff. input, or analogue 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.E701

Connector description				
	Pin	Name	Type	Description
J3	1	LH3 / FDBK	I	Linear Hall 3 input or Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback (as tacho), or used as general purpose analogue input
	2	Z1	I	Incr. encoder1 Z single-ended
	3	LH2	I	Linear Hall 2 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
J4	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+/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
	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	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback (as tacho), or used as general purpose analogue 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 CAN connectors pinout

Connector description				
	Pin	Name	Type	Description
J5, J6	1	n.c.	-	not connected
	2	GND	-	Return ground for CAN-Bus
	3	Can-Hi	I/O	CAN-Bus positive line (dominant high)
	4	Can-Lo	I/O	CAN-Bus negative line (dominant low)

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

Connector description				
	Pin	Name	Type	Description
J7	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	Analogue input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or used as general purpose analogue 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 5
	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	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback (as tacho), or used as general purpose analogue 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
J8	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
J8	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 Axis ID selection switches

Switch description		
Switch	**Position**	**Description**
SW1	0..F(15)	HW Axis ID = 1..F(15) exception: SW1=0 →Axis ID = 255 when in MPLCAN and LSS Non-configured when in CANopen.

3.3.12. SW2 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
6	down(ON)	Select CANopen protocol
	up(Off)	Select MPLCAN protocol

3.3.13. 24V Digital I/O Connection

3.3.13.1 PNP Inputs

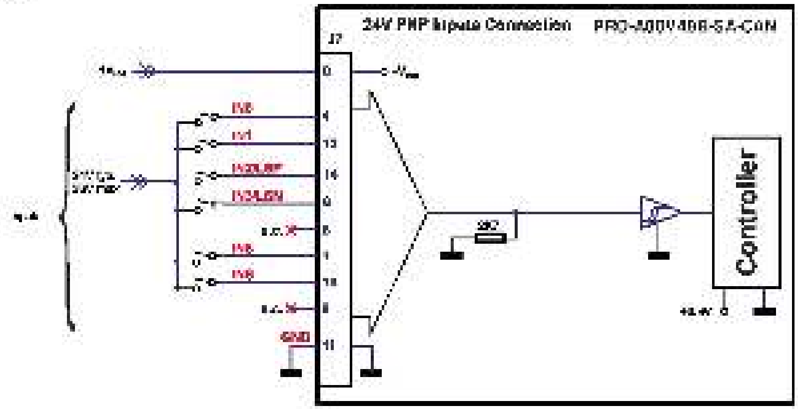


Figure 3.5. 24V Digital PNP Inputs connection

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

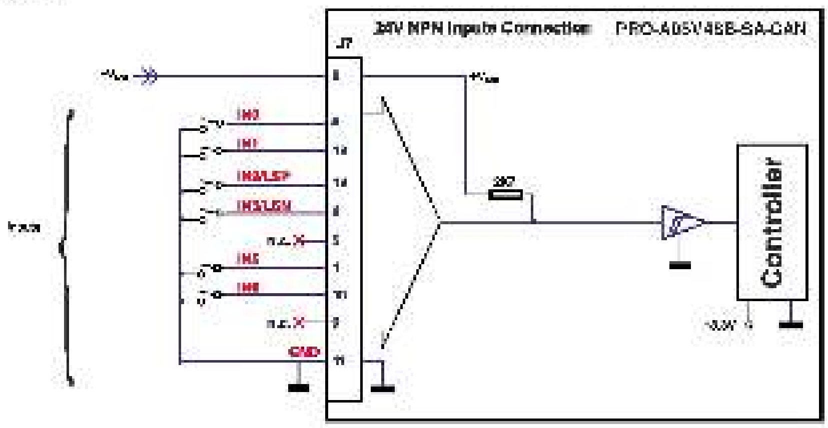


Figure 3.6. 24V Digital NPN Inputs connection

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

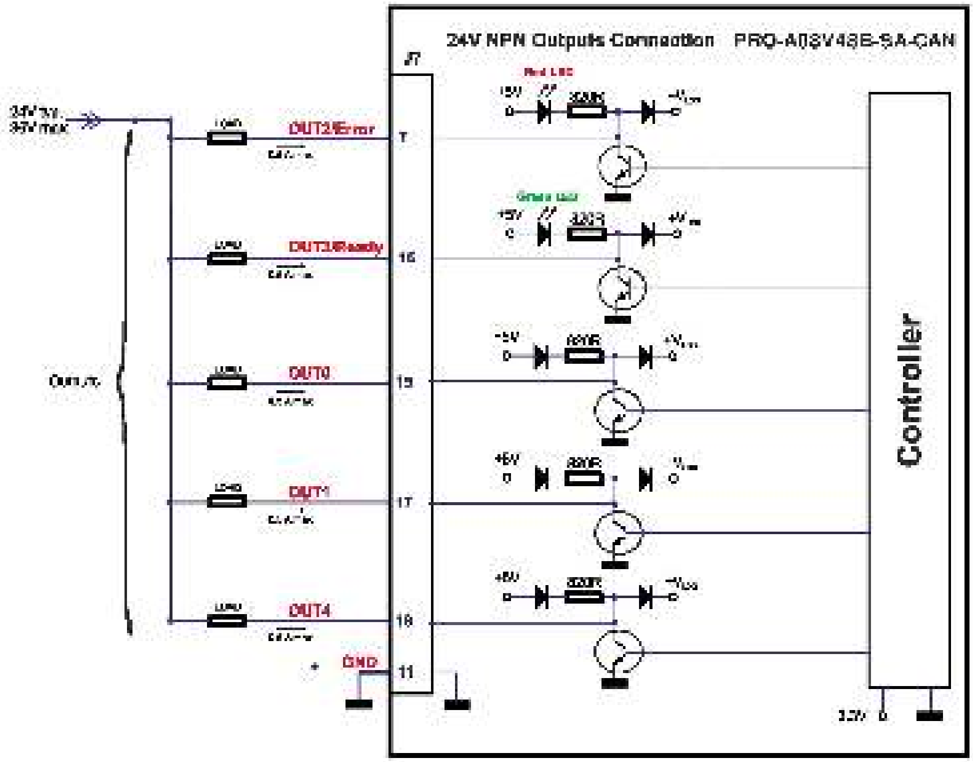


Figure 3.7. 24V Digital NPN inputs connection

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

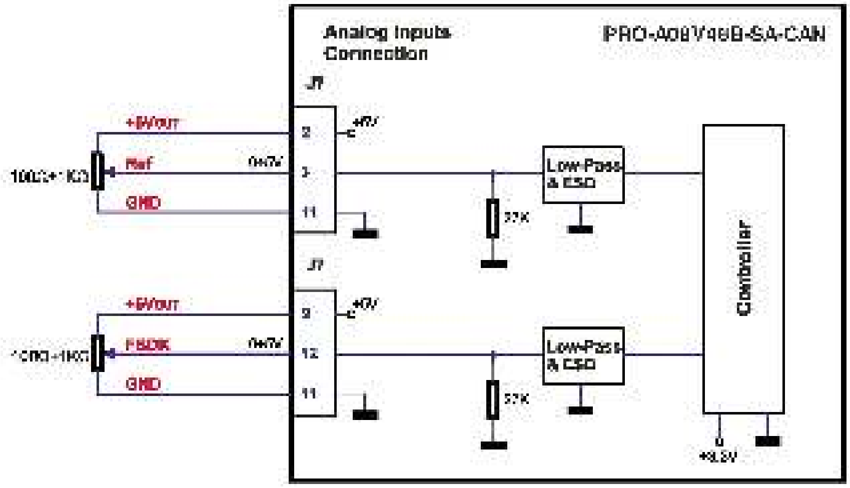


Figure 3.8. Analog inputs connection

Remark: *Default input range for analog inputs is 0÷5 V for REF and FBDK. For a +/-10 V range, see Figure 3.9.*

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

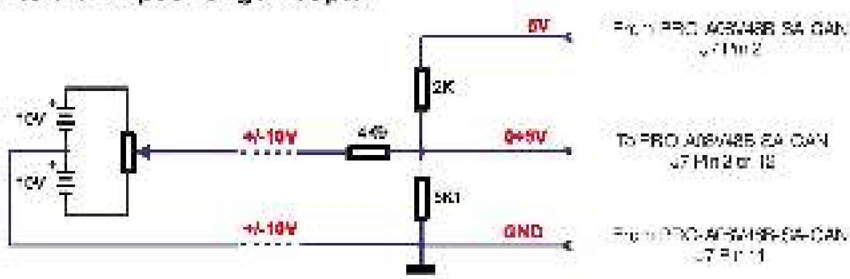


Figure 3.9. +/-10V to 0-5V adapter

3.3.14.3 Recommendations for Analog Signals Wiring

a) If the analogue 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 analogue 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 analogue 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

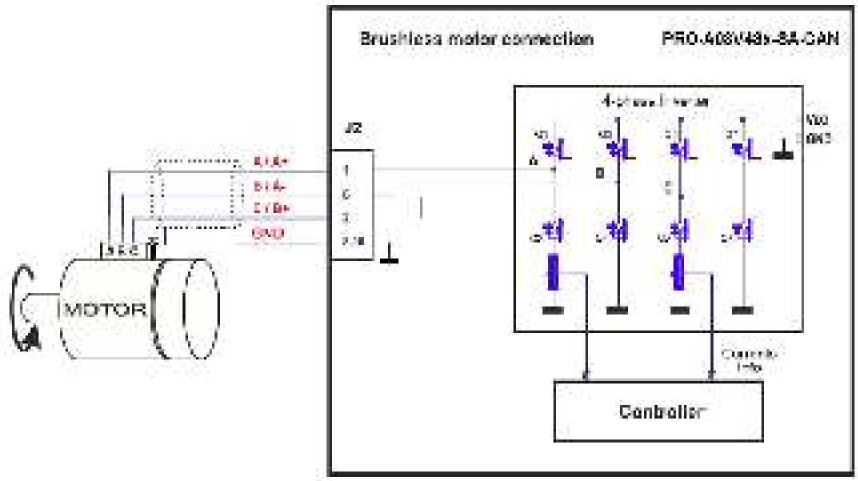


Figure 3.10. Brushless motor connection

3.3.15.2 2-phase Step Motor connection

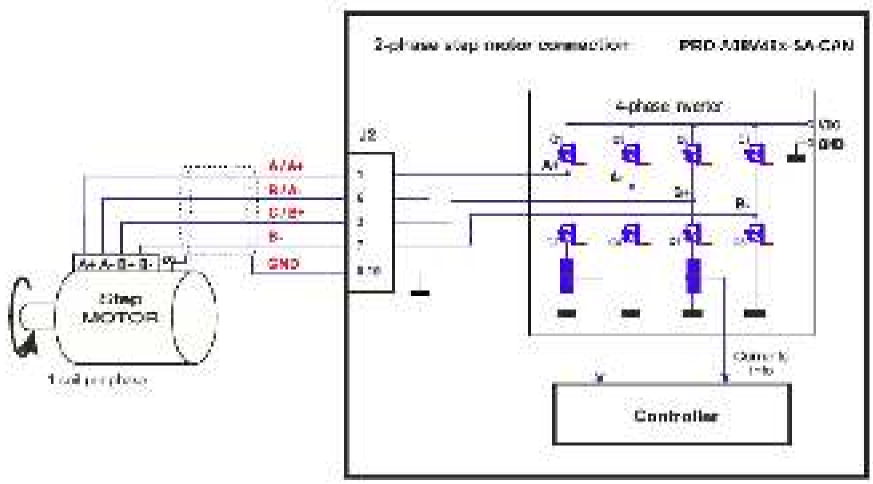


Figure 3.11. 2 phase step motor connection, one coil per phase

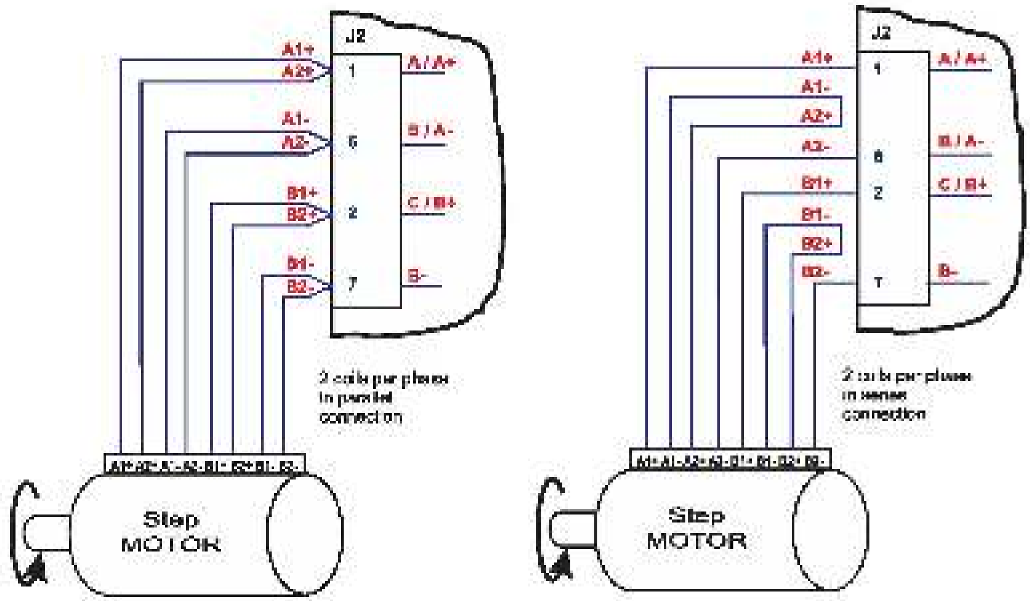


Figure 3.12. 2-phase step motor connection, two coils per phase

3.3.15.3 3-Phase Step Motor connection

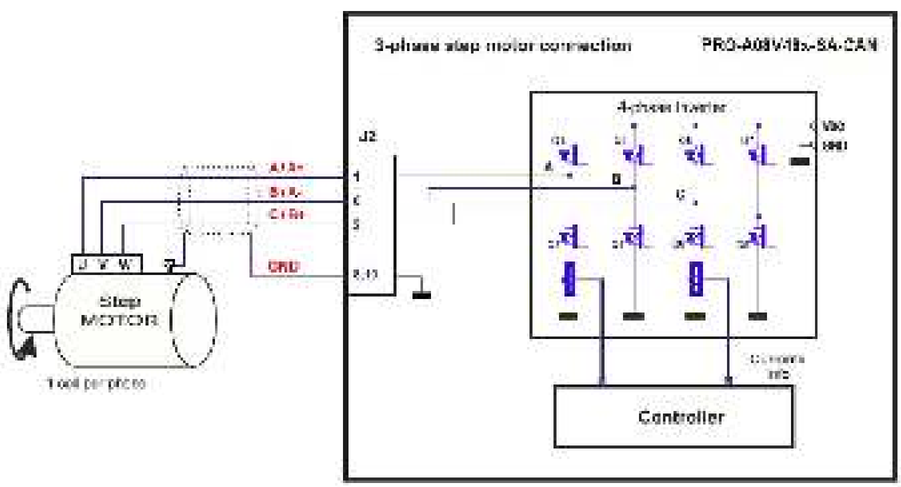


Figure 3.13. 3-phase step motor connection

3.3.15.4 DC Motor connection

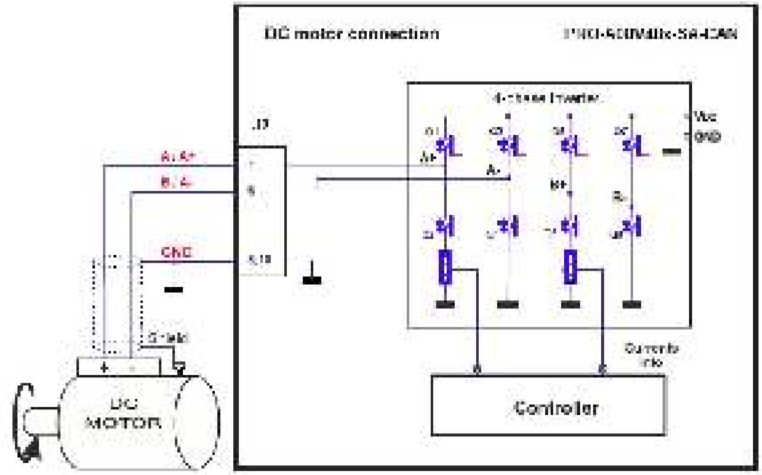


Figure 3.14. DC Motor connection

3.3.15.5 Recommendations for motor wiring

a) 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.

b) 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 µH.

c) 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

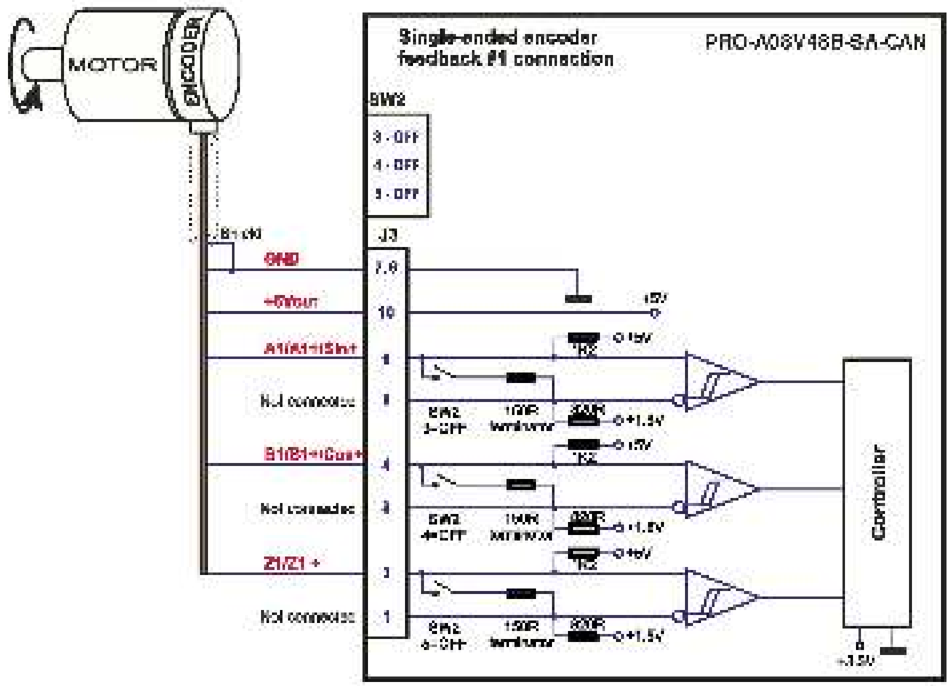


Figure 3.15. Single-ended incremental encoder Feedback #1 connection

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 Connection[1]

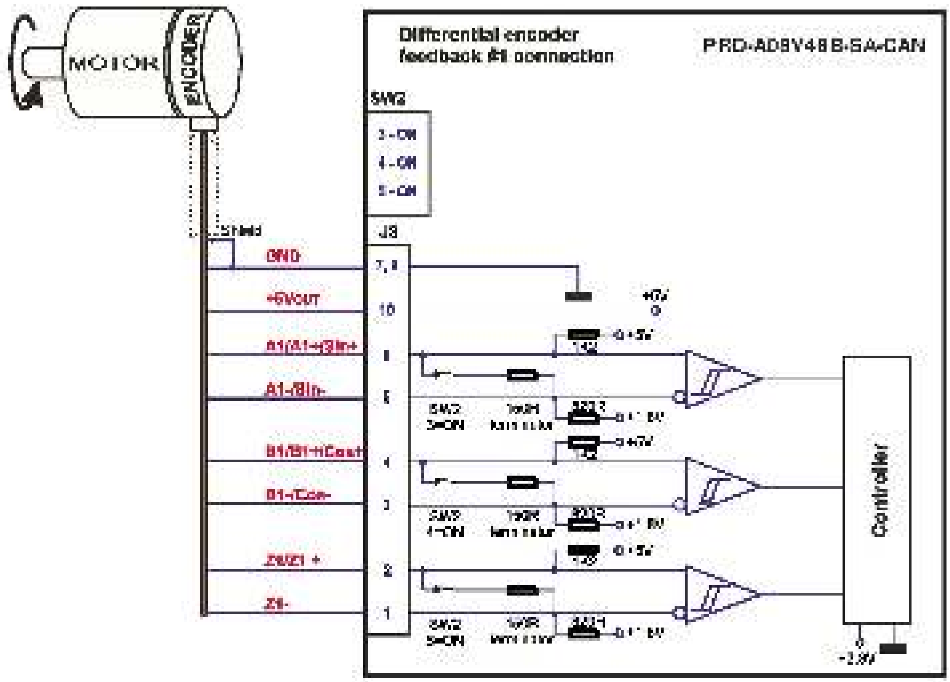


Figure 3.16. Differential incremental encoder feedback #1 connection

Remark: *150Ω terminators are required for long encoder cables, or noisy environments. They are available through the SW2 DIP switch.*

[1] Differential Feedback #1 is not available with the Linear Halls hardware version

3.3.16.3 Differential Incremental Encoder Feedback #2 Connection

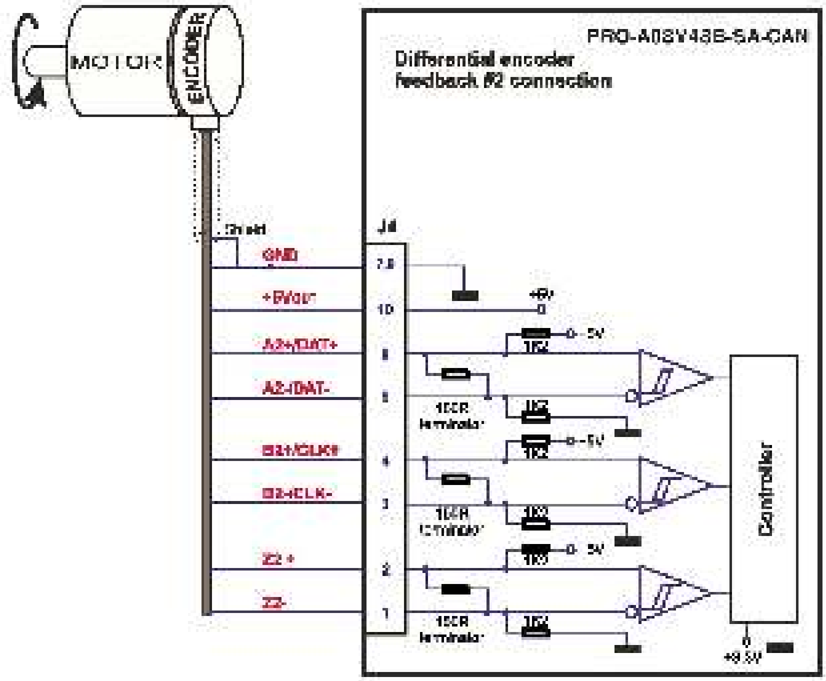


Figure 3.17. *Differential incremental encoder feedback #2 connection*

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

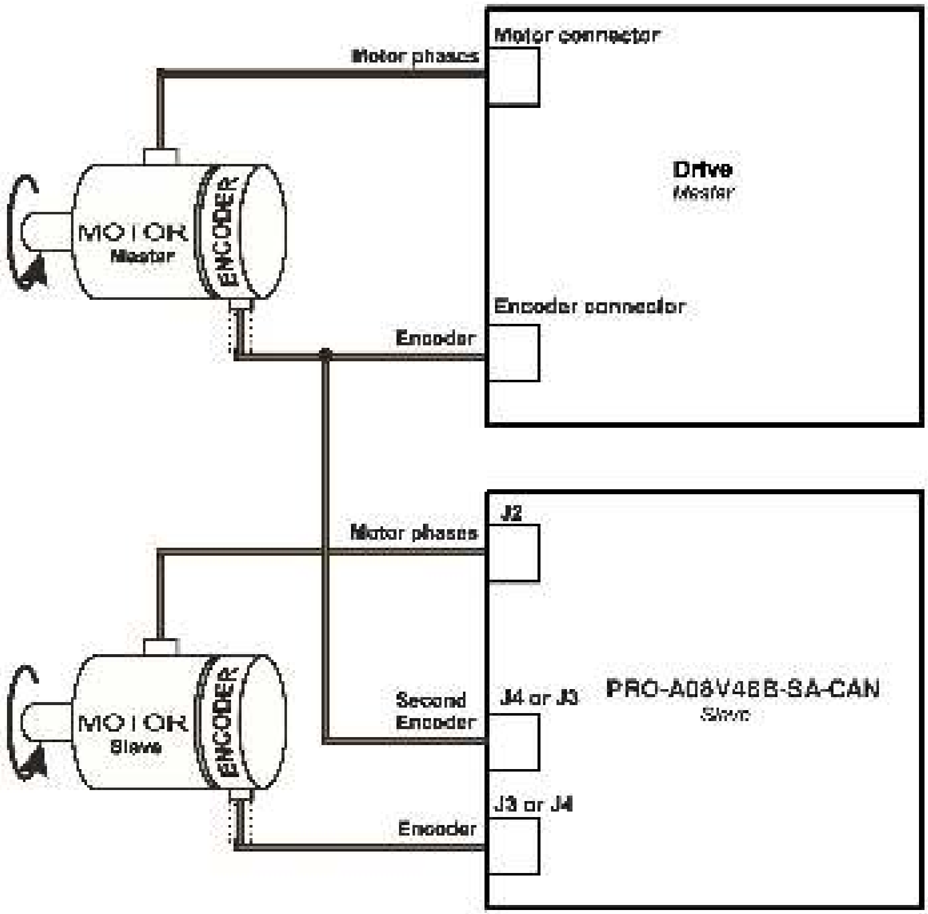


Figure 3.18. **Master – Slave connection using second encoder input**

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

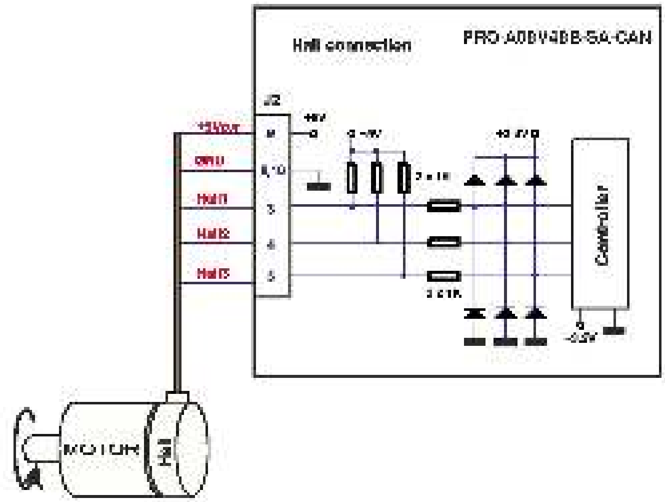


Figure 3.19. Digital Hall connection

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 ended connection on Feedback #1

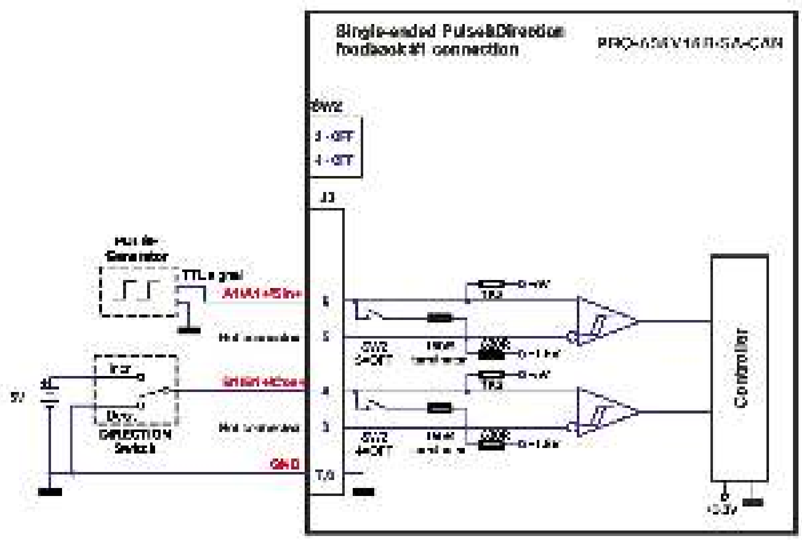


Figure 3.20. Single ended 5V Pulse & Direction Feedback #1 connection

3.3.16.6.2 Differential connection of Feedback #2

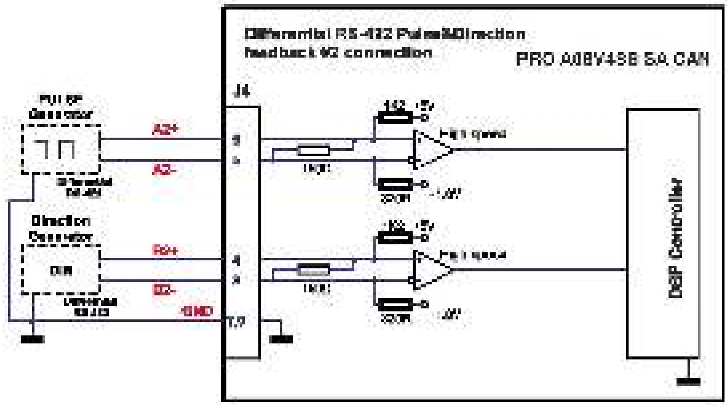


Figure 3.21. Differential (RS-422) Pulse & Direction Feedback #2 connection

3.3.16.7 SSI Feedback #2 Connection

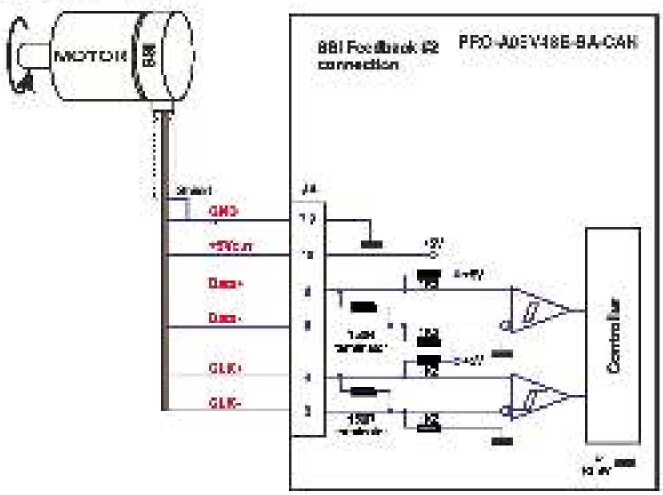


Figure 3.22. SSI Feedback #2 connection

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

3.3.16.8 BiSS Feedback #2 Connection[1]

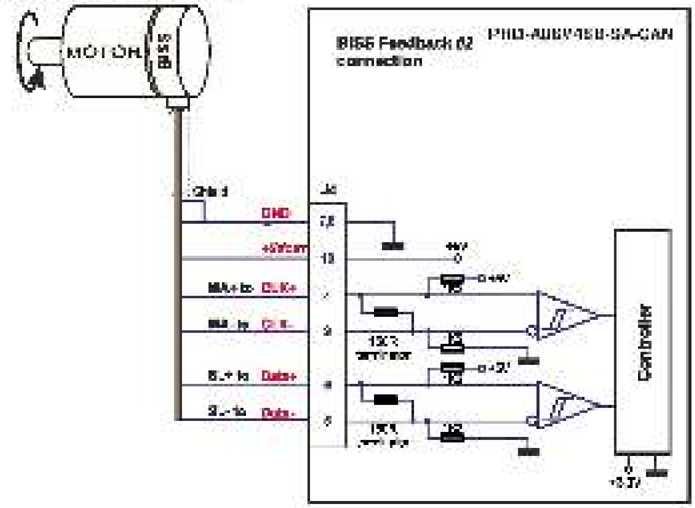


Figure 3.23. *SSI Feedback #2 connection*

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

3.3.16.9 Linear Hall Feedback #1 Connection

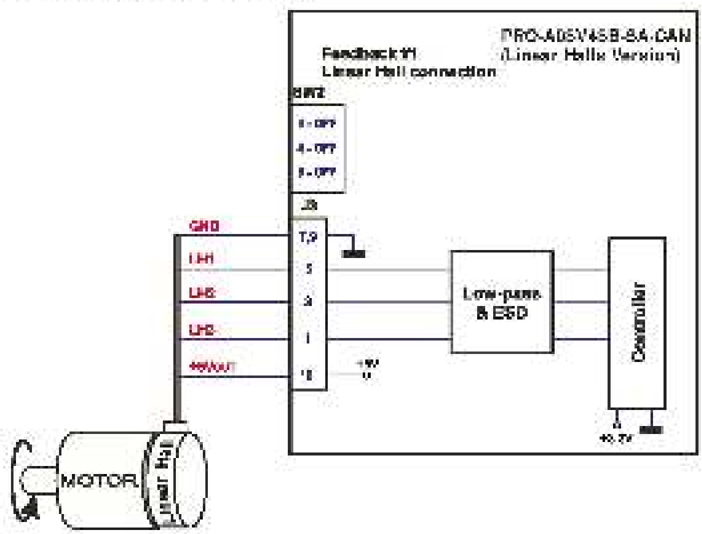


Figure 3.24. *Linear Hall connection*

Remark: The Linear hall connection is available only on the Linear Halls hardware version of the PRO-A08V48B-SA-CAN.

[1] Currently in development

3.3.16.10 Sine-Cosine Analog Encoder Feedback #1 Connection

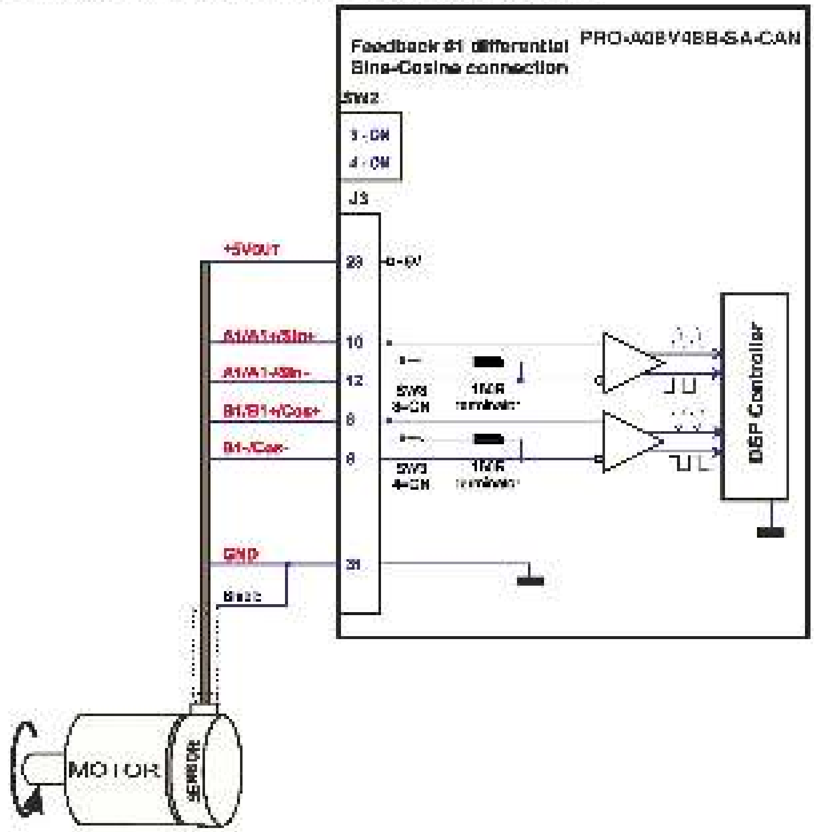


Figure 3.25. Sine-Cosine analogue encoder Feedback #1 connection

3.3.16.11 Recommendations for wiring

a) 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.

b) 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.

c) 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

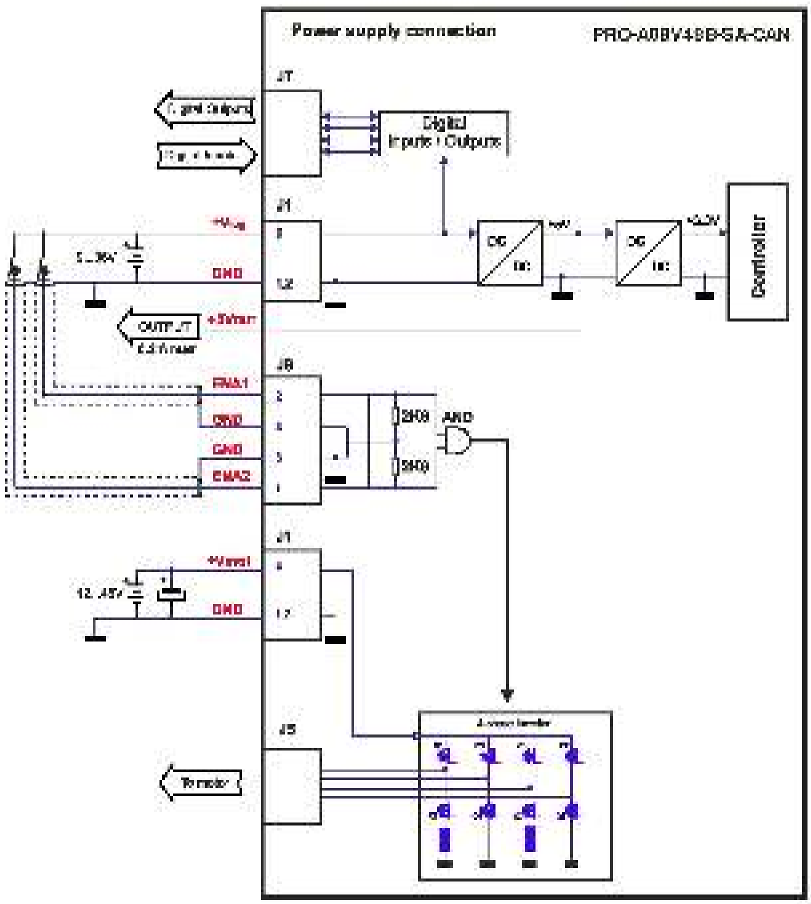


Figure 3.26. Supply connection

3.3.17.2 Recommendations for Supply Wiring

The PRO-A08V48B-SA-CAN 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 4,700µF (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:

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

where:

J_M – total rotor inertia [kgm²]

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

ϖ_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 ϖ_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 EasyMotion / 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

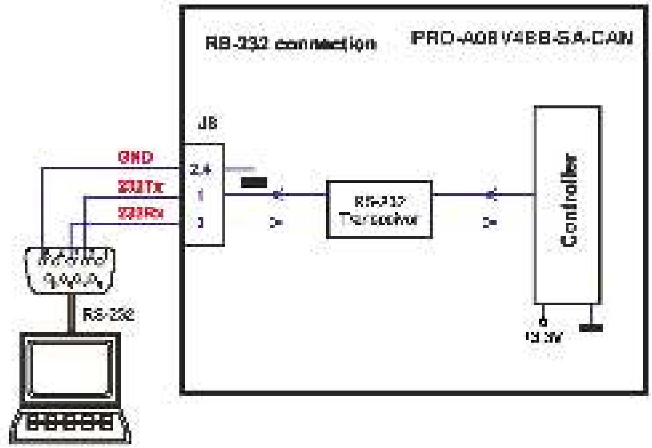


Figure 3.27. Serial RS-232 connection

3.3.18.2 Recommendation for wiring

a) 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

b) Always power-off all the PRO-A08V48B-SA-CAN supplies before inserting/removing the RS-232 serial connector

c) 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. CAN-bus connection

3.3.19.1 CAN connection

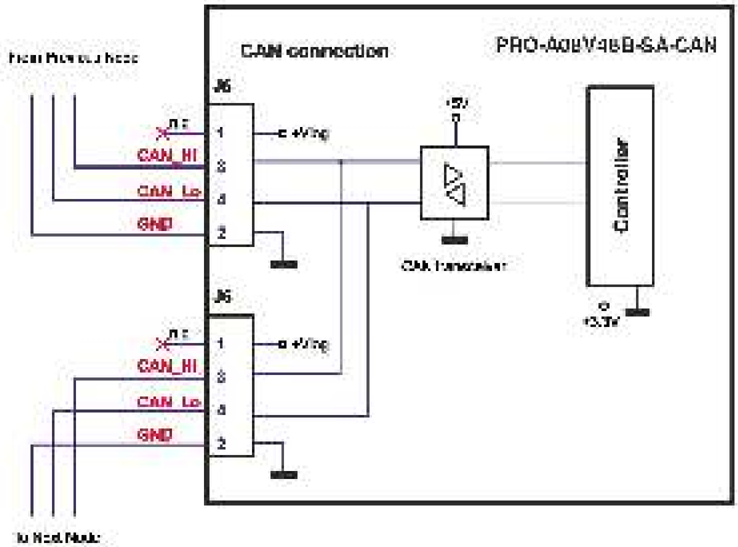


Figure 3.28. CAN connection

Remarks:

1. *The CAN network requires a 120-Ohm terminator. This is not included in the drive.*
2. *CAN signals are not insulated from other PRO-A08V48 circuits.*

3.3.19.2 Recommendation for wiring

a) Build CAN network using cables with twisted wires (2 wires/pair), with CAN-Hi twisted together with CAN-Lo. It is recommended but not mandatory to use a shielded cable. If so, connect the shield to GND. The cable impedance must be 105 ... 135 ohms (120 ohms typical) and a capacitance below 30pF/meter.

b) The 120Ω termination resistors must be rated at 0.2W minimum. Do not use winded resistors, which are inductive.

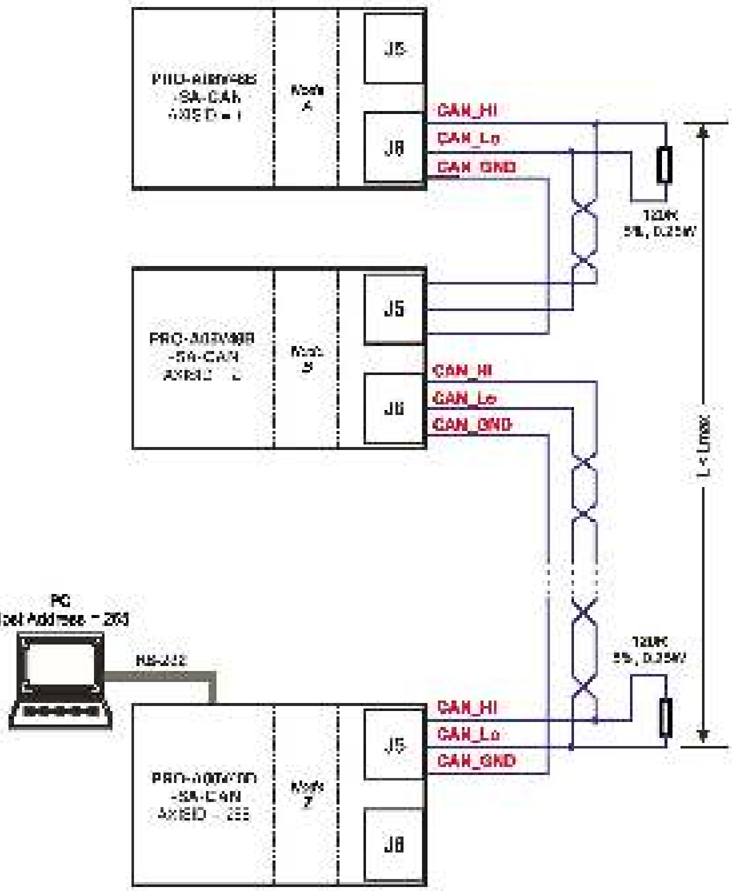


Figure 3.29. Multiple-Axis CAN network

Remarks:

1. *The axis IDs in* ***Figure 3.29***, *are valid for MPLCAN mode. For CANopen mode, the highest axis ID a drive can have is 127.*
2. *Lmax is the bus length defined in paragraph* ***2.7.17***.

3.3.20. Disabling Autorun Mode

When an PRO-A08V48B-SA-CAN is set in MPLCAN operation mode, by default after power on it enters automatically in *Autorun* mode. In this mode, if the drive has in its local EEPROM a valid MPL application (motion program), this is automatically executed as soon as the motor supply V_{MOT} is turned on.

In order to disable *Autorun* mode, there are 2 methods:

a) Software - by writing value 0x0001 in first EEPROM location at address 0x4000

b) Hardware – by temporary connecting all digital Hall inputs to GND, during the power-on for about 1 second, until the green LED is turned on, as shown in *Figure 3.30*. This option is particularly useful when it is not possible to communicate with the drive.

After the drive is set in *non-Autorun/slave* mode using 2nd method, the 1st method may be used to invalidate the MPL application from the EEPROM. On next power on, in absence of a valid MPL application, the drive enters in the *non-Autorun/slave* mode independently of the digital Hall inputs status.

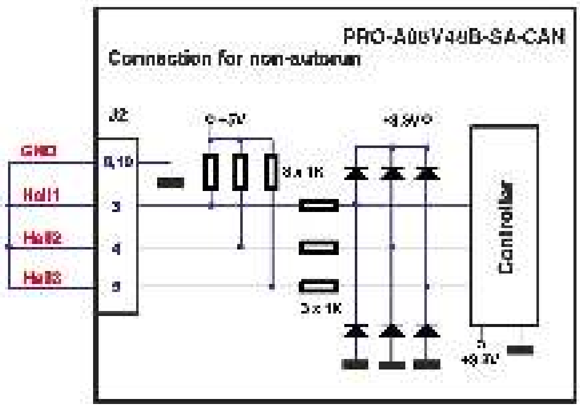


Figure 3.30. Temporary connection during power-on to disable ***Autorun*** *mode*

3.3.21. Installation Requirements for CE Compliance

For EMC compliance, correct cable selection and wiring practices are mandatory. The following contains installation instructions necessary for meeting EMC requirements according to EN 61800-3: 2004.

- Cables should not exceed 3m (9.8ft) in length without consulting factory.
- Shielded cables are mandatory for the motor, power and control cabling to the drive. The shielding suppresses interference with other devices and reduces electrical noise. The cables must be connected according to the instructions in the above wiring sections of this manual.

WARNING!	***This product is not intended to be used on a low-voltage public network which supplies domestic premises. Radio frequency interference is expected if used on such a network.***

3.4. Operation Mode and Axis ID Selection

3.4.1. Selection of the Operation Mode

On PRO-A08V48B-SA-CAN, the selection of the operation mode CANopen or MPLCAN is done by setting the JP1 jumper:

- CANopen mode, SW2 pin6 – ON
- MPLCAN mode, SW2 pin6 – OFF

3.4.2. Selection of the Axis ID

The Hardware Axis ID selection is done through the hex switch SW1. It contains numbers from 0x0 to 0xF. Depending on SW1 position, the axis ID will be:

SW1 position	AxisID in MPLCAN mode	AxisID in CANopen mode
0x0	255	LSS non-configured state
0x1	1	1
0x2	2	2
0x3	3	3
0x4	4	4
0x5	5	5
0x6	6	6
0x7	7	7
0x8	8	8
0x9	9	9
0xA	10	10
0xB	11	11
0xC	12	12
0xD	13	13
0xE	14	14
0xF	15	15

Note: LSS "non configured" state, is a state in which the drive does not have assigned an active Axis ID while connected to the CAN network. In this mode the Axis ID for RS232 communication is 255. The Axis ID can be configured via a LSS master using CiA-305 protocol, which can set and save a new unique value. While the drive has a non-configured Axis ID, it cannot communicate with other drives in the network.

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.

PRO Config is installed together with **MotionPRO Developer** platform for motion programming using MPL. You will need MotionPRO Developer only if you plan to use the advanced features presented in Section 5.3.

4.2. Getting Started with PRO Config

Using PRO Config you can quickly setup a drive for your application. The drive can be connected with your PC in one of the following ways:

1. Via an RS232 link, directly connected to the PC, or via an USB to RS232 adapter or using Electrocraft Ethernet to RS232 adaptor, function of your PC communication interfaces;
2. Via a CAN-bus link, directly connected to the PC through a PC-CAN interface, or using Electrocraft Ethernet to CAN adaptor
3. Via another drive from the same CAN-bus network, which is connected to the PC via one of the above options from point 1.

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 **CANopen** master to control the PRO-A08V48 as a standard CANopen drive
- Use **MotionPRO Developer** to create and download a **MPL** program into the drive/motor memory
- Use one of the **MPL** LIB motion libraries to control the drives/motors from your host/master. If your host is a **PC**, MPL_LIB offers a collection of high level motion functions which can be called from applications written in C/C++, Visual Basic, Delphi Pascal or LabVIEW. If your host is a **PLC**, MPL_LIB offers a collection of function blocks for motion programming, which are **IEC61131-3 compatible** and can be integrated in your PLC program.
- **Implement** on your master the MPL commands you need to send to the drives/motors 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

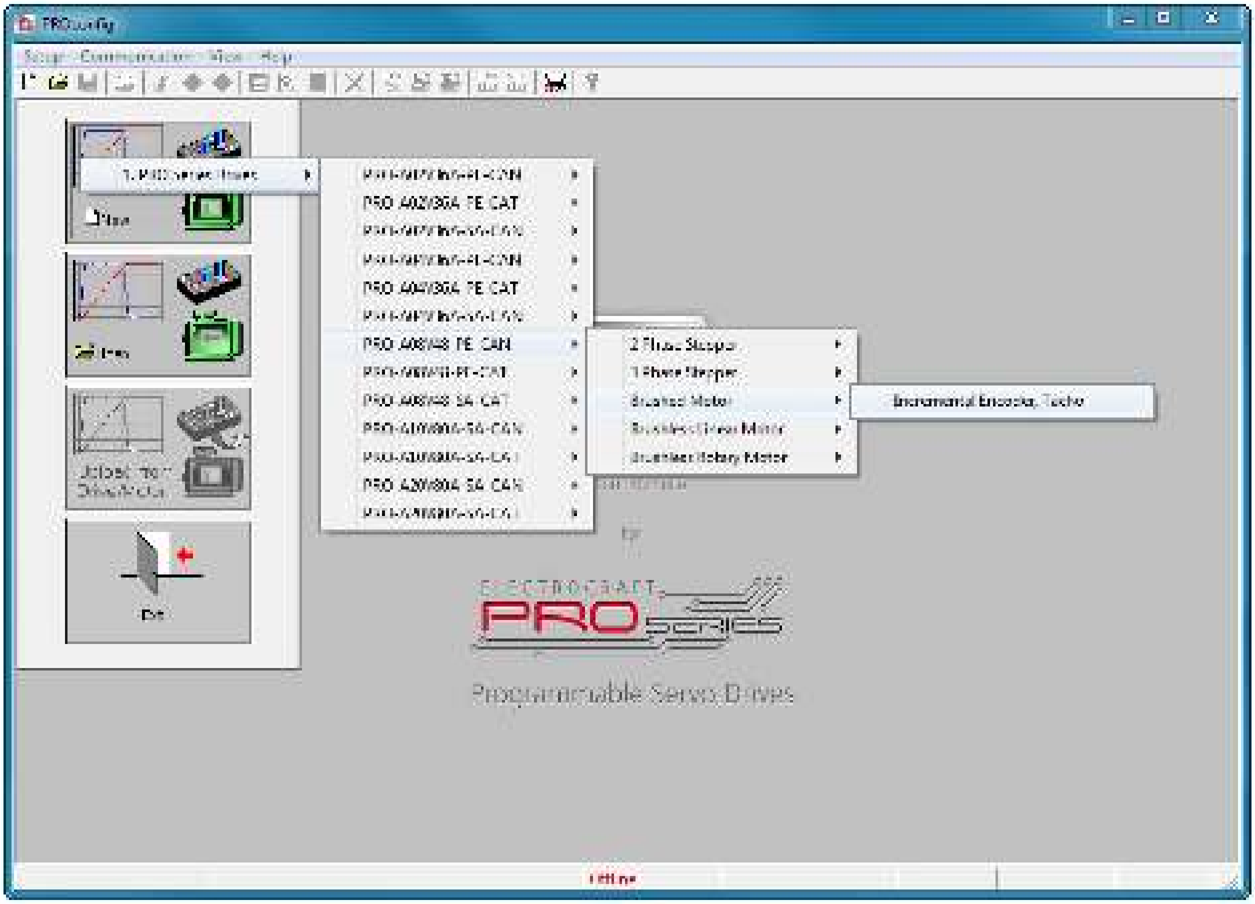
PRO Config starts with an empty window from where you can create a **New** setup, **Open** a previously created setup which was saved on your PC, or **Upload** the setup from the drive/motor.

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 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****. If this drive is part of a CANbus network, use the menu command* ***Communication | Scan Network***

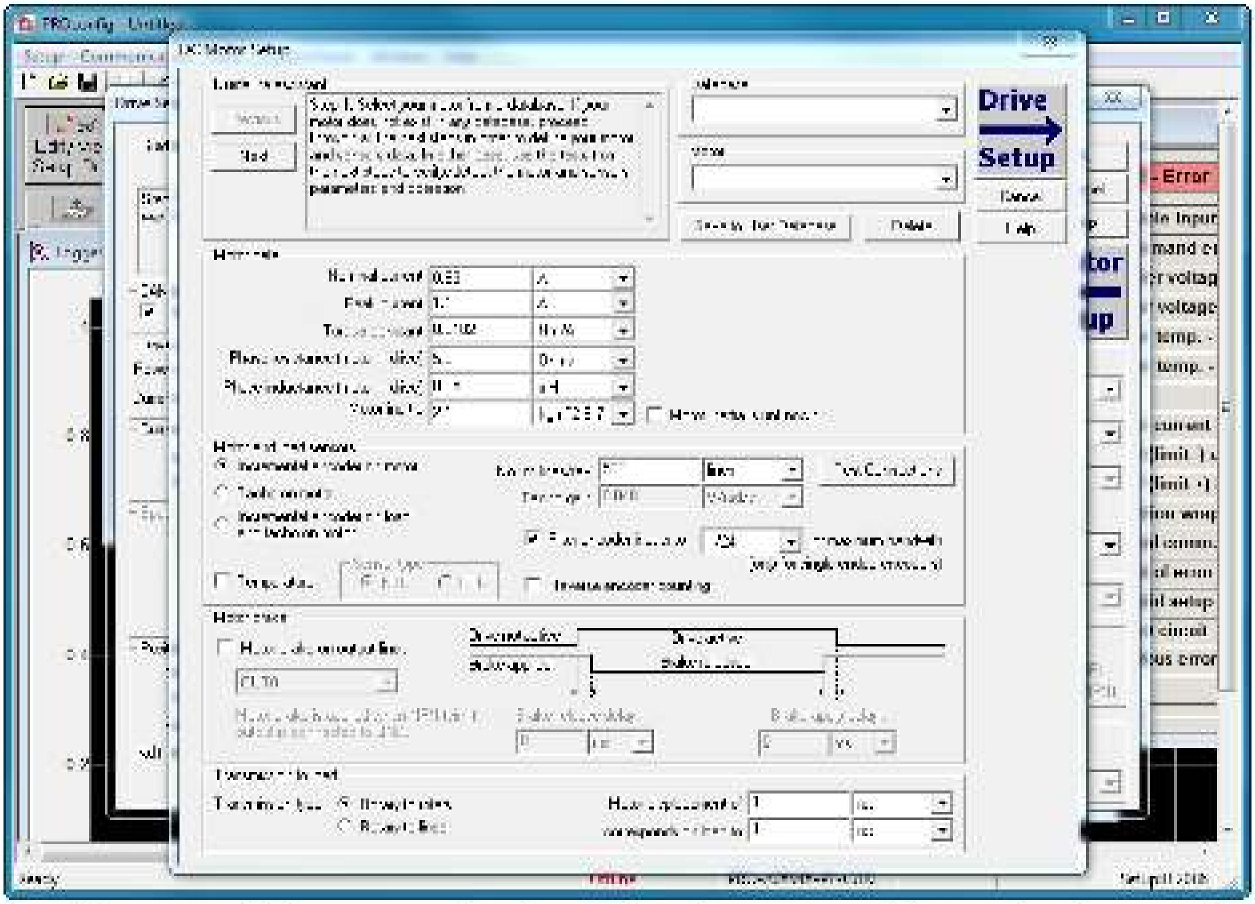
4.2.2. Setup drive/motor

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



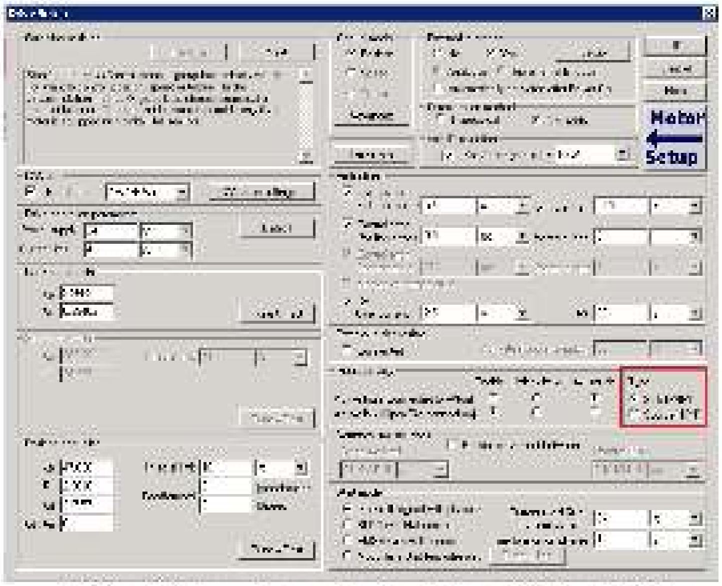
The selection continues with the motor technology (for example: brushless or brushed) and type of feedback device (for example: Incremental encoder, Linear Halls).

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



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.

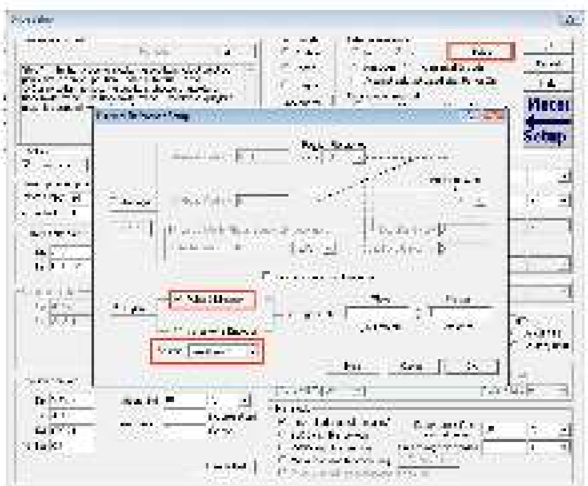
4.2.3. Selecting NPN/PNP inputs type in Setup



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

4.2.4. Selecting the feedback source for Pulse and Direction

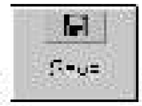
The Pulse and Direction feedback source can be chosen in Setup/ Drive Setup/ External reference Setup button.



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.

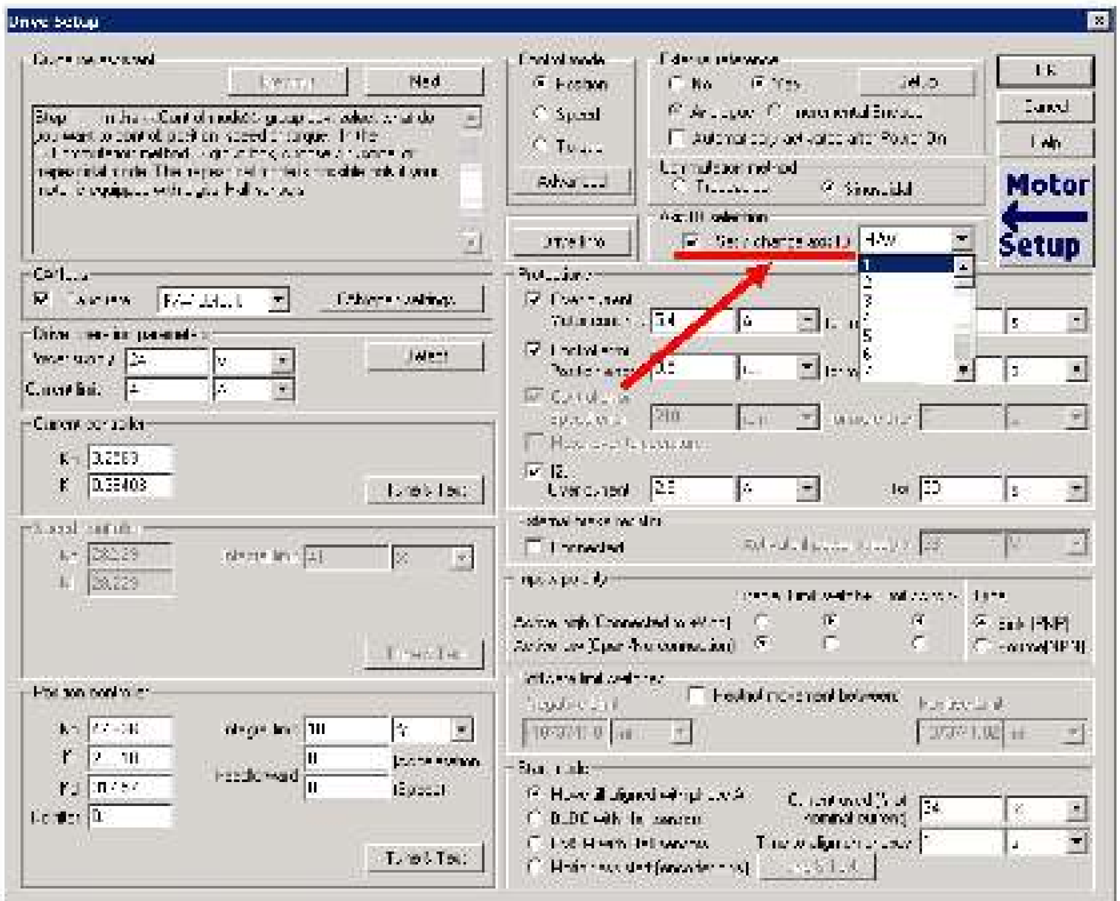
To summarize, you can define or change the setup data in the following ways:

- 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 an PRO-A08V48 drive can be set in 3 ways:

- Hardware (H/W) – according with AxisID hex switch SW1 par. 3.4.2 .
- Software (via Setup)– any value between 1 and 255, stored in the setup table. If the drive is in CANopen mode, a Node ID value above 127 is automatically converted into 255 and the drive is

set with CAN communication in "non-configured" mode waiting for a CANopen master to configure it using CiA-305 protocol. A "non-configured" drive answers only to CiA-305 commands. All other CANopen commands are ignored and transmission of all other CANopen messages (including boot-up) is disabled. In absence of a CANopen master, you can get out a drive from "non-configured" mode, by setting another axis ID between 1 and 127, from above dialogue using a serial link between the drive and the PC.

- Software (via CANopen master) – using CiA-305 protocol

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

a) 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 or can indicate that axis ID will be set according with the AxisID hex switch. If the drive is set in CANopen mode and the Axis ID is over 127 it is converted into 255 and the drive enters in CAN communication "LSS non-configured" mode

b) 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 either from a valid setup table or by a CANopen master via CiA-305 protocol. This value can be an axis number 1 to 255 for MPLCAN, 1 to 127 for CANopen, or can indicate that axis ID will be set according with the AxisID hex switch

c) If the setup table is invalid, with the last value set either from a valid setup table or by a CANopen master via CiA-305 protocol. This value can be an axis number 1 to 255 for MPLCAN, 1 to 127 for CANopen, or can indicate that axis ID will be set according with the AxisID hex switch

d) If the setup table is invalid, there is no previous axis ID set from a valid setup table or by a CANopen master, according with the AxisID hex switch

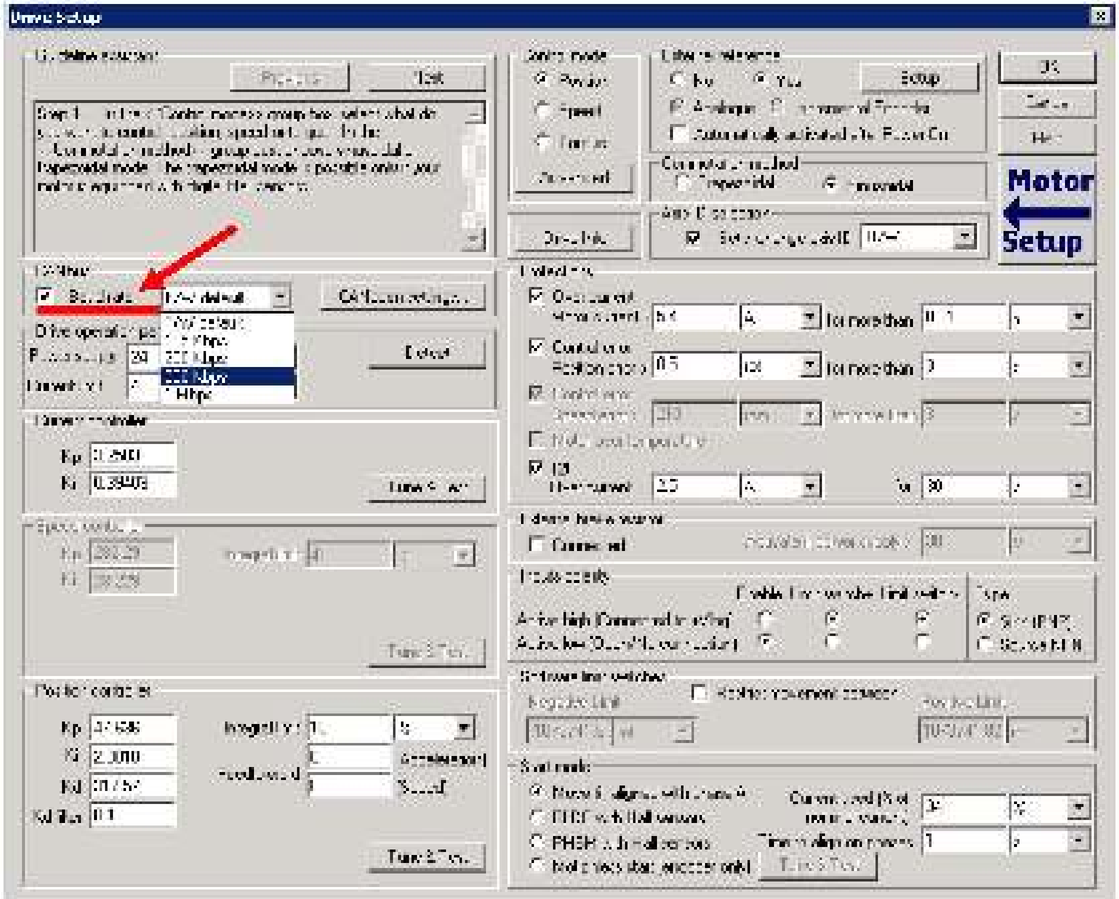
Remark: *If you don't know the axis ID set in a drive, you can find it in the following way:*

a) Connect the drive via a serial RS232 link to a PC where PRO Config or MotionPRO Developer are installed

b) 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.*

c) If the access to the drive with the unknown Axis ID is difficult, but this drive is connected via CANbus with other Electrocraft drives having an easier access, connect your PC serially to one of the other drives. Use PRO Config or MotionPRO Developer menu command ***Communication | Scan Network*** *to find the axis IDs of all the Electrocraft drives present in the network.*

4.4. Setting CANbus rate



The PRO-A08V48 drives accept the following CAN rates: 125Kbps, 250 Kbps, 500kbps and 1Mbps. Using the Drive Setup dialogue you can choose the initial CAN rate after power on. This information is stored in the setup table The CAN rate is initialized using the following algorithm:

a) If a valid setup table exists, and this setup table was created with the *Set baud rate* checkbox <u>checked</u> in the Drive Setup dialogue (see above) – with the value read from the setup table. This value can be one of the above 4 values or the firmware default (F/W default) which is 500kbs

b) If a valid setup table exists, and this setup table was created with the *Set baud rate* checkbox <u>unchecked</u> in the Drive Setup dialogue (see above) – with the last value set either from a valid setup table or by a CANopen master via CiA-305 protocol

c) If the setup table is invalid, with the last value set either from a valid setup table or by a CANopen master via CiA-305 protocol.

d) If the setup table is invalid, there is no previous CAN rate set from a valid setup table or by a CANopen master, with f/w default value which is 500kbs

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 raw contains a single data value. When less then 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 a CANopen master, using the communication objects for writing data into the drive EEPROM
- from a host PC or PLC, using the MPL_LIB functions 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 a CANopen Master (for PRO-A08V48 CANopen execution)

The PRO-A08V48 drive conforms to **CiA 301 v.4.2** application layer and communication profile, **CiA WD 305 v.2.2.13** layer settings services and protocols and **CiA DSP 402 v3.0** device profile for drives and motion control the now included in IEC 61800-7-1 Annex A, IEC 61800-7-201 and IEC 61800-7-301 standards. For details see ***PRO Series CANopen Programming*** **Manual**.

5.1.1. CiA-301 Application Layer and Communication Profile Overview

The PRO-A08V48 drive accepts the following basic services and types of communication objects of the CANopen communication profile CiA301 v4.2:

- **Service Data Object (SDO)**

Service Data Objects (SDOs) are used by CANopen master to access any object from the drive's Object Dictionary. Both expedited and segmented SDO transfers are supported. SDO transfers are confirmed services. The SDOs are typically used for drive configuration after power-on, for PDOs mapping and for infrequent low priority communication between the CANopen master and the drives.

- **Process Data Object (PDO)**

Process Data Objects (PDO) are used for high priority, real-time data transfers between CANopen master and the drives. The PDOs are unconfirmed services which are performed with no protocol overhead. Transmit PDOs are used to send data from the drive, and receive PDOs are used to receive on to the drive. The PRO-A08V48 accepts 4 transmit PDOs and 4 receive PDOs. The contents of the PDOs can be set according with the application needs using the dynamic PDO-mapping. This operation can be done during the drive configuration phase using SDOs.

- **Synchronization Object (SYNC)**

The SYNC message provides the basic network clock, as the SYNC producer broadcasts the synchronization object periodically. The service is unconfirmed. The PRO-A08V48 supports both SYNC consumer and producer.

- **Time Stamp Object (TIME)**

The Time Stamp Object is supported by the PRO-A08V48 device.

- **Emergency Object (EMCY)**

Emergency objects are triggered by the occurrence of a drive internal error situation. An emergency object is transmitted only once per 'error event'. As long as no new errors occur, the drive will not transmit further emergency objects.

- **Network Management Objects (NMT)**

The Network Management is node oriented and follows a master-slave structure. NMT objects are used for executing NMT services. Through NMT services the drive can be initialized, started, monitored, reset or stopped. The PRO-A08V48 is a NMT slave in a CANopen network.

- **Module Control Services** – through these unconfirmed services, the NMT master controls the state of the drive. The following services are implemented: Start Remote Node, Stop Remote Node, Enter Pre-Operational, Reset Node, Reset Communication
- **Error Control Services** – through these services the NMT master detects failures in a CAN-based network. Both error control services defined by DS301 v4.02 are supported by the PRO-A08V48: Node Guarding (including Life Guarding) and Heartbeat
- **Bootup Service** - through this service, the drive indicates that it has been properly initialized and is ready to receive commands from a master

5.1.2. CiA-305 Layer Setting Services (LSS) and Protocols Overview

When used in a CANopen network, the PRO-A08V48 drives accept node ID and CAN bus bit timing settings according with CiA 305 protocol. This allows a CANopen master supporting CiA WD 305 to configure each PRO-A08V48 from the network with the desired node-ID and CAN bus bit timing. CiA-305 protocol allows connecting non-configured drives to a CANopen network and performing the drives configuration on-the-fly via the CANopen master.

5.1.3. CiA-402 and Manufacturer Specific Device Profile Overview

The PRO-A08V48 supports the following CiA 402 modes of operation:

- **Profile position and velocity modes**
- **Homing mode**
- **Interpolated position mode**

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

- **External reference modes (position, speed or torque)**
- **Electronic gearing and camming position mode**

5.1.4. ElectroCAN Extension

In order to take full advantage of the powerful Electrocraft Motion Program Language (MPL) built into the PRO-A08V48, Electrocraft has developed an extension to CANopen, called ElectroCAN through which MPL commands can be exchanged with the drives. Thanks to ElectroCAN you can inspect or reprogram any of the Electrocraft drives from a CANopen network using EastSetup or MotionPRO Developer and an RS-232 link between your PC and any of the drives.

ElectroCAN uses only identifiers outside of the range used by the default by the CANopen predefined connection set (as defined by CiA 301). Thus, ElectroCAN protocol and CANopen protocol can co-exist and communicate simultaneously on the same physical CAN bus, without disturbing each other.

5.1.5. Checking Setup Data Consistency

During the configuration phase, a CANopen 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 Program Language Overview

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

- Set various motion modes (profiles, PVT, PT, electronic gearing or camming[1], etc.)
- Change the motion modes and/or the motion parameters
- Execute homing sequences[2]
- 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 analogue input signals
- Execute arithmetic and logic operations
- Perform data transfers between axes
- Control motion of an axis from another one via motion commands sent between axes
- Send commands to a group of axes (multicast). This includes the possibility to start simultaneously motion sequences on all the axes from the group
- Synchronize all the axes from a network

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

[1] Optional for PRO-A08V48 CANopen execution

[2] The customization of the homing routines is available only for PRO-A08V48 CAN execution

5.2.2. Installing MotionPRO Developer

MotionPRO Developer is an integrated development environment for the setup and motion programming of Electrocraft intelligent 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.

Once you have started the installation package, follow its indications. After installation, use the update via internet tool to check for the latest updates.

5.2.3. Getting Started with MotionPRO Developer

Using MotionPRO Developer you can quickly do the setup and the motion programming of an Electrocraft a drive according with your application needs. The drive can be connected with your PC in one of the following ways:

1. Via an RS232 link, directly connected to the PC, or via an USB to RS232 adapter
2. Via a CAN-bus link, directly connected to the PC through a PC-CAN interface
3. Via another drive from the same CAN-bus network, which is connected to the PC via one of the above options from point 1.

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 motor 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.

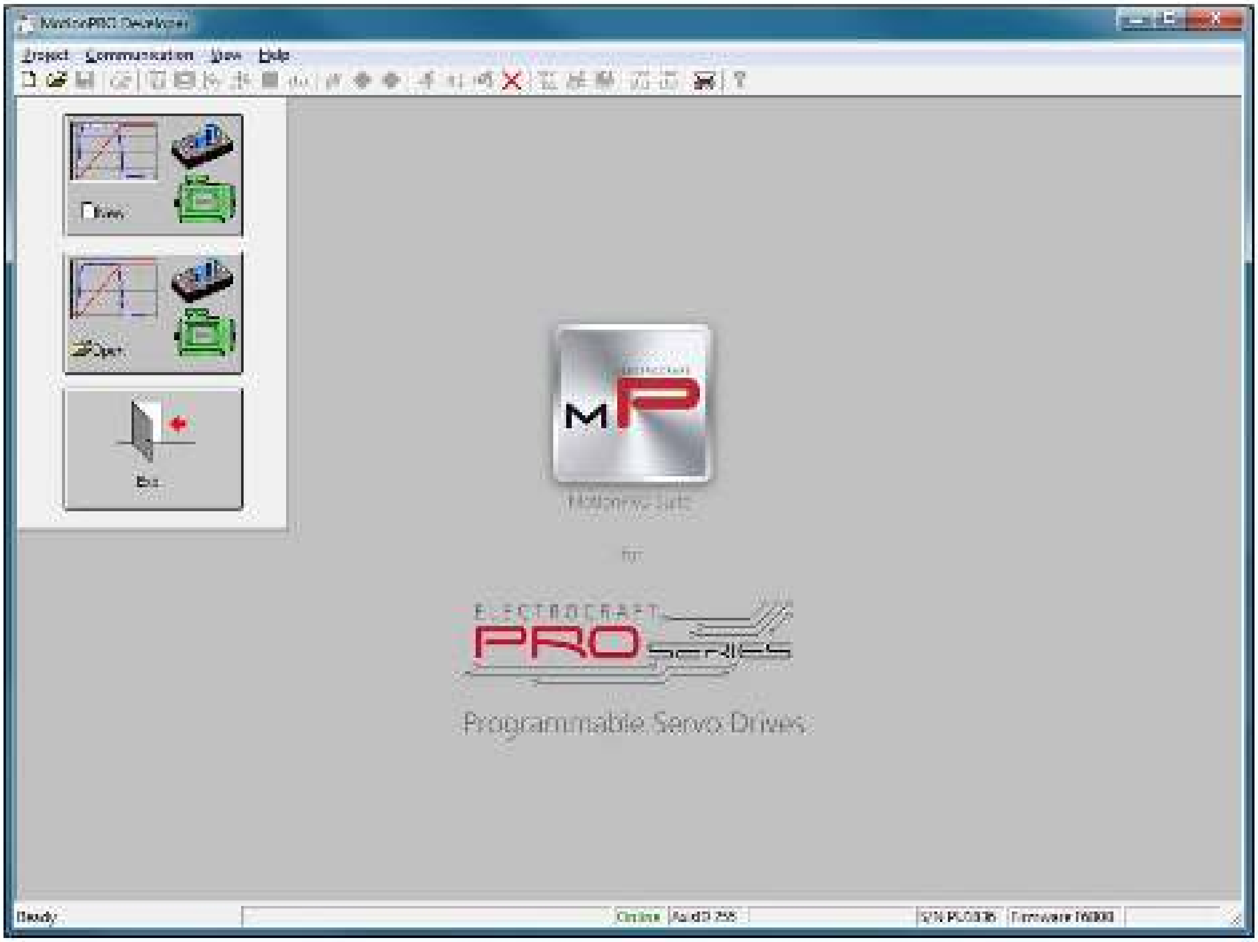
In the first case, each application has a different axis number corresponding to the axis ID of the drives/motors from the network. All data exchanges are done with the drive/motor having the same address as the selected application. In the second case, all the applications have the same axis number.

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 Program Language) program, which is executed by the drives/motors built-in motion controller.

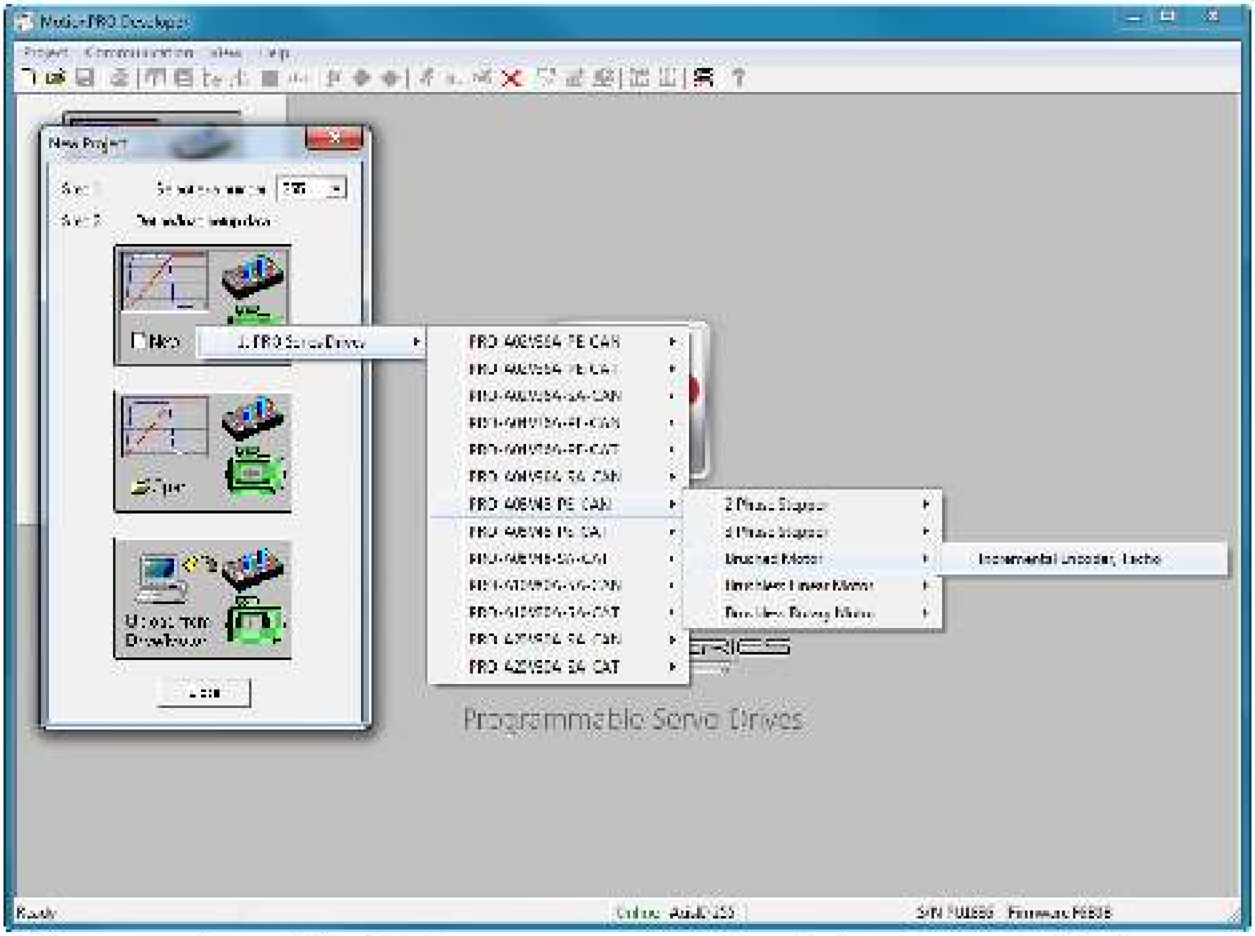
5.2.3.1 Create a new project

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

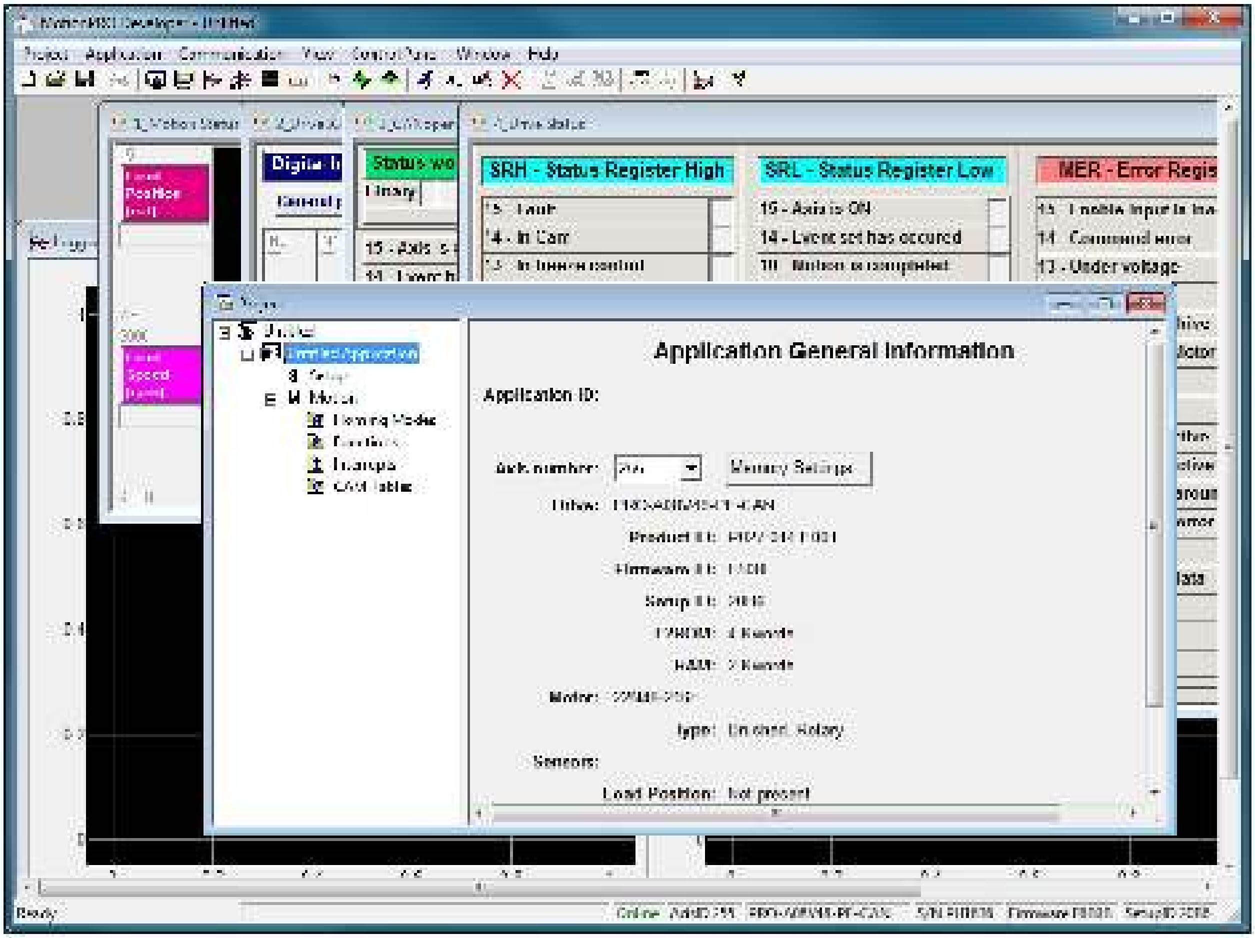


When you start a new project, MotionPRO Developer automatically creates a first application. Additional applications can be added later. You can duplicate an application or insert one defined in another project.

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).



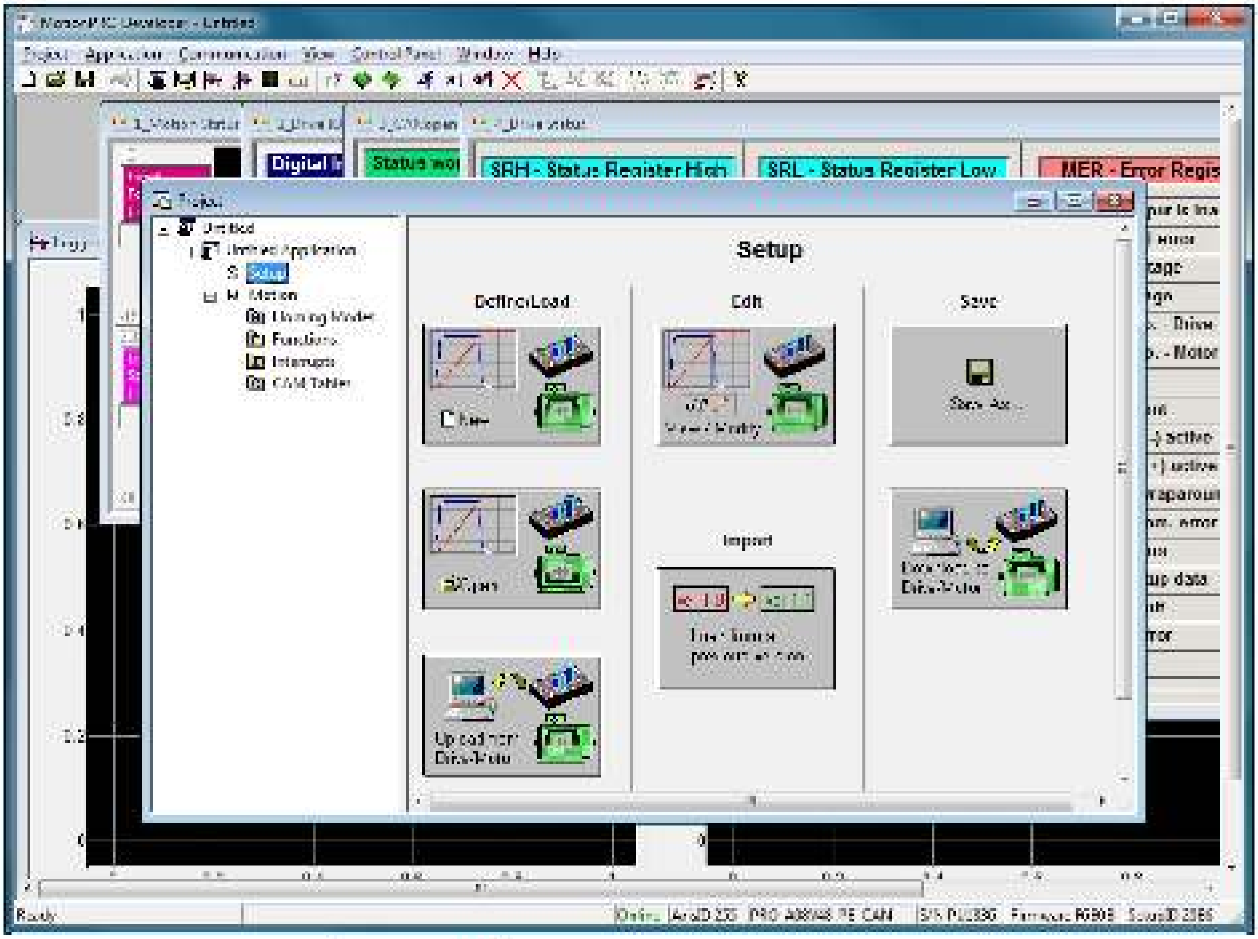
5.2.3.2 Step 2 Establish communication

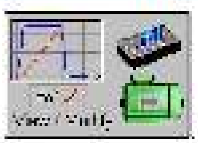
If you have a drive/motor connected with your PC, now it's time to check the communication. Use menu command **Communication | Setup** to check/change your PC communication settings. Press the **Help** button of the dialogue opened. Here you can find detailed information about how to setup your drive/motor 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 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.*** *If this drive is part of a CANbus network and the PC is serially connected with another drive, use the menu command* ***Communication | Scan Network***

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.

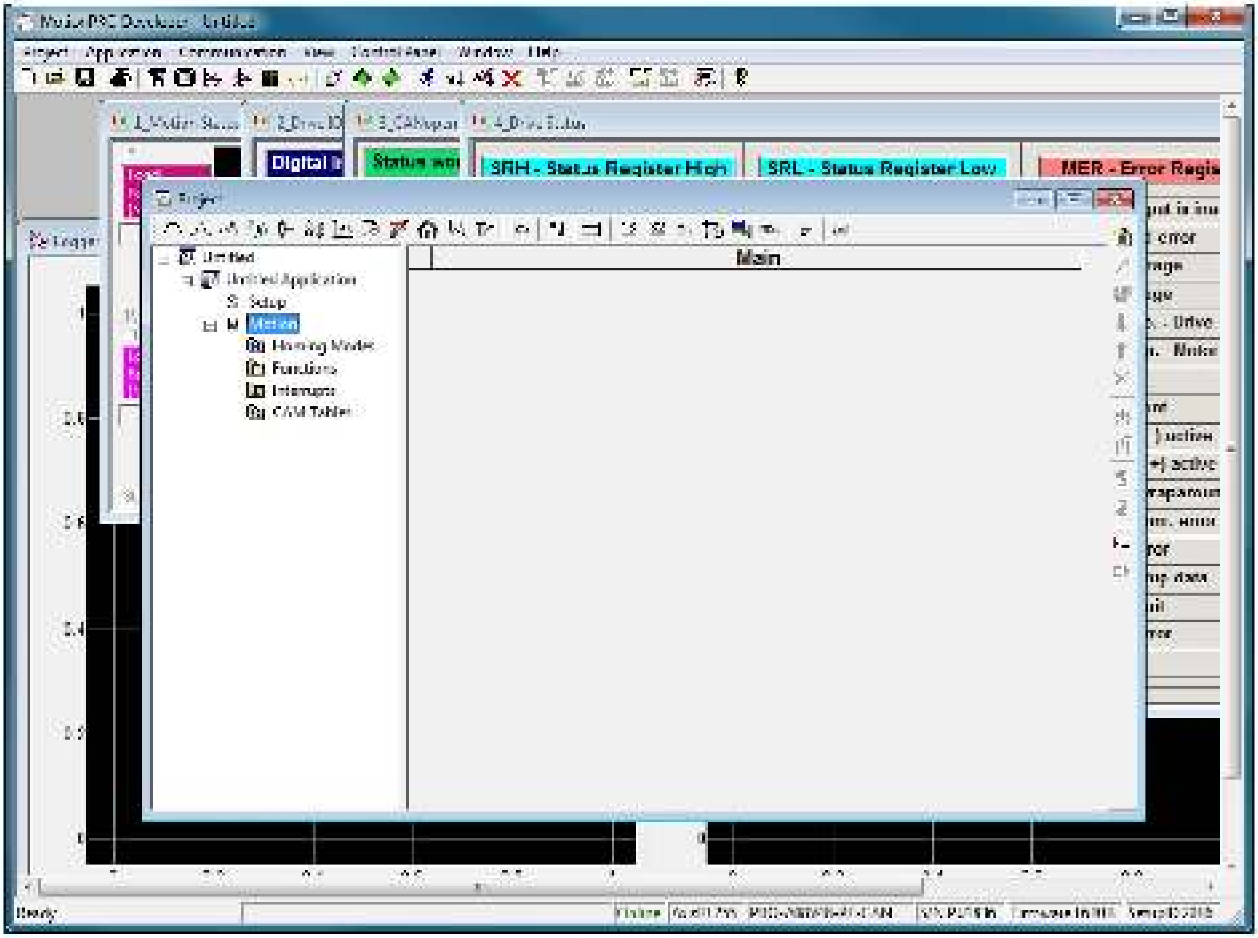
Press the **Download to Drive/Motor** button  to download your setup data in the drive/motor EEPROM memory in the *setup table*. From now on, at each power-on, the setup data is copied into the drive/motor RAM memory which is used during runtime. It is also possible to save the setup data on your PC 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[1]. The MPL program may also include cam tables used for electronic camming applications[2].

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

[1] The customization of the interrupt service routines and homing routines is available only for PRO-A08V48 CAN execution
[2] Optional for PRO-A08V48 CANopen execution

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 4.5

5.3. Combining CANopen /or other host with MPL

Due to its embedded motion controller, an PRO-A08V48 offers many programming solutions that may simplify a lot the task of a CANopen master. This paragraph overviews a set of advanced programming features which arise when combining MPL programming at drive level with CANopen master control. A detailed description of these advanced programming features is included in the ***CANopen Programming*** manual. All features presented below require usage of MotionPRO Developer as a 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-A08V48 is treated like a standard CANopen drive, whose setup is done using PRO Config.*

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

With Electrocraft intelligent drives you can really distribute the intelligence between a CANopen 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 procedures[1], 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

The PRO-A08V48 offers others motion modes like[2]: electronic gearing, electronic camming, external modes with analogue 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.

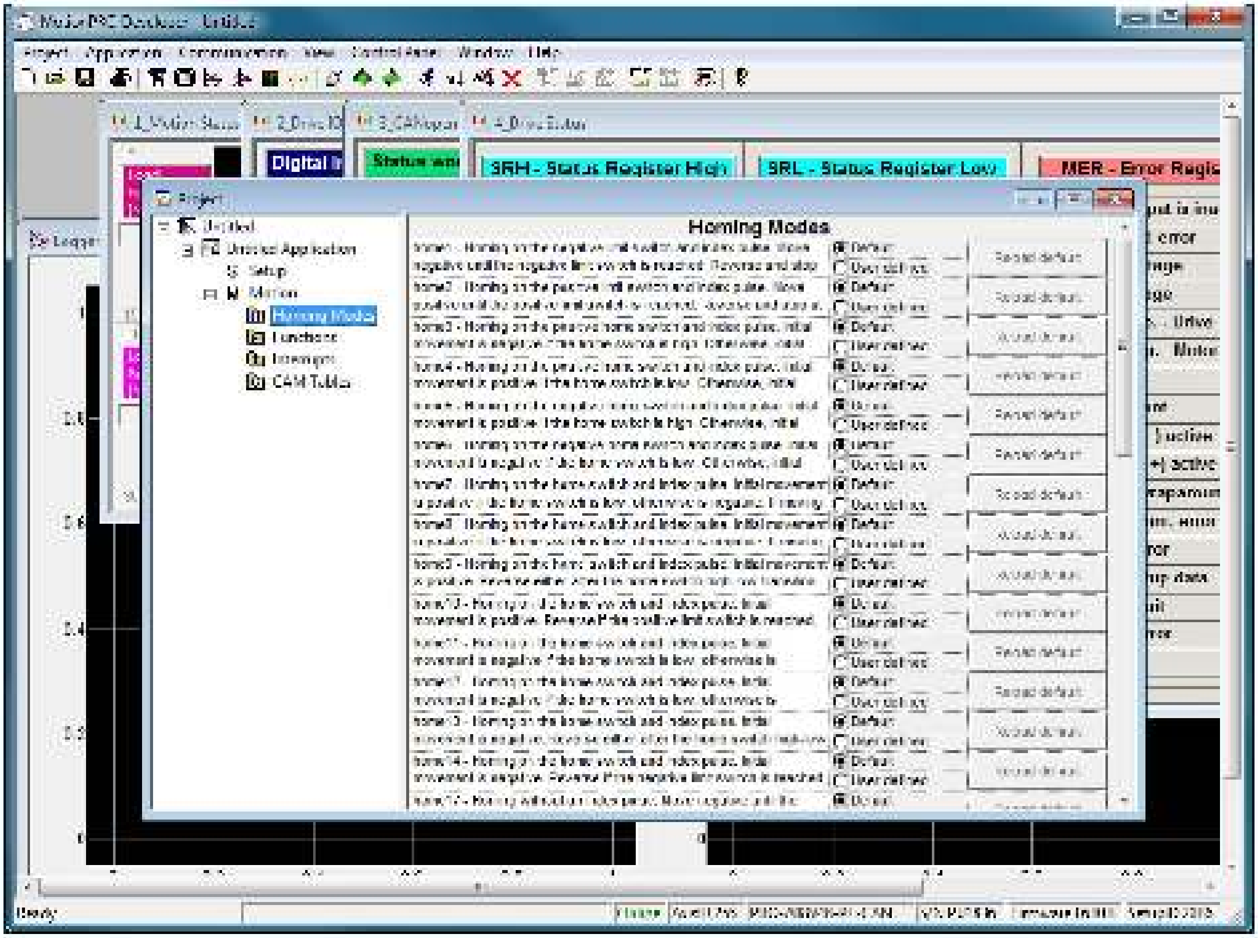
Remark: The cam tables are included in the .sw file generated with MotionPRO Developer. Therefore, the drives can check the cam presence in the drive EEPROM using the same procedure as for testing of the setup data.

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

[2] Optional for the PRO-A08V48 CANopen execution

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. It's 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.

5.4. Using Motion Libraries for PC-based Systems

A **MPL Library for PC** is a collection of high-level functions allowing you to control from a PC a network of Electrocraft intelligent drives. It is an ideal tool for quick implementation on PCs of motion control applications with Electrocraft products.

With the MPL Motion Library functions you can: communicate with a drive / motor via any of its supported channels (RS-232, CAN-bus, etc.), send motion commands, get automatically or on request information about drive / motor status, check and modify its setup parameters, read inputs and set outputs, etc.

The MPL Motion Library can work under a **Windows** or **Linux** operating system. Implemented as a .dll/.so, it can be included in an application developed in **C/C++/C#, Visual Basic, Delphi Pascal** or **Labview**.

Using a MPL Motion Library for PC, you can focus on the main aspects of your application, while the motion programming part can be reduced to calling the appropriate functions and getting the confirmation when the task was done.

5.5. Using Motion Libraries for PLC-based Systems

A **MPL Motion Library for PLC** is a collection of high-level functions and function blocks allowing you to control from a PLC the Electrocraft intelligent drives. The motion control function blocks are developed in accordance with the **PLC IEC61131-3 standard** and represent an ideal tool for quick implementation on PLCs of motion control applications with Electrocraft products.

With the MPL Motion Library functions you can: communicate with a drive/motor via any of its supported channels, send motion commands, get automatically or on request information about drive/motor status, check and modify its setup parameters, read inputs and set outputs, etc. Depending on the PLC type, the communication is done either directly with the CPU unit, or via a CANbus or RS-232 communication module.

Using a MPL Motion Library for PLC, you can focus on the main aspects of your PLC application, while the motion programming part can be reduced to calling the appropriate functions and monitoring the confirmations that the task was done.

All these blocks have been designed using the guidelines described in the PLC standards, so they can be used on any development platform that is **IEC 61136 compliant.**

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. Brushless motor with linear Hall signals

The internal position units are counts. The motor is rotary. The resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the load position in SI units is:

For rotary motors: $$\text{Load\_Position[SI]} = \frac{2 \times \pi}{\text{resolution} \times \text{Tr}} \times \text{Motor\_Position[IU]}$$

For linear motors: $$\text{Load\_Position[SI]} = \frac{\text{Pole\_Pitch}}{\text{Tr}} \times \text{Motor\_Position[IU]}$$

where:

resolution – is the motor position resolution

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

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

6.1.3. 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

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

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

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

$$Load\_Position[SI] = \frac{2 \times \pi}{No\_\mu steps \times No\_steps \times Tr} \times Motor\_Position[IU]$$

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** is:

$$Load\_Position[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times Tr} \times Motor\_Position[IU]$$

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

6.1.5. 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:

$$Load\_Position[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines} \times Load\_Position[IU]$$

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

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

6.1.6. 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:

$$Load\_Position[SI] = \frac{2 \times \pi}{4 \times Enc\_periods \times Interpolation \times Tr} \times Motor\_Position[IU]$$

For linear motors:

$$Load\_Position[SI] = \frac{Encoder\_accuracy}{Interpolation \times Tr} \times Motor\_Position[IU]$$

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 an 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:

$$\text{Load\_Speed}[SI] = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times Tr \times T} \times \text{Motor\_Speed}[IU]$$

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. Brushless motor with linear Hall signals

The internal speed units are counts / (slow loop sampling period). The motor is rotary. The position resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the load speed in SI units is:

For rotary motors: $$\text{Load\_Speed}[SI] = \frac{2 \times \pi}{\text{resolution} \times Tr \times T} \times \text{Motor\_Speed}[IU]$$

For linear motors: $$\text{Load\_Speed}[SI] = \frac{\text{Pole\_Pitch}}{\text{resolution} \times Tr \times T} \times \text{Motor\_Speed}[IU]$$

where:

resolution – is the motor position resolution

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"

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

6.2.3. 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:

$$\text{Load\_Speed}[SI] = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times T} \times \text{Load\_Speed}[IU]$$

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"

6.2.4. 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** is:

$$\text{Load\_Speed[SI]} = \frac{\text{Analogue\_Input\_Range}}{4096 \times \text{Tacho\_gain} \times \text{Tr}} \times \text{Motor\_Speed[IU]}$$

where:

Analogue_Input_Range – is the range of the drive analogue 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]

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

The internal speed units are motor µsteps / (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".

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

6.2.6. 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:

$$Load\_Speed[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times Tr \times T} \times Motor\_Speed[IU]$$

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".

6.2.7. 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:

$$Load\_Speed[SI] = \frac{2 \times \pi}{4 \times Enc\_periods \times Interpolation \times Tr \times T} \times Motor\_Speed[IU]$$

For linear motors:

$$Load\_Speed[SI] = \frac{Encoder\_accuracy}{Interpolation \times Tr \times T} \times Motor\_Speed[IU]$$

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".

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

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. Brushless motor with linear Hall signals

The internal acceleration units are counts / (slow loop sampling period)^2. The motor is rotary. The position resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the load **acceleration in SI units**[1] is:

For rotary motors:

$$\text{Load\_Acceleration[SI]} = \frac{2 \times \pi}{\text{resolution} \times \text{Tr} \times \text{T}^2} \times \text{Motor\_Acceleration[IU]}$$

For linear motors:

$$\text{Load\_Acceleration[SI]} = \frac{\text{Pole\_Pitch}}{\text{resolution} \times \text{Tr} \times \text{T}^2} \times \text{Motor\_Acceleration[IU]}$$

where:

resolution – is the motor position resolution

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"

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

[1] SI units for acceleration are [rad/s^2] for a rotary movement, [m/s^2] for a linear movement

6.3.3. 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:

$$Load\_Acceleration[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times T^2} \times Load\_Acceleration[IU]$$

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"

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

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

$$Load\_Acceleration[SI] = \frac{2 \times \pi}{No\_\mu steps \times No\_steps \times Tr \times T^2} \times Motor\_Acceleration[IU]$$

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".

6.3.5. 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:

$$Load\_Acceleration[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times T^2} \times Load\_Acceleration[IU]$$

For rotary-to-linear transmission:

$$Load\_Acceleration[m/s^2] = \frac{Encoder\_accuracy}{T^2} \times Load\_Acceleration[IU]$$

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".

6.3.6. 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:

$$\text{Load\_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times Tr \times T^2} \times \text{Motor\_Acceleration[IU]}$$

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"

6.3.7. 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:

$$\text{Load\_Acceleration[SI]} = \frac{2 \times \pi}{4 \times \text{Enc\_periods} \times \text{Interpolation} \times Tr \times T^2} \times \text{Motor\_Acceleration[IU]}$$

For linear motors:

$$\text{Load\_Acceleration[SI]} = \frac{\text{Encoder\_accuracy}}{\text{Interpolation} \times Tr \times T^2} \times \text{Motor\_Acceleration[IU]}$$

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 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"

[1] SI units for acceleration are [rad/s^2] for a rotary movement, [m/s^2] 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** is:

$$\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times \text{Tr} \times T^3} \times \text{Motor\_Jerk[IU]}$$

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. Brushless motor with linear Hall signals

The internal jerk units are counts / (slow loop sampling period)[3]. The motor is rotary. The position resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the load acceleration in SI units is:

For rotary motors: $\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{\text{resolution} \times \text{Tr} \times T^3} \times \text{Motor\_Jerk[IU]}$

For linear motors: $\text{Load\_Jerk[SI]} = \frac{\text{Pole\_Pitch}}{\text{resolution} \times \text{Tr} \times T^3} \times \text{Motor\_Jerk[IU]}$

where:

resolution – is the motor position resolution

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"

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

[3] SI units for jerk are [rad/s^3] for a rotary movement, [m/s^3] for a linear movement

6.4.3. 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:

$$\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times T^3} \times \text{Load\_Jerk[IU]}$$

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"

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

The internal jerk units are motor µsteps / (slow loop sampling period)^3. The correspondence with the load **jerk in SI units**[1] is:

$$\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{\text{No\_}\mu\text{steps} \times \text{No\_steps} \times Tr \times T^3} \times \text{Motor\_Jerk[IU]}$$

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"

6.4.5. 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:

$$\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times T^3} \times \text{Load\_Jerk[IU]}$$

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".

[1] SI units for jerk are [rad/s^3] for a rotary movement, [m/s^3] for a linear movement

6.4.6. 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".

6.4.7. Brushless motor with sine/cosine encoder on motor

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: $$\text{Load\_Jerk[SI]} = \frac{2 \times \pi}{4 \times \text{Enc\_periods} \times \text{Interpolation} \times \text{Tr} \times \text{T}^3} \times \text{Motor\_Jerk[IU]}$$

For linear motors: $$\text{Load\_Jerk[SI]} = \frac{\text{Encoder\_accuracy}}{\text{Interpolation} \times \text{Tr} \times \text{T}^3} \times \text{Motor\_Jerk[IU]}$$

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 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"

6.5. Current units

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

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

where Ipeak – 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:

$$\text{Voltagecommand}[V] = \frac{1.1 \times \text{Vdc}}{65534} \times \text{Voltagecommand}[IU]$$

where Vdc – 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:

$$\text{Voltagecommand}[V] = \frac{\text{Vdc}}{32767} \times \text{Voltagecommand}[IU]$$

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:

$$\text{Voltage\_measured}[V] = \frac{\text{VdcMaxMeasurable}}{65520} \times \text{Voltage\_measured}[IU]$$

where VdcMaxMeasurable – 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:

$$Time[s] = T \times Time[IU]$$

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 = 1ms, 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:

$$Motor\_Position[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines} \times Motor\_Position[IU]$$

where:

No_encoder_lines – is the rotary encoder number of lines per revolution

6.11.2. Brushless motor with linear Hall signals

The internal motor position units are counts. The motor is rotary. The resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the motor position in SI units is:

For rotary motors: $$Motor\_Position[SI] = \frac{2 \times \pi}{resolution} \times Motor\_Position[IU]$$

For linear motors: $$Motor\_Position[SI] = \frac{Pole\_Pitch}{resolution} \times Motor\_Position[IU]$$

where:

resolution – is the motor position resolution

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

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

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

The motor position is not computed.

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

The internal motor position units are motor µsteps. The correspondence with the motor **position in SI units**[1] is:

$$Motor\_Position[SI] = \frac{2 \times \pi}{No\_\mu steps \times No\_steps} \times Motor\_Position[IU]$$

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.

6.11.5. 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.

6.11.6. 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:

$$Motor\_Position[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines} \times Motor\_Position[IU]$$

where:

No_encoder_lines – is the motor encoder number of lines per revolution

6.11.7. 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:

$$Motor\_Position[SI] = \frac{2 \times \pi}{4 \times Enc\_periods \times Interpolation} \times Motor\_Position[IU]$$

For linear motors:

$$Motor\_Position[SI] = \frac{Encoder\_accuracy}{Interpolation} \times Motor\_Position[IU]$$

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 an 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:

For rotary motors: $$Motor\_Speed[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times T} \times Motor\_Speed[IU]$$

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. Brushless motor with linear Hall signals

The internal motor speed units are counts / (slow loop sampling period). The motor is rotary. The position resolution i.e. number of counts per revolution is programmable as a power of 2 between 512 and 8192. By default it is set at 2048 counts per turn. The correspondence with the motor speed in SI units is:

For rotary motors: $$Motor\_Speed[SI] = \frac{2 \times \pi}{resolution \times T} \times Motor\_Speed[IU]$$

For linear motors: $$Motor\_Speed[SI] = \frac{Pole\_Pitch}{resolution \times T} \times Motor\_Speed[IU]$$

where:

resolution – is the motor position resolution

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"

Pole_Pitch – is the magnetic pole pitch NN (distance expressed in [m])

6.12.3. 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:

$$Motor\_Speed[SI] = \frac{Analogue\_Input\_Range}{4096 \times Tacho\_gain} \times Motor\_Speed[IU]$$

where:

Analogue_Input_Range – is the range of the drive analogue 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. 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:

$$Motor\_Speed[SI] = \frac{Analogue\_Input\_Range}{4096 \times Tacho\_gain} \times Motor\_Speed[IU]$$

where:

Analogue_Input_Range – is the range of the drive analogue 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]

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

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

$$Motor\_Speed[SI] = \frac{2 \times \pi}{No\_\mu steps \times No\_steps \times T} \times Motor\_Speed[IU]$$

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.

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. 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:

$$Motor\_Speed[SI] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times T} \times Motor\_Speed[IU]$$

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".

6.12.7. 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:

$$Motor\_Speed[SI] = \frac{2 \times \pi}{4 \times Enc\_periods \times Interpolation \times T} \times Motor\_Speed[IU]$$

For linear motors:

$$Motor\_Speed[SI] = \frac{Encoder\_accuracy}{Interpolation \times T} \times Motor\_Speed[IU]$$

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"

7. Memory Map

PRO-A08V48B-SA-CAN has 2 types of memory available for user applications: 16K×16 SRAM and 16K×16 serial E^2ROM.
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 E^2ROM 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*

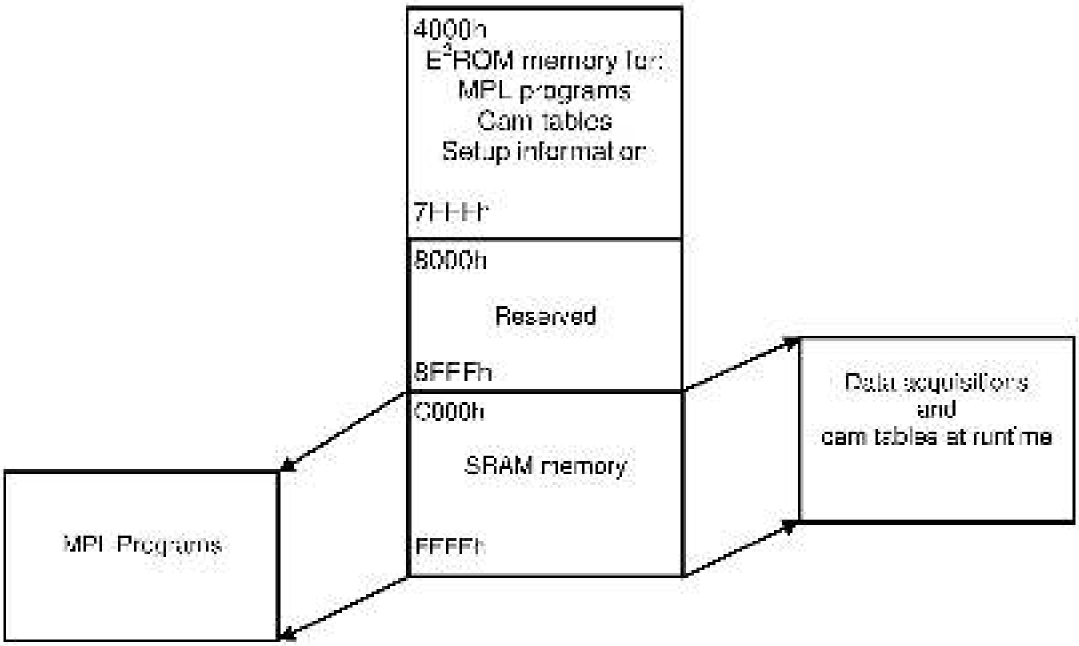


Figure 7.1. *PRO-A08V48B-SA-CAN Memory Map*

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