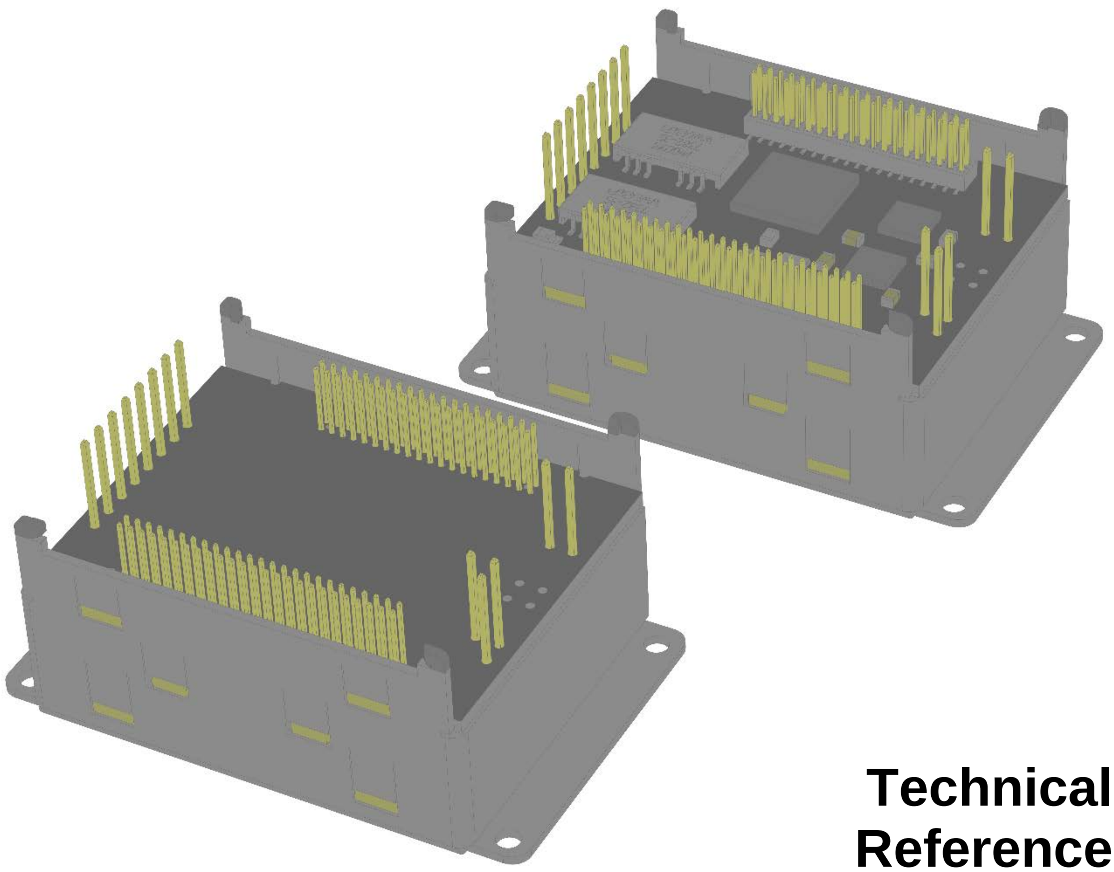
iMOTIONCUBE CAN/ CAN-STO/ CAT-STO

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

TECHNOSOFT

Intelligent Servo Drives



Technical Reference

P091.027.iMOTIONCUBE.CAN.CAT.UM.0319

Read This First

About This Manual

This book is a technical reference manual for:

Product Name	Part Number	Description
iMOTIONCUBE CAN	P025.126.E101	Pin plug version, CAN
iMOTIONCUBE CAN-STO	P025.126.E111	Pin plug version, CAN, STO inputs
iMOTIONCUBE CAT-STO	P025.326.E121	Pin plug version, EtherCAT®, STO inputs

In order to operate the **iMOTIONCUBE** drives, you need to pass through 3 steps:

- ❑ **Step 1 Hardware installation**
- ❑ **Step 2 Drive setup** using Technosoft **EasySetUp** software for drive commissioning
- ❑ **Step 3 Motion programming** using one of the options:
  - ❑ A **CANopen master**[1] or an **EtherCAT® master**[2]
  - ❑ The drives **built-in motion controller** executing a Technosoft Motion Language (**TML**) program developed using Technosoft **EasyMotion Studio** software
  - ❑ A **TML_LIB motion library for PCs** (Windows or Linux)
  - ❑ A **TML_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 TML

This manual covers **Step 1** in detail. It describes the **iMOTIONCUBE** hardware including the technical data, the connectors and the wiring diagrams needed for installation.

For Step 2 and 3, please consult the document ***iPOS Dual Loop drives Software reference***

(091.027.DL.Software.xxxx). It also includes the scaling factors between the real SI units and the drive internal units. For detailed information regarding the next steps, refer to the related documentation.

Notational Conventions

This document uses the following conventions:

- **iMOTIONCUBE**– 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.)
- **STO** – Safe Torque Off
- **TML** – Technosoft Motion Language
- **CANopen** – Standard communication protocol that uses 11-bit message identifiers over CAN-bus
- **TMLCAN** – Technosoft communication protocol for exchanging TML commands via CAN-bus, using 29bit message identifiers
- **CoE** – CAN application protocol over EtherCAT®

Trademarks

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

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[1] when the iMOTIONCUBE CAN is set in CANopen mode

[2] when using an iMOTIONCUBE-CAT

Related Documentation

iMOTIONCUBE CAN Datasheet (P025.126.E101.DSH)

iMOTIONCUBE CAN-STO Datasheet (P025.126.E111.DSH)

iMOTIONCUBE CAT-STO Datasheet (P025.326.E121.DSH)

– describes the hardware connections of the iMOTIONCUBE intelligent servo drive including the technical data and connectors.

iPOS Dual Loop drives Software reference (091.027.DL.Software.xxxx)

– describes the compatible software installation, drive software setup commissioning, introduction to TML motion programming, includes the scaling factors between the real SI units and the drive internal units.

Help of the EasySetUp software – describes how to use **EasySetUp** to quickly setup any Technosoft drive for your application using only 2 dialogues. The output of EasySetUp 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 EasySetUp it is also possible to retrieve the complete setup information from a drive previously programmed. **EasySetUp can be downloaded free of charge from Technosoft web page**

iPOS CANopen Programming **(part no. P091.063.iPOS.UM.xxxx)** – explains how to program the iPOS family of intelligent 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

CoE Programming **(part no. P091.064.UM.xxxx)** – explains how to program the Technosoft intelligent drives using **CAN application protocol over EtherCAT®** and describes the associated object dictionary.

Motion Programming using EasyMotion Studio (part no. P091.034.ESM.UM.xxxx) – describes how to use the EasyMotion Studio to create motion programs using in Technosoft Motion Language (TML). EasyMotion Studio platform includes **EasySetUp** 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 TML instructions. *With EasyMotion Studio you can fully benefit from a key advantage of Technosoft drives – their capability to execute complex motions without requiring an external motion controller, thanks to their built-in motion controller.* **A demo version of EasyMotion Studio (with EasySetUp part fully functional) can be downloaded free of charge from the Technosoft web page**

TML_LIB v2.0 **(part no. P091.040.v20.UM.xxxx)** – explains how to program in **C, C++,C#, Visual Basic or Delphi Pascal** a motion application for the Technosoft intelligent drives using TML_LIB v2.0 motion control library for PCs. The TML_lib includes ready-to-run examples that can be executed on **Windows** or **Linux** (x86 and x64).

TML_LIB_LabVIEW v2.0 **(part no. P091.040.LABVIEW.v20.UM.xxxx)** – explains how to program in **LabVIEW** a motion application for the Technosoft intelligent drives using TML_LIB_Labview v2.0 motion control library for PCs. The TML_Lib_LabVIEW includes over 40 ready-to-run examples.

TML_LIB_S7 **(part no. P091.040.S7.UM.xxxx)** – explains how to program in a PLC **Siemens series S7-300 or S7-400** a motion application for the Technosoft intelligent drives using TML_LIB_S7 motion control library. The TML_LIB_S7 library is **IEC61131-3 compatible**.

TML_LIB_CJ1 **(part no. P091.040.CJ1.UM.xxxx)** – explains how to program in a PLC **Omron series CJ1** a motion application for the Technosoft intelligent drives using TML_LIB_CJ1 motion control library for PLCs. The TML_LIB_CJ1 library is **IEC61131-3 compatible**.

TML_LIB_X20 **(part no. P091.040.X20.UM.xxxx)** – explains how to program in a PLC **B&R series X20** a motion application for the Technosoft intelligent drives using TML_LIB_X20 motion control library for PLCs. The TML_LIB_X20 library is **IEC61131-3 compatible**.

TechnoCAN **(part no. P091.063.TechnoCAN.UM.xxxx)** – presents TechnoCAN protocol – an extension of the CANopen communication profile used for TML commands

If you Need Assistance …

If you want to …	Contact Technosoft at …
Visit Technosoft online	World Wide Web: http://www.technosoftmotion.com/
Receive general information or assistance (see Note)	World Wide Web: http://www.technosoftmotion.com/ Email: contact@technosoftmotion.com
Ask questions about product operation or report suspected problems (see Note)	Fax: (41) 32 732 55 04 Email: hotline@technosoftmotion.com
Make suggestions about, or report errors in documentation.	Mail: Technosoft SA Avenue des Alpes 20 CH-2000 Neuchatel, NE Switzerland

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.

The following safety symbols are used in this manual:

WARNING!	*SIGNALS A DANGER TO THE OPERATOR WHICH MIGHT CAUSE BODILY INJURY. 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*
CAUTION!	*Indicates areas SENSITIVE TO electrostatic discharges (ESD) WHICH REQUIRE HANDLING IN AN ESD PROTECTED ENVIRONMENT*

1.1 Warnings

WARNING!	*THE VOLTAGE USED IN THE DRIVE MIGHT CAUSE ELECTRICAL SHOCKS. DO NOT TOUCH LIVE PARTS WHILE THE POWER SUPPLIES ARE ON*
WARNING!	*TO AVOID ELECTRIC ARCING AND HAZARDS, NEVER CONNECT / DISCONNECT WIRES FROM THE DRIVE 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 TECHNOSOFT***

CAUTION! ***THE DRIVE CONTAINS ELECTROSTATICALLY SENSITIVE COMPONENTS WHICH MAY BE DAMAGED BY INCORRECT HANDLING. THEREFORE THE DRIVE SHALL BE REMOVED FROM ITS ORIGINAL PACKAGE ONLY IN AN ESD PROTECTED ENVIRONMENT***

To prevent electrostatic damage, avoid contact with insulating materials, such as synthetic fabrics or plastic surfaces. In order to discharge static electricity build-up, place the drive on a grounded conductive surface and also ground yourself.

1.3 Quality system, conformance and certifications

IQNet and **Quality Austria** certification about the implementation and maintenance of the Quality Management System which fulfills the requirements of Standard **ISO 9001:2015**.
Quality Austria Certificate about the application and further development of an effective **Quality Management System** complying with the requirements of Standard **ISO 9001:2015**
REACH Compliance - TECHNOSOFT hereby confirms that this product comply with the legal obligations regarding Article 33 of the European REACH Regulation 1907/2006 (Registration, Evaluation, Authorization and Restriction of Chemicals), which came into force on 01.06.2007.
RoHS Compliance - Technosoft SA here with declares that this product is manufactured in compliance with the RoHS directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
Technosoft SA hereby declares that this product conforms to the following European applicable directives: **2014/30/EU** **Electromagnetic Compatibility (EMC) Directive** **2014/35/EU** **Low Voltage Directive (LVD)** **93/68/EEC** **CE Marking Directive** **EC 428/2009** **Non dual-use item, output frequency limited to 590Hz**
Conflict minerals statement - Technosoft declares that the company does not purchase 3T&G (tin, tantalum, tungsten & gold) directly from mines or smelters... We have no indication that Technosoft products contain minerals from conflict mines or smelters in and around the DRC.
STO compliance – TUV SUD certifies that this product is SIL 3 / Cat 3 / PL e compatible and is in conformity with the following safety – related directives: **EN ISO 13849-1:2015 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design** **EN 61800-5-1:2007 Adjustable speed electrical power drive systems — Safety requirements — Electrical, thermal and energy** **EN 61800-5-2:2007 Adjustable speed electrical power drive systems - Safety requirements –Functional** **EN 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems** **EN ISO 13849-1:2008 Safety of machinery - Safety-related parts of control systems** **EN 61326-3-1:2008 - General industrial applications - EMC - Immunity requirements for functional safety**

For other certifications visit: http://technosoftmotion.com/en/quality-system

2 Product Overview

2.1 Introduction

The **iMOTIONCUBE** is part of the **iPOS** 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 iMOTIONCUBE drives accept as position feedback incremental encoders (quadrature or sine/cosine), linear Hall signals abd absolute encoders (SSI and BiSS-C) using additional circuit.

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 iMOTIONCUBE 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 Technosoft Motion Language (**TML**) the following operations can be executed directly at drive level:

- ❑ Setting various motion modes (profiles, PVT, PT, electronic gearing[1] or camming[1], etc.)
- ❑ Changing the motion modes and/or the motion parameters
- ❑ Executing homing sequences
- ❑ Controlling the program flow through:
  - Conditional jumps and calls of TML functions
  - TML 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[2]
- ❑ Sending commands to a group of axes (multicast). This includes the possibility to start simultaneously motion sequences on all the axes from the group[2]
- ❑ 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 TML 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 TML functions stored in the drive EEPROM and waiting for a message, which confirms the TML functions execution completion.

All iMOTIONCUBE CAN drives are equipped with a serial RS232 and a CAN 2.0B interface that can be set by hardware pins to operate in 2 communication protocol modes:

- ❑ **CANopen**
- ❑ **TMLCAN**

The iMOTIONCUBE CAT drives support only the EtherCAT® communication protocol. They communicate through the serial RS232 interface for software commissioning and the EtherCAT® interface. The CAT veriosn also supports **FoE** protocol which allows firmware update and setup download using directly an EtherCAT master.

When **CANopen** mode is selected, the iMOTIONCUBE conforms to **CiA 301 v4.2** application layer communication profile, the **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 iMOTIONCUBE may be controlled via a CANopen master. The iPOS drive offers the possibility for a CANopen master to call motion sequences/ functions, written in TML and stored in the drive EEPROM, using manufacturer specific objects. Also, the drives can communicate separately between each other by using non reserved 11 bit identifiers.

When **TMLCAN** mode is selected, the iMOTIONCUBE behaves as standard Technosoft intelligent drive and conforms to Technosoft protocol for exchanging TML commands via CAN-bus. When TMLCAN protocol is used, it is not mandatory to have a master. Any iMOTIONCUBE can be set to operate standalone, and may play the role of a master

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[1] Available if the master axis sends its position via a communication channel, or by using the secondary encoder input

[2] Available only for CAN drives

to coordinate both the network communication/synchronization and the motion application via TML commands sent directly to the other drives.

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

For iMOTIONCUBE commissioning **EasySetUp** or **EasyMotion Studio** PC applications may be used.

EasySetUp is a subset of EasyMotion Studio, including only the drive setup part. The output of EasySetUp 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 EasySetUp it is also possible to retrieve the complete setup information from a drive previously programmed. EasySetUp shall be used for drive setup in all cases where the motion commands are sent exclusively from a master. Hence neither the iMOTIONCUBE TML programming capability nor the drive camming mode are used. **EasySetUp can be downloaded free of charge from Technosoft web page.**

EasyMotion Studio platform includes EasySetUp 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 TML instructions. *With EasyMotion Studio you can execute complex motions, thanks to their built-in motion controller*s. EasyMotion Studio, may be used to program motion sequences in TML. This is the iMOTIONCUBE typical CAN operation mode when TMLCAN protocol is selected. EasyMotion Studio can also be used with the CANopen protocol, if the user wants to call TML functions stored in the drive EEPROM or to use the camming mode. With camming mode, EasyMotion Studio offers the possibility to quickly download and test a cam profile and also to create a **.sw** file with the cam data. The .sw file can be afterwards stored in a master and downloaded to the drive, wherever needed. **A demo version of EasyMotion Studio (with EasySetUp part fully functional) can be downloaded free of charge from Technosoft web page.**

2.2 Product 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: torque, speed or position control; position or speed profiles, Cyclic Synchronous Position (CSP) for CANopen mode, external reference mode (analogue or encoder feedback) or sent via a communication bus
- Technosoft Motion Language (TML) instruction set for the definition and execution of motion sequences
- Standalone operation with stored motion sequences
- Motor supply: 12-80V
- Logic supply: 12-36V.
- Output current: 20A[1] continuous; 40A peak
- PWM switching frequency up to 120kHz
- Communication:
  - RS-232 serial up to 115kbits/s
  - CAN-bus 2.0B up to 1Mbit/s (for CAN drives)
- Digital and analog I/Os:
  - 4 digital inputs: 5-36 V, programmable polarity: sourcing/NPN or sinking/PNP: 2 Limit switches, 2 general-purpose
  - 4 digital outputs: 5-36 V, with 0.5 A, sinking/NPN open-collector (Ready, Error and 2 general-purpose)
  - NTC/PTC analogue Motor Temperature sensor input
- Electro-Mechanical brake support: software configurable digital output to control motor brake
- Feedback devices (dual-loop support)

  1st feedback devices supported:
  - Incremental encoder interface (single ended or differential)
  - Analog sin/cos encoder interface (differential $1V_{PP}$)
  - Linear Hall sensors interface
  - Pulse & direction interface (single ended) for external (master) digital reference

  2nd feedback devices supported:

[1] 20A cont. with DC, step and BLDC motors (trapezoidal), 20A amplitude ($14.2A_{RMS}$) for PMSM (sinusoidal)

- Incremental encoder interface (single ended 3.3V TTL)
- Pulse & direction interface (single ended 3.3V TTL) for external (master) digital reference
- SSI/BiSS interface (only with additional circuit)

- Separate feedback devices supported:
  - Digital Hall sensor interface (single-ended and open collector)
  - 4 analogue inputs: 12 bit, 0-5V: Reference and Feedback (for Tacho) or general purpose, Anlg 3 and Anlg 4
- 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
  - Cyclic Synchronous Position (CSP) for CANopen mode and EtherCAT® drives.
  - Cyclic Synchronous Velocity (CSV) only for EtherCAT® drives.
  - Cyclic Synchronous Torque (CST) only for EtherCAT® drives.
  - Electronic gearing and camming
  - 35 Homing modes
- 127 h/w selectable addresses in CANopen mode and 196 h/w addresses in TMLCAN mode
- Two CAN operation modes selectable by HW pin (only for CAN drives):
  - **CANopen** – conforming with **CiA 301 v4.2, CiA WD 305 v2.2.13** and **CiA DSP 402 v3.0**
  - **TMLCAN** – intelligent drive conforming with Technosoft protocol for exchanging TML commands via CAN-bus
- EtherCAT® with CAN application protocol over EtherCAT (CoE) and File over EtherCAT (FoE) for CAT drives
- 16K × 16 internal SRAM memory for data acquisition
- 16K × 16 E^2ROM to store TML motion programs, cam tables and other user data
- 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

2.3 Identification Labels

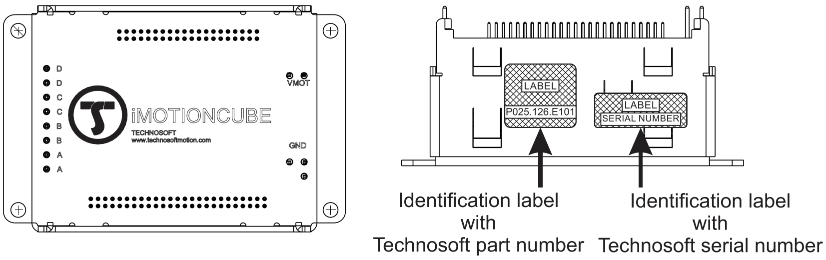


Figure 2.3.1. *iMOTIONCUBE CAN identification labels*

The iMOTIONCUBE family can have the following part numbers and names on the identification label:

p.n. **P025.126.E101** name iMOTIONCUBE CAN – standard pin plug CAN execution

p.n. **P025.126.E111** name iMOTIONCUBE CAN-STO – standard pin plug CAN execution with STO input pins

p.n. **P025.326.E121** name iMOTIONCUBE CAT-STO – standard pin plug EtherCAT execution with STO input pins

2.4 Supported Motor-Sensor Configurations

2.4.1 Single loop configurations

The position and/or speed are controlled using one feedback sensor. The other available feedback sensor input can be used for External reference Position or Velocity, Pulse and Direction, Electronic Gearing or Camming.

Sensor (Motor →) Sensor type	Sensor location	Brushless PMSM	Brushless BLDC	DC Brush	Stepper 2 phase	Stepper 3 phase
Incr. encoder	FDBK #1 (single ended or diff.) FDBK #2 (single ended 3.3V TTL)	Yes	-	Yes	Yes	-
Incr. encoder + Digital Hall	FDBK #1 (single ended or diff.) + Digital halls interface FDBK #2 (single ended 3.3V TTL) + Digital halls interface	Yes	Yes	-	-	-
Digital halls only	Digital halls interface	Yes	-	-	-	-
Linear halls (analogue)	Linear halls interface	Yes	-	-	-	-
SSI*	FDBK #2 (diff.)	Yes	-	Yes	Yes	-
BiSS-C*	FDBK #2 (diff.)	Yes	-	Yes	Yes	-
Analogue Sin/Cos encoder	FDBK #1 (diff.)	Yes	-	Yes	Yes	-
Tacho	Analogue input: Feedback	-	-	Yes	-	-
Open-loop (no sensor)	-	-	-	-	Yes	Yes
Open-loop (with step loss detection using Incr. Encoder/SinCos)	FDBK #1 (single ended or diff.) FDBK #2 (single ended 3.3V TTL)	-	-	-	Yes	Yes

* Available only with an additional circuit. See ***Figure 3.24***.

2.4.2 Dual loop configurations

The motor speed control loop is closed on one feedback connected on the motor while the motor position control loop is closed on the other available feedback which is placed on the load. There is usually a transmission between the load and the motor.

Motor type	Feedback #1	Feedback #2
PMSM	• Incremental encoder (single-ended or differential) • Analogue Sin/Cos encoder • Linear Halls (only on motor)	• Incremental encoder (single-ended 3.3V TTL) • *SSI/BiSS C encoder
BLDC	• Incremental encoder (single-ended or differential) + Digital halls	• Incremental encoder (single-ended 3.3V TTL) + Digital Halls • *SSI/BiSS C encoder (only on load)
Stepper 2ph	• Incremental encoder (single-ended or differential) • Analogue Sin/Cos encoder	• Incremental encoder (single-ended 3.3V TTL) • *SSI/BiSS C encoder
DC Brush	• Incremental encoder (single-ended or differential) • Analogue Sin/Cos encoder • Analogue Tacho (only on motor)	• Incremental encoder (single-ended 3.3V TTL) • *SSI/BiSS C encoder

* Available only with an additional circuit. See ***Figure 3.24***.

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 Incremental encoder (from feedback #2) on motor and Sin/Cos encoder (from feedback #1) on load.

2.5 iMOTIONCUBE BX Evaluation module

For evaluation, the iMOTIONCUBE can also be bought as a BX version. The BX version has mounted an I/O board with multiple connectors for easier access.

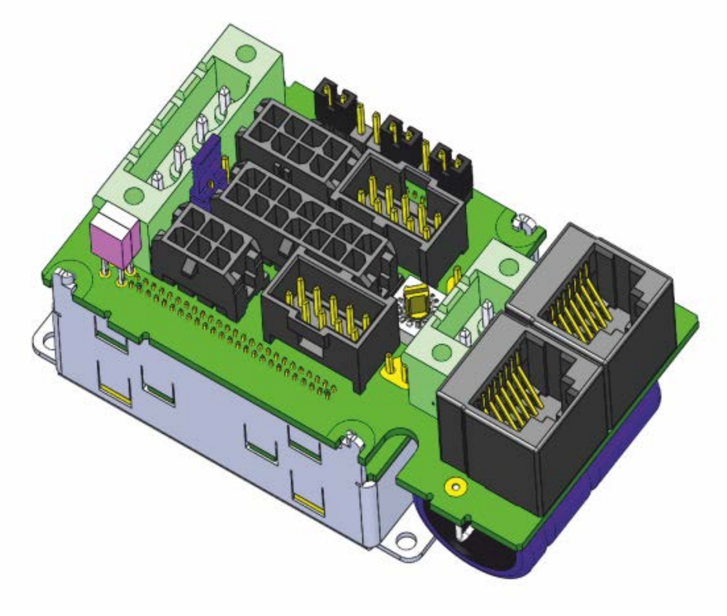


Figure 2.5.1. *iMOTIONCUBE BX-CAN with external connector*

Ordering information

Part number	**Description**
P025.126.E201	iMOTIONCUBE BX-CAN – standard execution with IO connectors and CAN
P025.126.E211	iMOTIONCUBE BX-CAN STO – standard execution with IO connectors, STO inputs and CAN
P025.326.E221	iMOTIONCUBE BX-CAT STO – standard execution with IO connectors, STO inputs and EtherCAT

3 Hardware Installation

3.1 iMOTIONCUBE Board Dimensions (all versions)

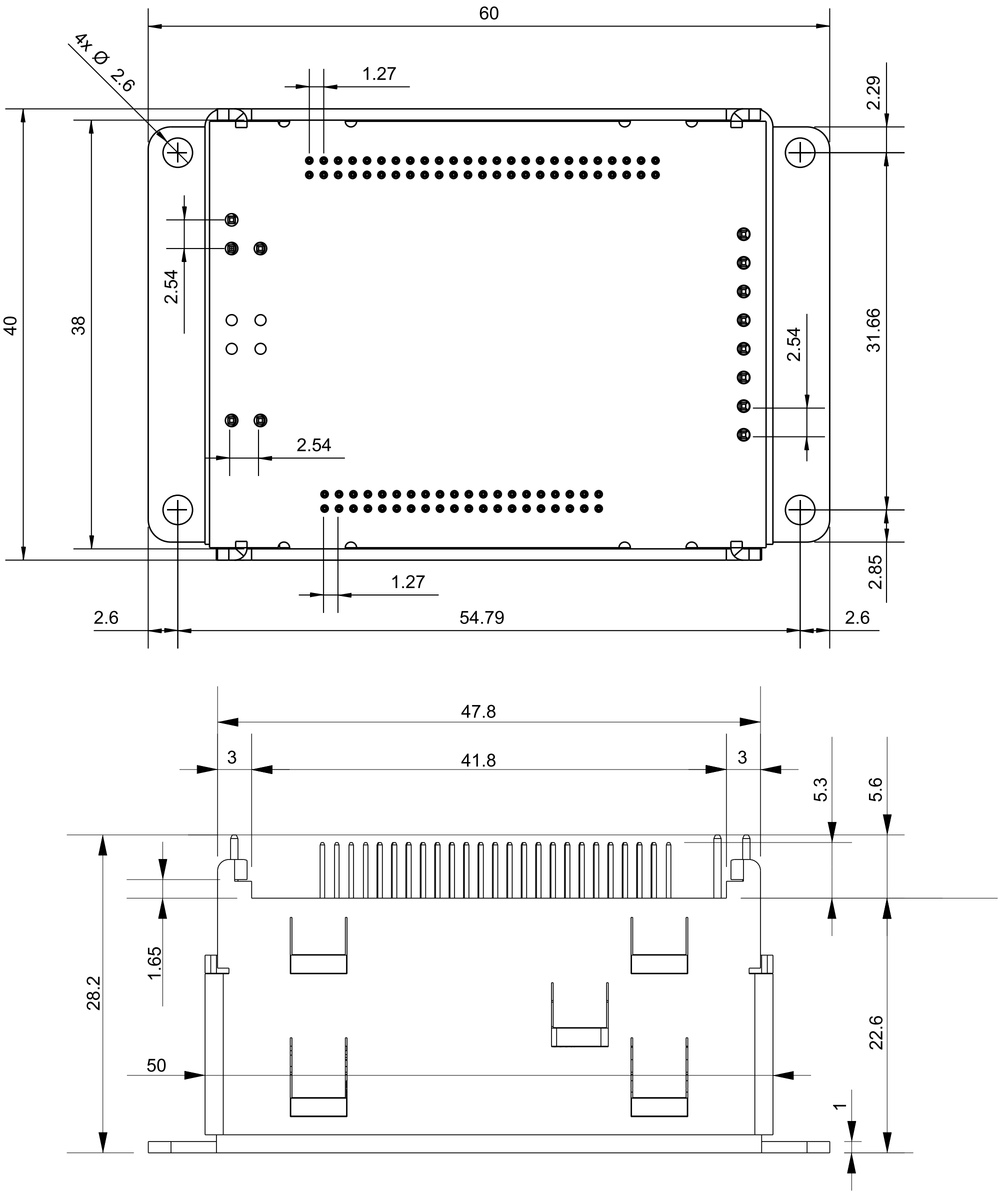


Figure 3.1.1. *iMOTIONCUBE CAN drive dimensions*

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

3.2 Mechanical Mounting

The iMOTIONCUBE drive is intended to be mounted horizontally on a motherboard equipped with the recommended mating connectors for the IOs, as specified in chapter **3.4.2 Mating Connectors**. For full current capability, the motor output and power input pins are meant to be soldered directly on the motherboard. Also, a heat sink must be mounted on the back plate of the drive.

3.2.1 iMOTIONCUBE CAN PCB Footprint

For iMOTIONCUBE CAN motherboard PCB design, use the dimensional drawing from Figure ***3.2*** below or request a .dxf file or at support@technosoftmotion.com.

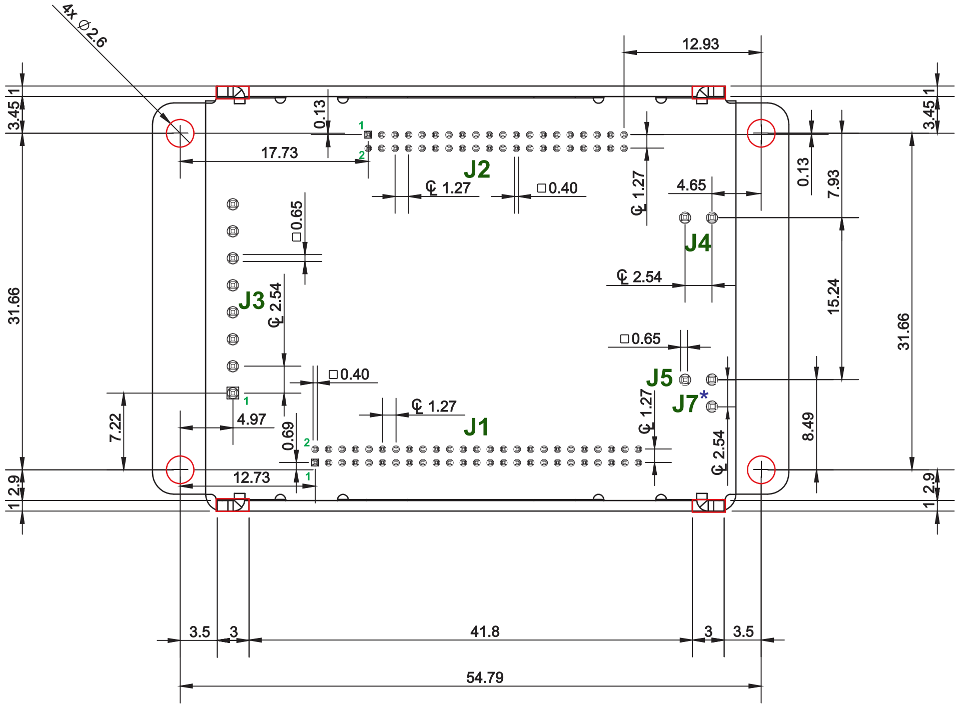


Figure 3.2 **iMOTIONCUBE CAN PCB Footprint**

All dimensions are in mm. Holes are marked with **RED**.

***** J7 is not available on previous versions of iMOTIONCUBE v2.0.

3.2.2 iMOTIONCUBE CAN-STO PCB Footprint

For iMOTIONCUBE CAN-STO motherboard PCB design, use the dimensional drawing from Figure ***3.3*** below or request a .dxf file at support@technosoftmotion.com.

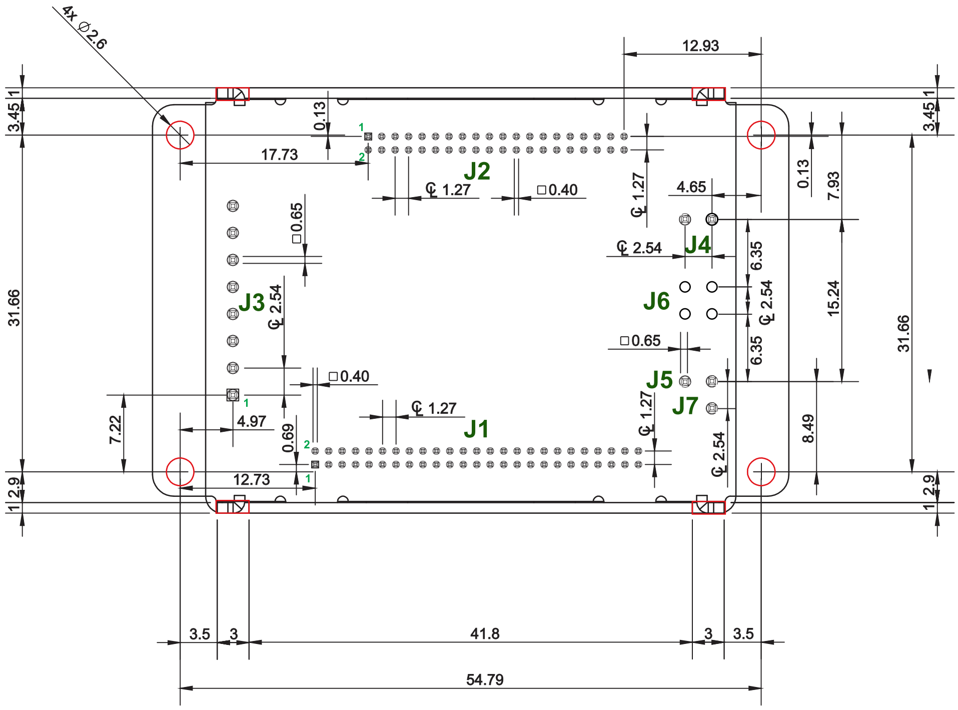


Figure 3.3 **iMOTIONCUBE CAN-STO PCB Footprint**

All dimensions are in mm. Holes are marked with **RED**.

3.2.3 MOTIONCUBE CAT-STO PCB Footprint

For iMOTIONCUBE CAT-STO motherboard PCB design, use the dimensional drawing from Figure ***3.4*** below or request a .dxf file at support@technosoftmotion.com.

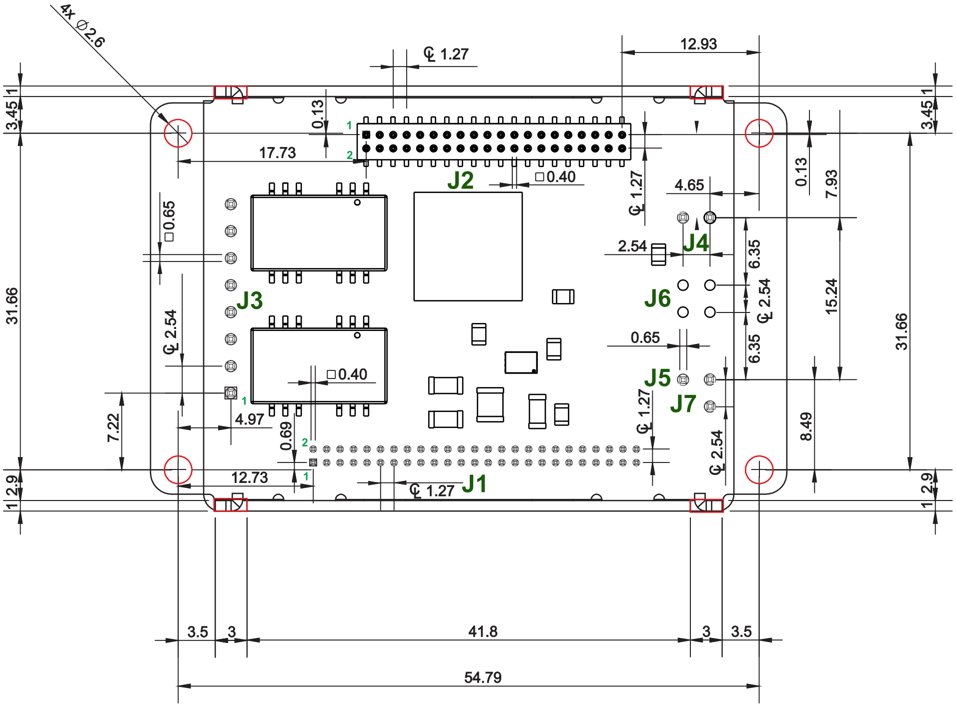


Figure 3.4 **iMOTIONCUBE CAT-STO PCB Footprint**

All dimensions are in mm. Holes are marked with **RED**.

3.3 Motherboard PCB Design

It is recommended to use a multi-layer PCB for the motherboard, in order to have enough room for routing all the pins of the iMOTIONCUBE. Using a 2-layer PCB is possible when some of the iMOTIONCUBE pins remain un-connected.

Below is a list of recommendations for the PCB design of the motherboard:

- Motor supply and motor outputs: use islands / areas of copper to escape connector area; this will maximize current capability. When using simple tracks, use at least 100mil cross section (75mil track width for 1oz/ft^2 copper thickness) – for iMOTIONCUBE.
- Motor supply and ground return tracks between iMOTIONCUBE and the nearby V_{MOT} decoupling capacitor are to be considered as EMI sources, and kept to a minimum length.
- Place the decoupling capacitors on V_{MOT} and V_{LOG} (see also 0 Power Supply Connection) as close as physically possible to the iMOTIONCUBE, to minimize EM radiated emissions. For un-shielded applications (no metallic box) and typical EMC regulations, the spacing between iMOTIONCUBE and capacitors must be less than 3 centimeters.
- In multi-axis applications (multiple iMOTIONCUBE drives on the same motherboard), it is preferable to have a separate decoupling capacitor for each drive's V_{MOT}. For V_{LOG} it is acceptable to share one decoupling capacitor for two drives.
- For stringent EMI requirements, it may be necessary to add common-mode filtering on the motor and/or logic supply inputs. Be sure to use 3-phase EMC filters, not 2-phase filters, in order to fulfill the basic requirement of zero common-mode current through the filter. This is necessary because the ground negative return is shared between V_{MOT} and V_{LOG}.
- Motor outputs shall be routed with parallel traces, and minimizing the loop area between these tracks. Avoid placing components above or below the motor output tracks, as these components may become effective antennas radiating EMI. If possible, route all 4 motor outputs in strip-line configuration (above or below a ground plane).
- For stringent EMI requirements, it may be necessary to add common-mode inductors on the motor outputs. Place these filters near the iMOTIONCUBE, not near the external connector, to reduce radiation from the PCB tracks.

- Motor outputs must be separated from any nearby track (on the same layer) by a guard ring / track / area connected to ground. It is recommended to use the same guarding precaution also for tracks on nearby layers, i.e. use intermediate guard layer(s) connected to ground. The motor outputs must be treated as first source of noise on the motherboard. Second source of noise is the current flow between each iMOTIONCUBE and it's decoupling V_{MOT} capacitor.
- For best EMC performance, it is strongly recommended to provide an un-interrupted ground plane on one of the inner layers.
- All GND pins of the iMOTIONCUBE are galvanically connected together on-board the iMOTIONCUBE. If the motherboard provides an uninterrupted ground plane, it is recommended to connect all GND pins to the ground plane, and use the ground plane to distribute GND wherever needed. If the motherboard does not provide an uninterrupted ground plane, it is best to use each GND pin for its intended purpose, as described in par. 0. This will create local "star point" ground connection on-board each iMOTIONCUBE. For a multi-axis motherboard with one common power supply for all motors, each motor power supply return track shall be routed separately for each iMOTIONCUBE, and star-point connected at the power supply terminal.
- The following signal pairs must be routed differentially, i.e. using parallel tracks with minimal loop area: A1+/Sin+, A1-/Sin- ; B1+/Cos+, B1-/Cos- ; Z1+, Z1- ; A2; B2 ; Z2-, CAN-Hi, CAN-Lo.
- CAN-Bus tracks must be routed with a bus topology, without branches / bifurcations, in a daisy-chain fashion. The bus ends must be at the termination resistor(s) and/or external connectors.
- When using $+5V_{OUT}$ as supply for external devices (like encoders, Hall sensors, etc.) provide extra filtering and protection: use series resettable (PTC) fuses to add short-circuit protection; use transient absorbers to protect against ESD and over-voltage; add high-frequency filtering to protect against external noise injected on $+5V_{OUT}$.
- The outer box / case / cabinet must be connected to the motherboard ground either galvanically (directly) or through high-frequency decoupling capacitors, rated at an appropriate voltage.

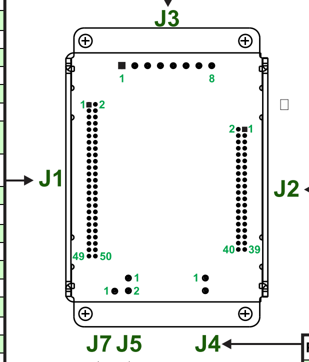
CAUTION!	***WHEN THE iMOTIONCUBE IS SET IN TMLCAN MODE, IT STARTS TO EXECUTE AUTOMATICALLY AT POWER ON THE TML APPLICATION FROM ITS EEPROM. ADD ON THE MOTHERBOARD THE POSSIBILITY TO DISABLE THIS FEATURE AS SHOWN PAR. 3.5.12. THIS MIGHT BE NEEDED DURING DEVELOPMENT PHASE IN CASE THE EEPROM CONTENT IS ACCIDENTALLY CORRUPTED.***

3.4 Connectors and Pinouts

3.4.1 Pinouts for iMOTIONCUBE CAN

Pin	Name	Description
1	232RX	RS232 data reception
2	Enc1 A+/Sin1+	Incr. encoder # A+ diff. input, analogue encoder #1 Sin+ diff. input.
3	232TX	RS232 data transmission
4	Enc1 A-/Sin1-	Incr. encoder #1 A- diff. input, analogue encoder #1 Sin1- diff. input
5	AxisID 0	Axis ID / Address input #0. Analogue input, 0-5V
6	Enc1 B+/Cos1+	Incr. encoder # B+ diff. input, analogue encoder #1 Cos+ diff. input.
7	AxisID 1	Axis ID / Address input #1. Analogue input, 0-5V
8	ENC1 B-/Cos1-	Incr. encoder #1 B- diff. input, analogue encoder Cos1- diff. input
9	AxisID 2	Axis ID / Address input #2. Analogue input, 0-5V
10	Enc1 Z+	Incr. encoder #1 Z+ diff. input.
11	CAN-Hi	CAN-Bus positive line (dominant high)
12	Enc1 Z-	Incr. encoder Z- diff. input
13	CAN-Lo	CAN-Bus negative line (dominant low)
14	Hall1	Hall 1 sensor 5V digital input
15	ENA1	Enable circuit input1; connect ENA1&ENA2 to +24V to activate motor operation
16	Hall2	Hall 2 sensor 5V digital input
17	ENA2	Enable circuit input2; connect ENA1&ENA2 to +24V to activate motor operation
18	Hall3	Hall 3 sensor 5V digital input
19	Ref	Analogue input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or as general purpose analogue input
20	Fdbk	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback, or as general purpose analogue input
21	+Vlog	Positive terminal for logic supply 9-36V_{DC}
22	+$5V_{OUT}$	5V output supply. Max. 300mA for feedback sensors and I/Os
23	IN0	24V digital input #0, programmable NPN or PNP, general-purpose
24	OUT0	24 digital output #0, NPN, general-purpose
25	IN1	24V digital input #1, programmable NPN or PNP, general-purpose
26	OUT1	24V digital output #1, NPN, general-purpose
27	IN2/LSP	24V digital input #2, programmable NPN or PNP, positive limit switch
28	Out2/Error	24V digital output #2, NPN, drive error
29	In3/LSN	24V digital input #3, programmable NPN or PNP type, negative limit switch
30	Out3/Ready	24V digital output 3, NPN type, drive ready
31	TMOT	Motor temperature sensor input. Analogue input, 0-3.3V
32..34	Reserved	Reserved
35	GND	Ground
36	GND	Ground
37..40	Reserved	Reserved
41	Enc2 A	Incr. encoder #2 A digital input, 0-3.3V
42	Anlg 3	Analogue input, 12-bit, 0-3.3V. Used as a general purpose analogue input
43	Enc2 B	Incr. encoder #2 B digital input, 0-3.3V
44	Anlg 4	Analogue input, 12-bit, 0-3.3V. Used as a general purpose analogue input
45	Enc2 Z	Incr. encoder #2 Z digital input, 0-3.3V
46	+5Vout	5V output supply. Max. 650mA for feedback sensors and I/Os
47..50	Reserved	Reserved

Pin	Name	Description
1,2	A/A+	Phase A for 3-ph motors, A+ for 2-ph steppers, Motor+ for DC brush motors
3,4	B / A-	Phase B for 3-ph motors, A- for 2-ph steppers, Motor- for DC brush motors
5,6	C / B+	Phase C for 3-ph motors, B+ for 2-ph steppers
7,8	CR / B-	Chopping resistor output/ Phase B- for step motors



Pin	Name	Description
1..28	Reserved	Reserved
29	CAN-Hi	CAN-Bus positive line (dominant high)
30	Reserved	Reserved
31	CAN-Lo	CAN-Bus negative line (dominant low)
32	Reserved	Reserved
33	+5V	+5V output power supply
34	GND	Ground
35..39	Reserved	Reserved
40	GND	Ground

Pin	Name	Description
1,2	$+V_{MOT}$	Positive terminal of the motor supply

Pin	Name	Description
1,2	GND	Negative return (ground) of the motor supply

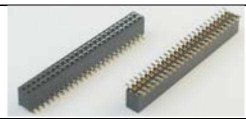
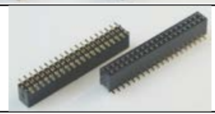
Pin	Name	Description
1	Earth	Earth

***Remarks:**

-Connector J7 is not available on previous versions of iMOTIONCUBE

-In case J7.pin1 (Earth) is not present, connect the cables Shield (if present) to GND instead.

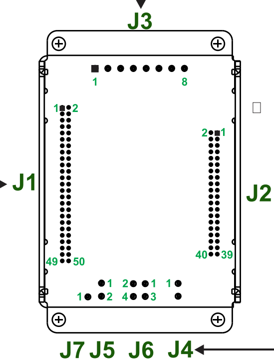
3.4.2 Mating Connectors

Connector	Description	Manufacturer	Part Number	Image
J1	Socket 2x25 pins, 1.27x1.27mm pitch, square 0.40 mm pins, pass-through SMD socket	WPPro	6062-050-00-10-PPST	
		Harwin	M50-3152542	
		Samtec	CLP-125-02-F-D-BE	
J2	Socket 2x20 pins, 1.27x1.27mm pitch, square 0.40 mm pins, pass-through SMD socket	WPPro	6062-040-00-10-PPST	
		Harwin	M50-3152042	
		Samtec	CLP-120-02-F-D-BE	
J3	To use full current capabilities of the drive, solder the pins directly to the motherboard without using socket connectors			
	High-current socket, 8 pins, 2.54 mm pitch, square 0.635 mm pins - use only if needed nominal current is 8A -			
J4,J5,J7	To use full current capabilities of the drive, solder the pins directly to the motherboard without using socket connectors			
	High-current socket, 2 pins (J4), 2x2 pins (J5), 2.54 mm pitch, square 0.635 mm pins - use only if needed nominal current is 8A -			
J6	Connector Header Through Hole 4 position 0.100" (2.54mm)	Samtec	TSW-102-14-F-D	

3.4.3 Pinouts for iMOTIONCUBE CAN-STO

Pin	Name	Description
1	232RX	RS232 data reception
2	Enc1 A+/Sin1+	Incr. encoder # A+ diff. input, analogue encoder #1 Sin+ diff. input.
3	232TX	RS232 data transmission
4	Enc1 A-/Sin1-	Incr. encoder #1 A- diff. input, analogue encoder #1 Sin1- diff. input
5	AxisID 0	Axis ID / Address input #0. Analogue input, 0-5V
6	Enc1 B+/Cos1+	Incr. encoder # B+ diff. input, analogue encoder #1 Cos+ diff. input.
7	AxisID 1	Axis ID / Address input #1. Analogue input, 0-5V
8	ENC1 B-/Cos1-	Incr. encoder #1 B- diff. input, analogue encoder Cos1- diff. input
9	AxisID 2	Axis ID / Address input #2. Analogue input, 0-5V
10	Enc1 Z+	Incr. encoder #1 Z+ diff. input.
11	CAN-Hi	CAN-Bus positive line (dominant high)
12	Enc1 Z-	Incr. encoder Z- diff. input
13	CAN-Lo	CAN-Bus negative line (dominant low)
14	Hall1	Hall 1 sensor 5V digital input
15	Reserved	Reserved
16	Hall2	Hall 2 sensor 5V digital input
17	Reserved	Reserved
18	Hall3	Hall 3 sensor 5V digital input
19	Ref	Analogue input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or as general purpose analogue input
20	Fdbk	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback, or as general purpose analogue input
21	+Vlog	Positive terminal for logic supply 9-36V_{DC}
22	$+5V_{OUT}$	5V output supply. Max. 300mA for feedback sensors and I/Os
23	IN0	24V digital input #0, programmable NPN or PNP, general-purpose
24	OUT0	24 digital output #0, NPN, general-purpose
25	IN1	24V digital input #1, programmable NPN or PNP, general-purpose
26	OUT1	24V digital output #1, NPN, general-purpose
27	IN2/LSP	24V digital input #2, programmable NPN or PNP, positive limit switch
28	Out2/Error	24V digital output #2, NPN, drive error
29	In3/LSN	24V digital input #3, programmable NPN or PNP type, negative limit switch
30	Out3/Ready	24V digital output 3, NPN type, drive ready
31	TMOT	Motor temperature sensor input. Analogue input, 0-3.3V
32..34	Reserved	Reserved
35	GND	Ground
36	GND	Ground
37..40	Reserved	Reserved
41	Enc2 A	Incr. encoder #2 A digital input, 0-3.3V
42	Anlg 3	Analogue input, 12-bit, 0-3.3V. Used as a general purpose analogue input
43	Enc2 B	Incr. encoder #2 B digital input, 0-3.3V
44	Anlg 4	Analogue input, 12-bit, 0-3.3V. Used as a general purpose analogue input
45	Enc2 Z	Incr. encoder #2 Z digital input, 0-3.3V
46	+5Vout	5V output supply. Max. 650mA for feedback sensors and I/Os
47..50	Reserved	Reserved

Pin	Name	Description
1,2	A/A+	Phase A for 3-ph motors, A+ for 2-ph steppers, Motor+ brush motors
3,4	B / A-	Phase B for 3-ph motors, A- for 2-ph steppers, Motor brush motors
5,6	C / B+	Phase C for 3-ph motors, B+ for 2-ph steppers
7,8	CR / B-	Chopping resistor output/ Phase B- for step motors



Pin	Name	Description
1..28	Reserved	Reserved
29	CAN-Hi	CAN-Bus positive line (dominant high)
30	Reserved	Reserved
31	CAN-Lo	CAN-Bus negative line (dominant low)
32	Reserved	Reserved
33	+5V	+5V output power supply
34	GND	Ground
35..39	Reserved	Reserved
40	GND	Ground

Pin	Name	Description
1,2	$+V_{MOT}$	Positive terminal of the motor

Pin	Name	Description
1,2	GND	Negative return (ground) of the motor supply

Pin	Name	Description
1	Earth	Earth

Pin	Name	Description
1	STO1+	Safe Torque Off input 1, positive input (opto-isolated, 18÷40V)
2	STO2+	Safe Torque Off input 2, positive input(opto-isolated, 18÷40V)
3	STO1-	Safe Torque Off input 1, negative return (opto-isolated, 0V)
4	STO2-	Safe Torque Off input 2, negative return (opto-isolated, 0V)

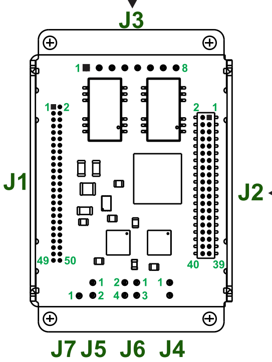
3.4.4 Pinouts for iMOTIONCUBE CAT-STO

J1

Pin	Name	Description
1	232RX	RS232 data reception
2	Enc1 A+/Sin1+	Incr. encoder # A+ diff. input, analogue encoder #1 Sin+ diff. input.
3	232TX	RS232 data transmission
4	Enc1 A-/Sin1-	Incr. encoder #1 A- diff. input, analogue encoder #1 Sin1- diff. input
5	AxisID 0	Axis ID / Address input #0. Analogue input, 0-5V
6	Enc1 B+/Cos1+	Incr. encoder # B+ diff. input, analogue encoder #1 Cos+ diff. input.
7	AxisID 1	Axis ID / Address input #1. Analogue input, 0-5V
8	ENC1B-/ Cos1-	Incr. encoder #1 B- diff. input, analogue encoder Cos1- diff. input
9	AxisID 2	Axis ID / Address input #2. Analogue input, 0-5V
10	Enc1 Z+	Incr. encoder #1 Z+ diff. input.
11	Reserved	Reserved
12	Enc1 Z-	Incr. encoder Z- diff. input
13	Reserved	Reserved
14	Hall1	Hall 1 sensor 5V digital input
15	Reserved	Reserved
16	Hall2	Hall 2 sensor 5V digital input
17	Reserved	Reserved
18	Hall3	Hall 3 sensor 5V digital input
19	Ref	Analogue input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or as general purpose analogue input
20	Fdbk	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback, or as general purpose analogue input
21	+Vlog	Positive terminal for logic supply 9-36V_{DC}
22	+$5V_{OUT}$	5V output supply. Max 300mA for feedback sensors and I/Os
23	IN0	24V digital input #0, programmable NPN or PNP, general-purpose
24	OUT0	24 digital output #0, NPN, general-purpose
25	IN1	24V digital input #1, programmable NPN or PNP, general-purpose
26	OUT1	24V digital output #1, NPN, general-purpose
27	IN2/LSP	24V digital input #2, programmable NPN or PNP, positive limit switch
28	Out2/ Error	24V digital output #2, NPN, drive error
29	In3/LSN	24V digital input #3, programmable NPN or PNP type, negative limit switch
30	Out3/ Ready	24V digital output 3, NPN type, drive ready
31	TMOT	Motor temperature sensor input. Analogue input, 0-3.3V
32..34	Reserved	Reserved
35	GND	Ground
36	GND	Ground
37	SIMO	Slave In Master Out (for SPI communication)
38	SPI_CLK	Serial Clock (for SPI communication)
39	SOMI	Slave Out Master In (for SPI communication)
40	Reserved	Reserved
41	Enc2 A	Incr. encoder #2 A digital input, 0-3.3V
42	SIN2	Analogue encoder #2 SIN input, 0-3.3V
43	Enc2 B	Incr. encoder #2 B digital input, 0-3.3V
44	COS2	Analogue encoder #2 COS input, 0-3.3V
45	Enc2 Z	Incr. encoder #2 Z digital input, 0-3.3V
46	+5Vout	5V output supply. Max 300mA for feedback sensors and I/Os
47	SPICS	SPI Chip Select
48..50	Reserved	Reserved

J3

Pin	Name	Description
1,2	A/A+	Phase A for 3-ph motors, A+ for 2-ph steppers, Motor+ brush motors
3,4	B / A-	Phase B for 3-ph motors, A- for 2-ph steppers, Motor brush motors
5,6	C / B+	Phase C for 3-ph motors, B+ for 2-ph steppers
7,8	CR / B-	Chopping resistor output/ Phase B- for step motors



J2

Pin	Name	Description
1	Rx0+	Receive/Transmit positive, ECAT IN port. Connect directly to RJ45 pin3.
2	Tx0+	Transmit/Receive positive, ECAT IN port. Connect directly to RJ45 pin1.
3	Rx0-	Receive/Transmit negative, ECAT IN port. Connect directly to RJ45 pin6.
4	Tx0-	Transmit/Receive negative, ECAT IN port. Connect directly to RJ45 pin2.
5	450	GND connection for ECAT IN port. Connect directly to RJ45 pins 4 and 5.
6	Shield0	Shield connection for ECAT IN port. Connect directly to RJ45 shield.
7	780	GND connection for ECAT IN port. Connect directly to RJ45 pins 7 and 8.
8..11	Rsvd	Reserved
12	781	GND connection for ECAT OUT port. Connect directly to RJ45 pins 7 and 8.
13	Shield1	Shield connection for ECAT OUT port. Connect directly to RJ45 shield.
14	451	GND connection for ECAT OUT port. Connect directly to RJ45 pins 4 and 5.
15	Tx1-	Transmit/Receive negative, ECAT OUT port. Connect directly to RJ45 pin2.
16	Rx1+	Receive/Transmit positive, ECAT OUT port. Connect directly to RJ45 pin3.
17	Tx1+	Transmit/Receive positive, ECAT OUT port. Connect directly to RJ45 pin1.
18	Rx1-	Receive/Transmit negative, ECAT OUT port. Connect directly to RJ45 pin6.
19..22	Rsvd	Reserved
23	ACT0	Anode of Link/Activity LED for port IN.
24	ERR	Anode of Error LED (EtherCAT status machine).
25	ACT1	Anode of Link/Activity LED for port OUT.
26	RUN	Anode of Run LED (EtherCAT status machine).
27	+3.3V	+3.3V output power supply
28	Sync0	Sync0 ECAT signal
29..31	Rsvd	Reserved
32	SPI_IRQ	EtherCAT communication interrupt signal
33	+5V	+5V output power supply
34	GND	Ground
35..39	Rsvd	Reserved
40	GND	Ground

J4

Pin	Name	Description
1,2	+V_{MOT}	Positive terminal of the motor

J5

Pin	Name	Description
1,2	GND	Negative return (ground) of the motor supply

J7

Pin	Name	Description
1	Earth	Earth

J6

Pin	Name	Description
1	STO1+	Safe Torque Off input 1, positive input (opto-isolated, 18÷40V)
2	STO2+	Safe Torque Off input 2, positive input(opto-isolated, 18÷40V)
3	STO1-	Safe Torque Off input 1, negative return (opto-isolated, 0V)
4	STO2-	Safe Torque Off input 2, negative return (opto-isolated, 0V)

3.5 Connection diagrams

3.5.1 iMOTIONCUBE CAN connection diagram

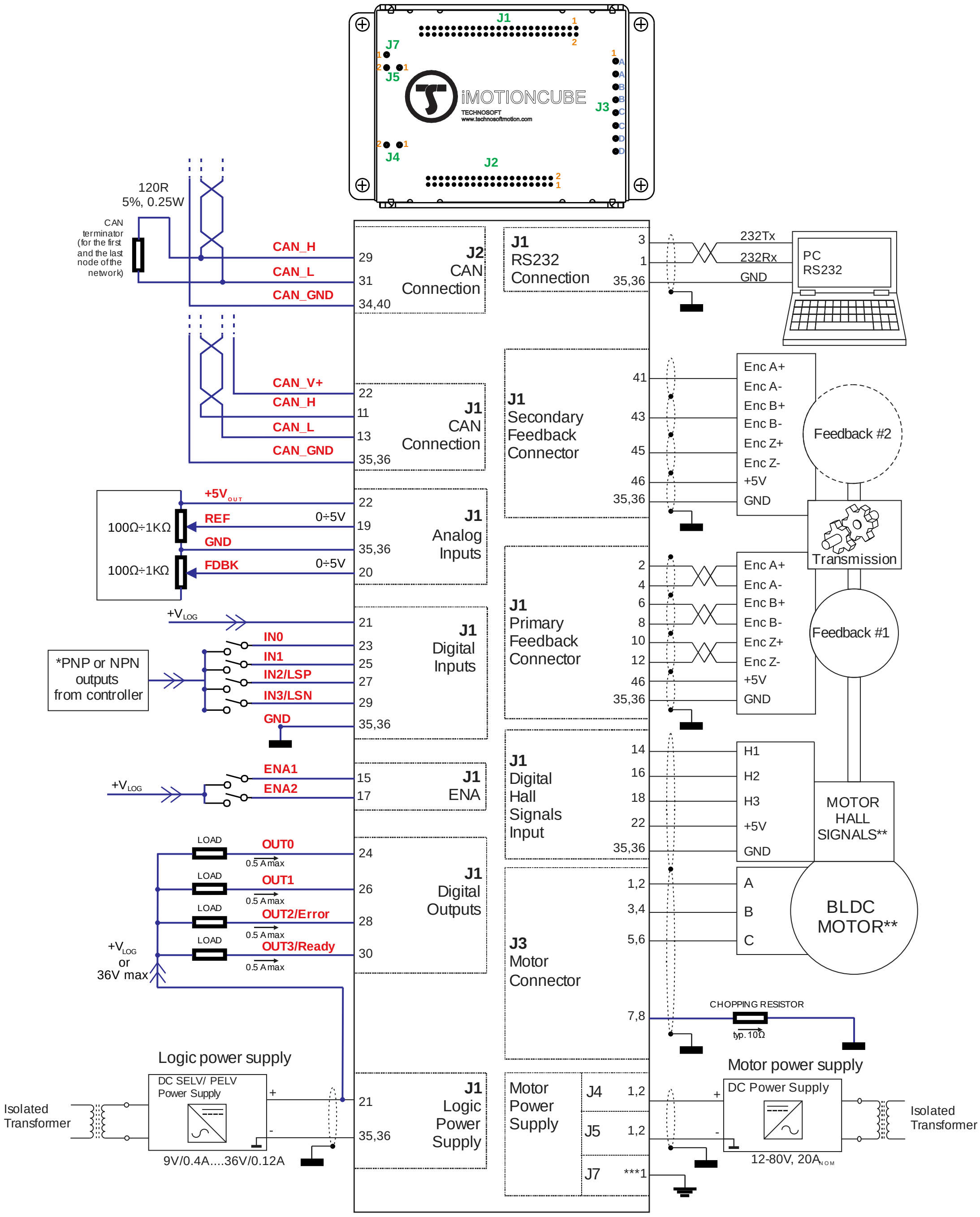


Figure 3.5. **iMOTIONCUBE CAN Connection diagram**

** For other available feedback / motor options, check the detailed connection diagrams below

*** Connector J7 is not available on previous versions of iMOTIONCUBE v2.0

3.5.2 iMOTIONCUBE CAN-STO connection diagram

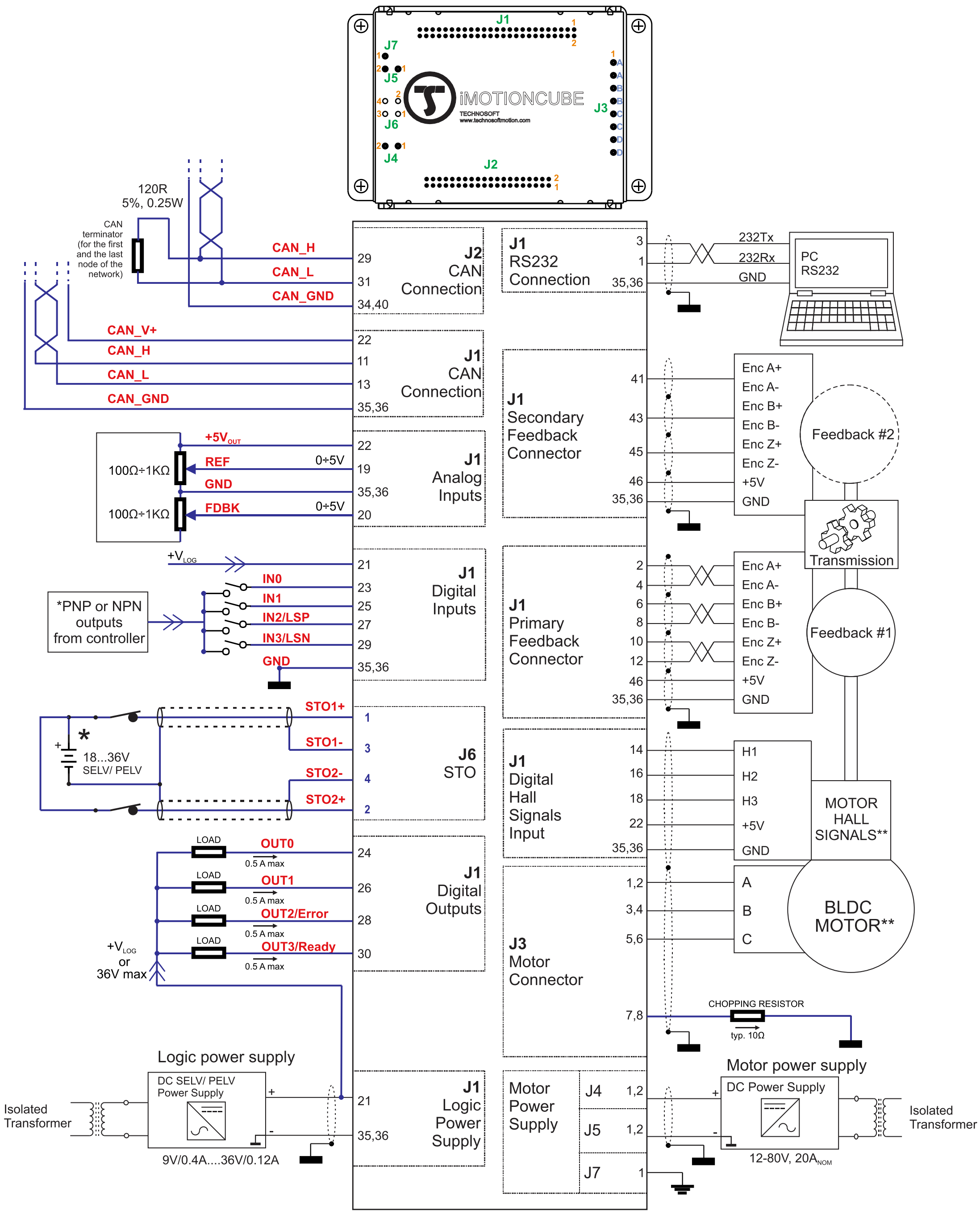


Figure 3.6. **iMOTIONCUBE CAN-STO Connection diagram**

** For other available feedback / motor options, check the detailed connection diagrams below

3.5.3 iMOTIONCUBE CAT-STO connection diagram

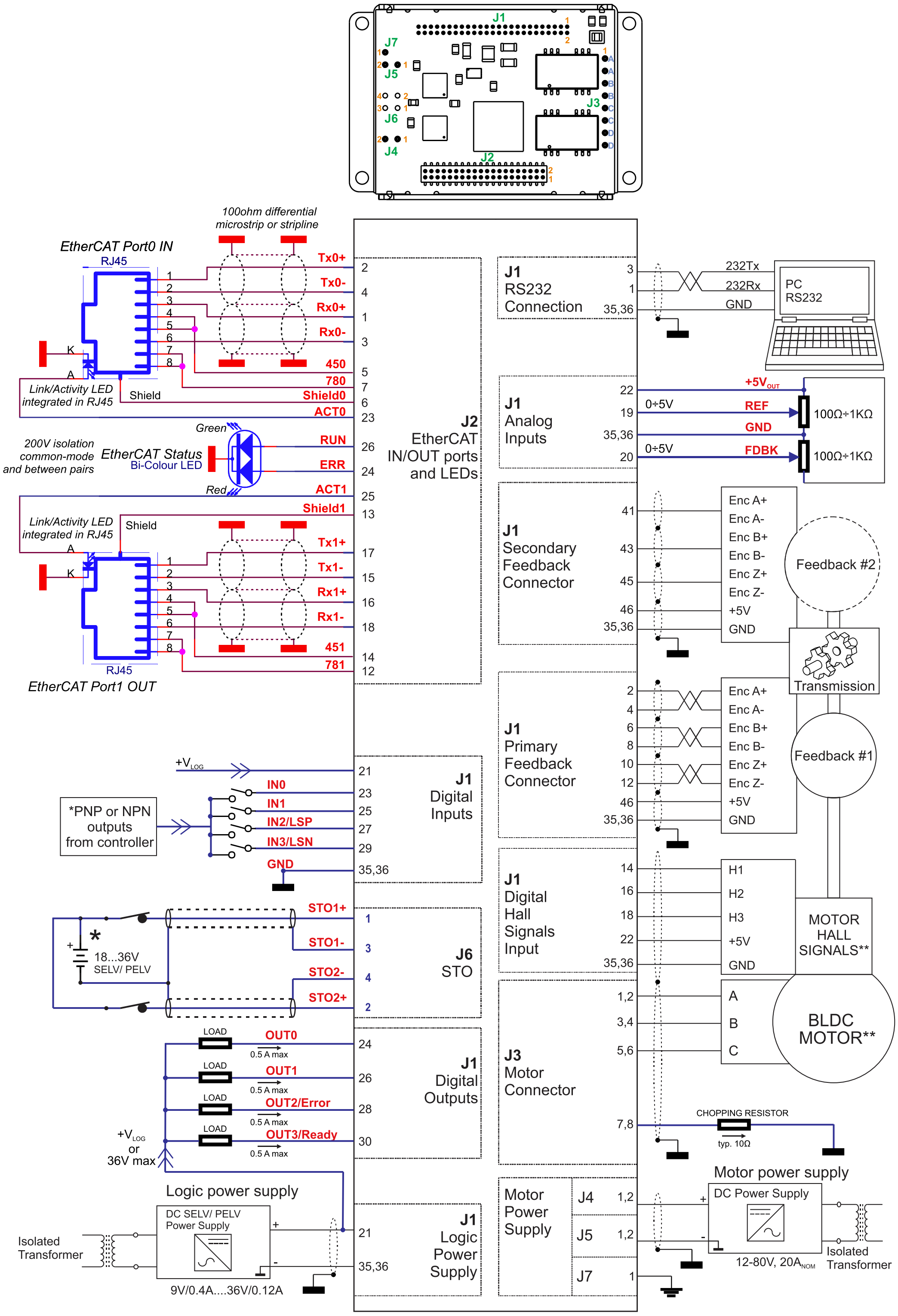


Figure 3.7. **iMOTIONCUBE CAT-STO Connection diagram**

** For other available feedback / motor options, check the detailed connection diagrams below

3.5.4 24V Digital I/O Connection

3.5.4.1 PNP inputs

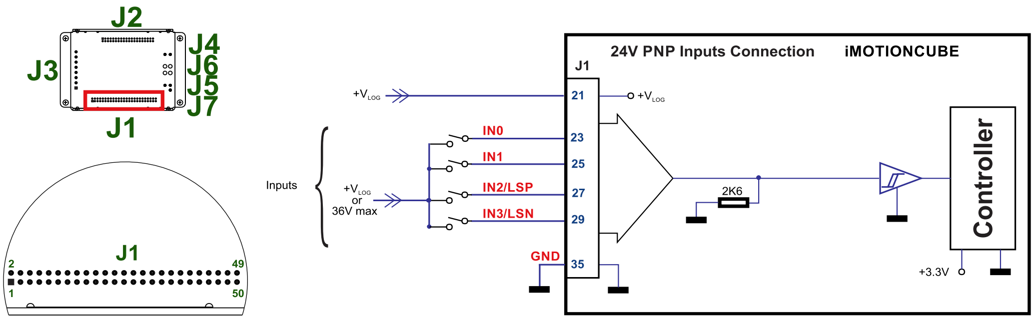


Figure 3.8. **24V Digital PNP Inputs connection**

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 (5-36V) to change its default state)*
3. *The length of the cables must be up to 30m, reducing the exposure to voltage surge in industrial environment.*

3.5.4.2 NPN inputs

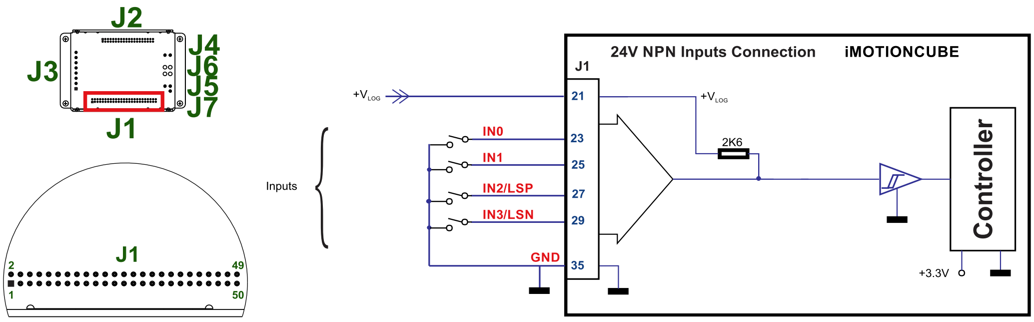


Figure 3.9. **24V Digital NPN Inputs connection**

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. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

3.5.4.3 NPN outputs

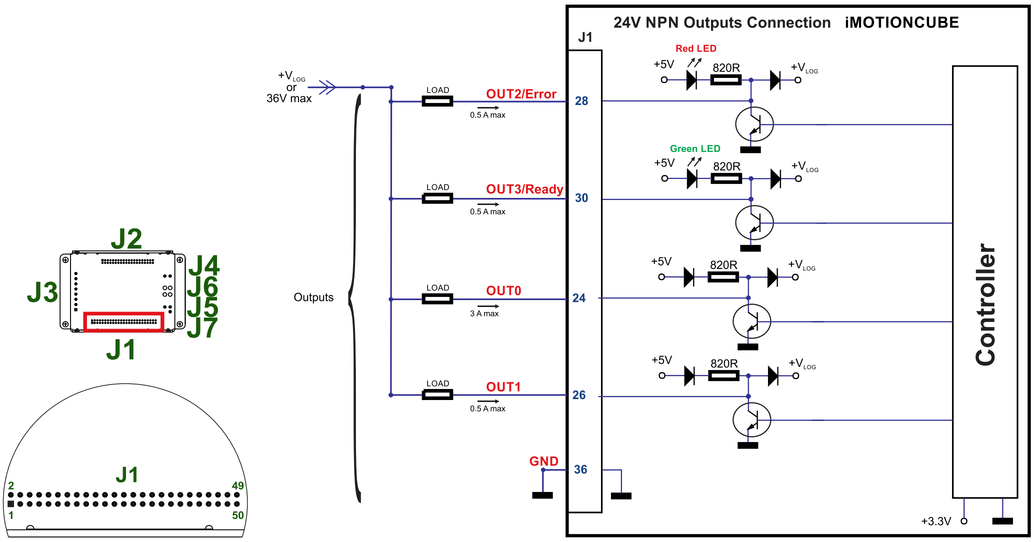


Figure 3.10. **24V Digital NPN Outputs connection**

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)*

3.5.4.4 PNP outputs (NPN to PNP outputs conversion)

The outputs can be converted to PNP by using an additional circuit.

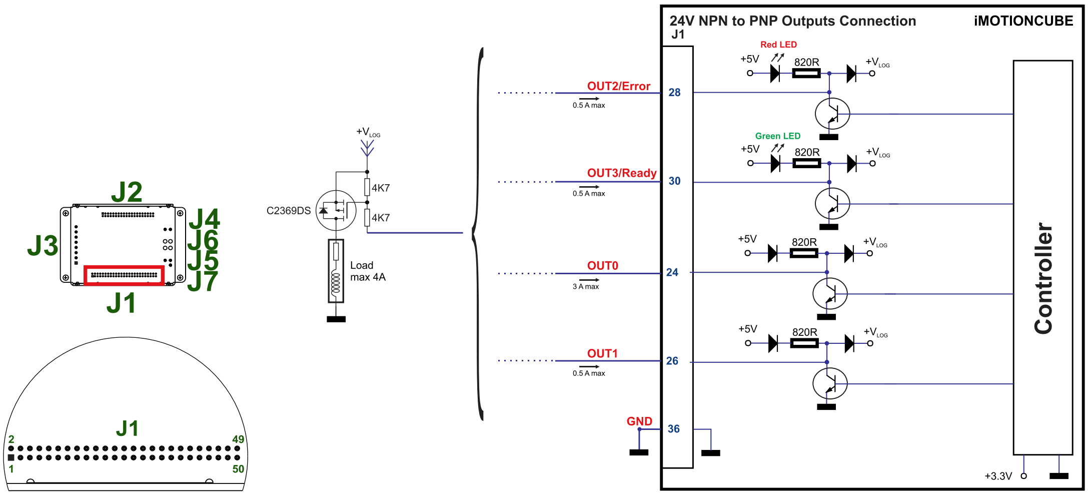


Figure 3.11. **24V Digital NPN to PNP Outputs connection**

3.5.5 5V Digital I/O Connection

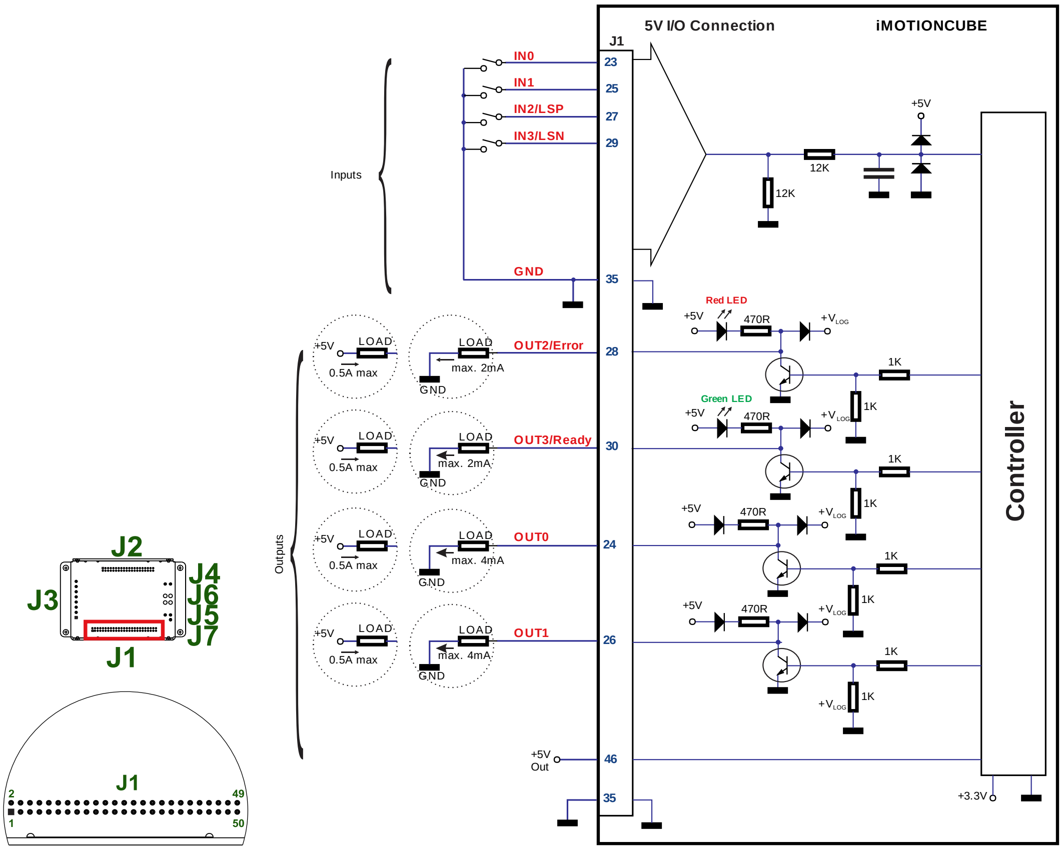


Figure 3.12. **5V Digital I/O connection**

Remarks:

1. *The inputs are selectable as PNP/ NPN by software. For the 5V connection they are selected as PNP. NPN is not compatible on a 5V connection.*
2. *The inputs are compatible with TTL(5V), LVTTL(3.3V), CMOS (3.3V-24V) outputs*
3. *The outputs are compatible with TTL (5V) and CMOS (5V) inputs*
4. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

The output loads can be individually and independently connected to +5V or to GND.

3.5.6 Analog Inputs Connection

3.5.6.1 0-5V Input Range

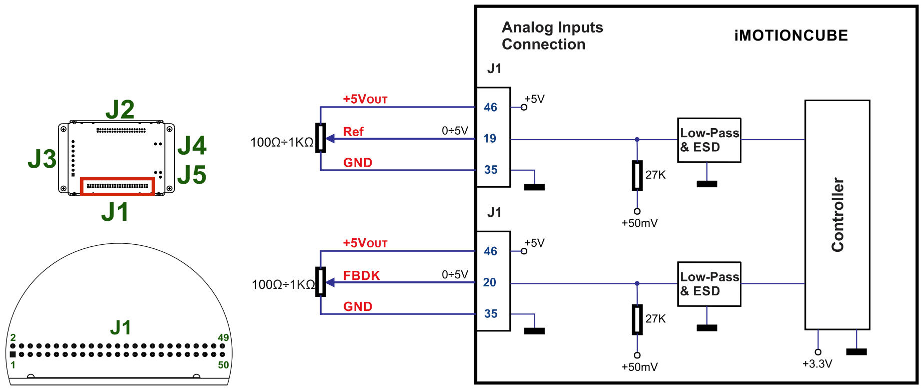


Figure 3.13. ***0-5V* Analog inputs connection**

Remarks:

1. *Default input range for analog inputs is 0÷5 V for REF and FBDK. For a +/-10 V range, see Figure 3.14.*
2. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

3.5.6.2 +/- 10V to 0-5V Input Range Adapter

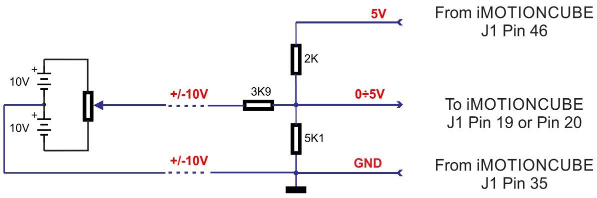


Figure 3.14. **+/-10V to 0-5V adapter**

Remark: *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

3.5.6.3 Recommendation for wiring

a) If the analogue signal source is single-ended, use a 2-wire twisted shielded cable as follows: 1st wire connects the live signal to the drive input; 2nd wire connects the source ground to the drive ground; shield will be connected to the drive ground terminal.

b) If the analogue signal source is differential and the signal source ground is isolated from the drive GND, use a 2-wire twisted shielded cable as follows: 1st wire connects the source plus (positive, in-phase) to the drive analogue input; 2nd wire connects the source minus (negative, out-of-phase) to the drive ground (GND). Shield is connected only at the drive side, to the drive GND, and is left unconnected at the source side.

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 source plus (positive, in-phase) to the drive analogue input; 2nd wire connects the source ground to the drive ground (GND); shield is connected only at the drive side, to the drive GND, and is left unconnected at the source side. The source minus (negative, out-of-phase) output remains unconnected.

3.5.7 Motor connections

3.5.7.1 Brushless Motor connection

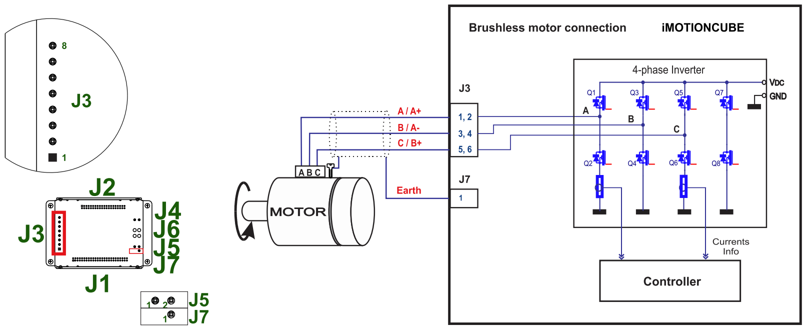


Figure 3.15. **Brushless motor connection**

Remark: In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

3.5.7.2 2-phase Step Motor connection

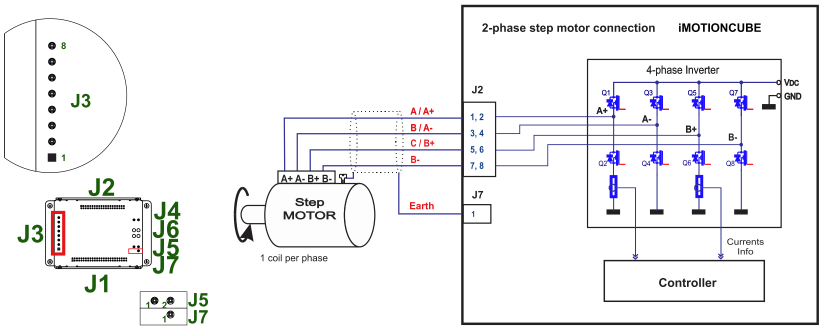


Figure 3.16. **2-phase step motor connection, one coil per phase**

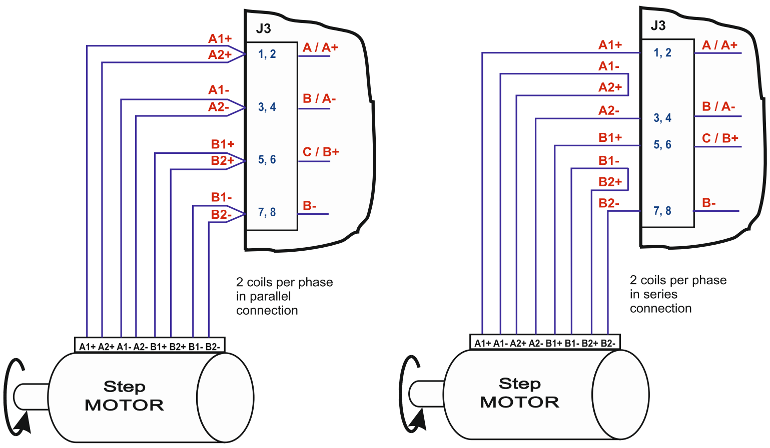


Figure 3.17. **2-phase step motor connection, two coils per phase**

Remark: In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

3.5.7.3 3-Phase Step Motor connection

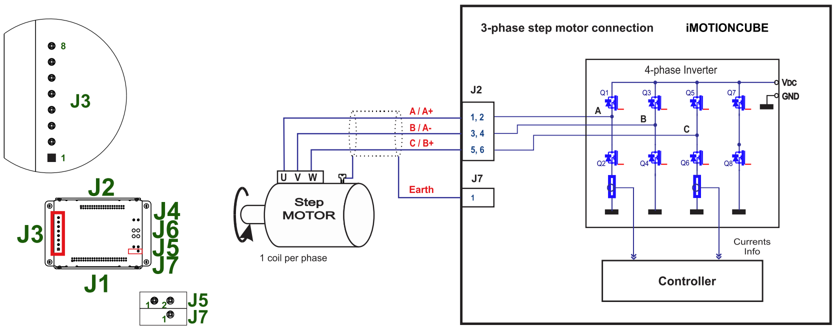


Figure 3.18. **3-phase step motor connection**

Remark: In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

3.5.7.4 DC Motor connection

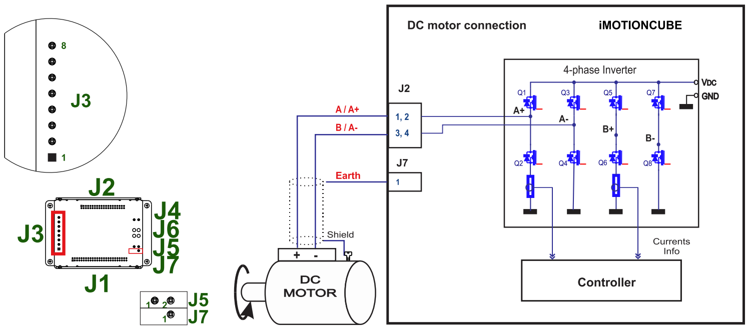


Figure 3.19. **DC Motor connection**

Remark: In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

3.5.7.5 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 iMOTIONCUBE 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 iMOTIONCUBE 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.

A good shielding can be obtained if the motor wires are running inside a metallic cable guide.

3.5.8 Feedback connections

3.5.8.1 Single ended Incremental Encoder #1 Connection

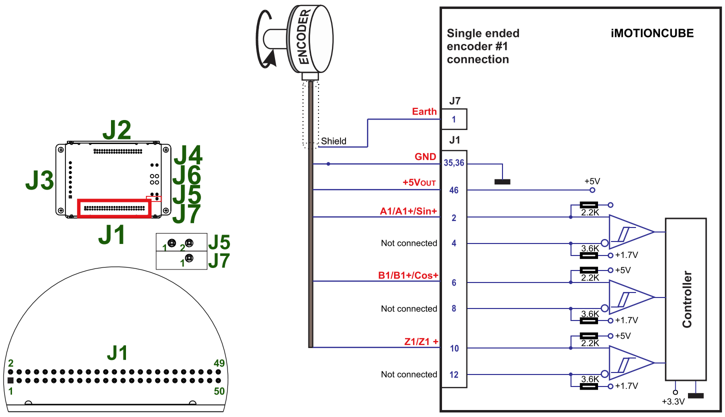


Figure 3.20. **Single ended incremental encoder #1 connection**

Remark: In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

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

3.5.8.2 Differential Incremental Encoder #1 Connection

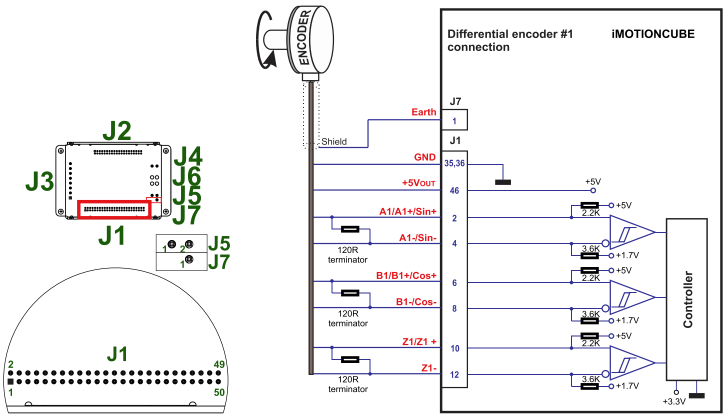


Figure 3.21. **Differential incremental encoder #1 connection**

Remarks:

1. *For encoder#1 differential connection, external 120Ω (0.25W) terminators are required for long encoder cables, or noisy environments.*
2. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment*
3. In case J7 (Earth) is not present, connect the Shield (if present) to GND instead.

3.5.8.3 Single ended Incremental Encoder #2 TTL Connection

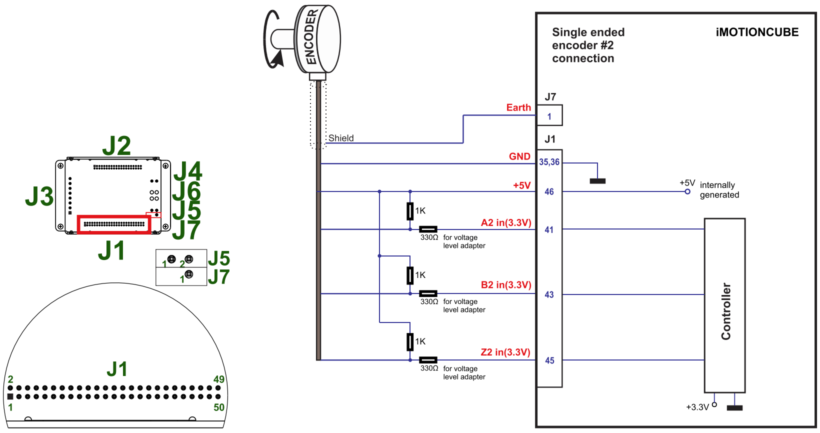


Figure 3.22. **Single-ended incremental encoder #2 connection**

Warning: *The encoder #2 inputs are connected directly to the DSP inputs and support only 3.3V. Do not connect directly to +5V signals.*

3.5.8.4 Differential Incremental Encoder #2 TTL Connection

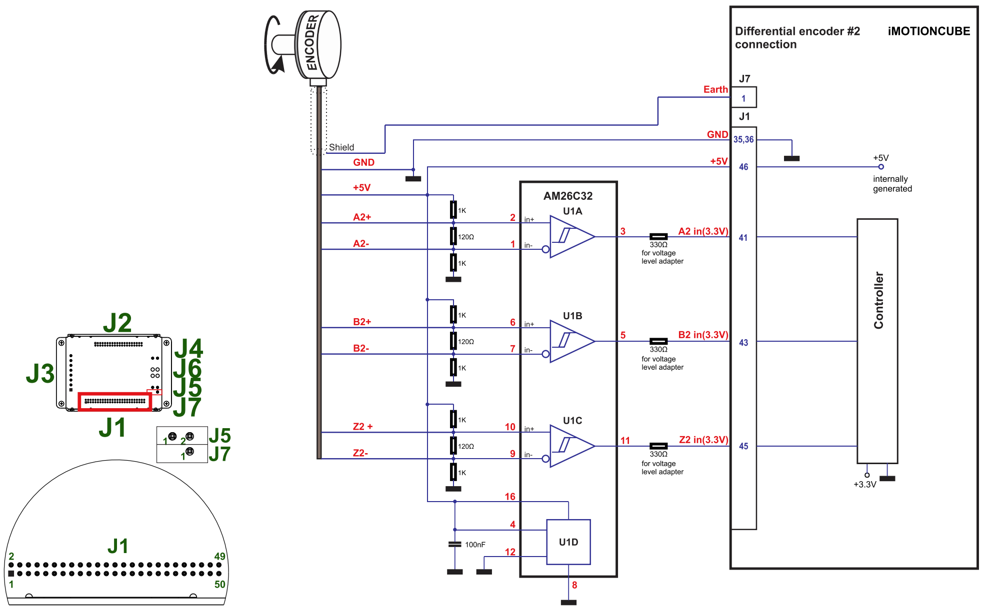


Figure 3.23. **Differential incremental encoder #2 connection**

Warning: *The encoder #2 inputs are connected directly to the DSP inputs and support only 3.3V. Do not connect directly to +5V signals.*

Remarks:

-The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.

3.5.8.5 Differential BiSS/SSI Feedback#2 Connection

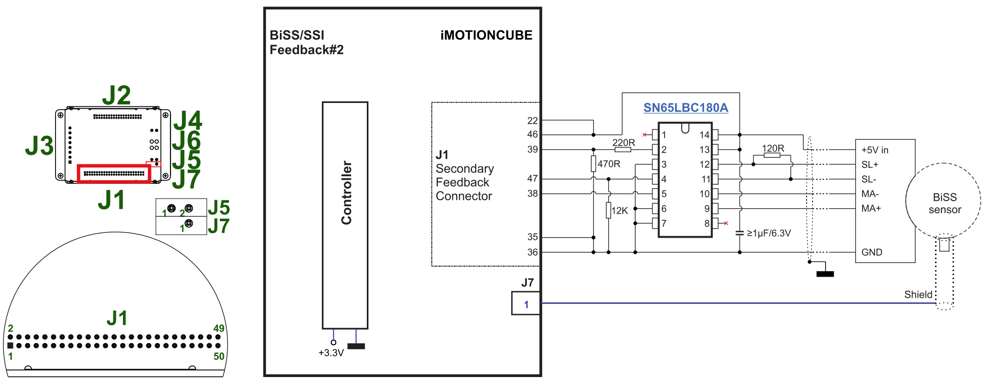


Figure 3.24. **Differential BiSS/SSI Feedback#2 Connection**

3.5.8.6 Sine-Cosine Analog Encoder Connection

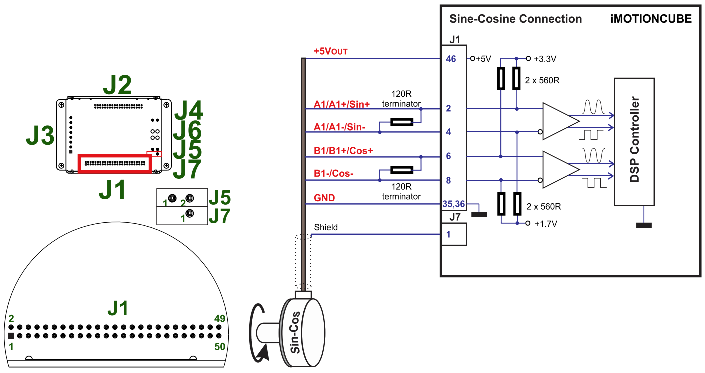


Figure 3.25. **Sine-Cosine analogue encoder connection**

Remark:

1. *For Sine-Cosine connection, external 120Ω (0.25W) terminators are required.*

3.5.8.7 Digital Hall Connection for Motor + Hall + Incremental Encoder

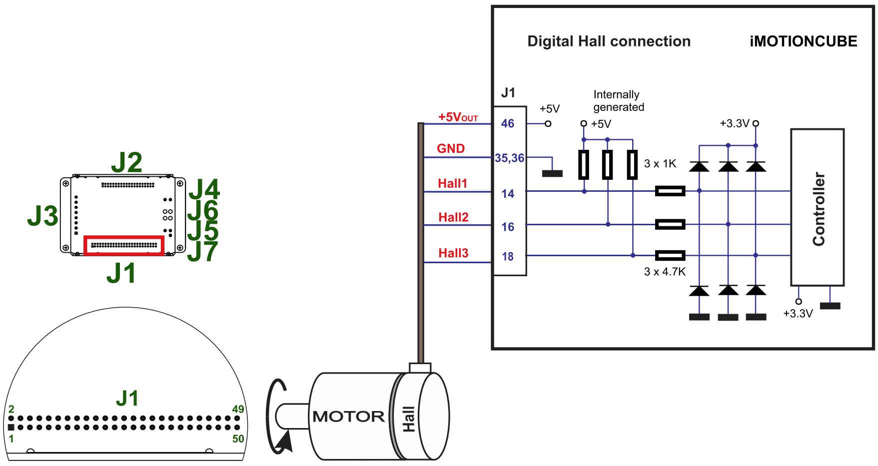


Figure 3.26. **Digital Hall connection**

Remarks:

1. *This connection is required when using Hall start method BLDC or PMSM and also for the Trapezoidal commutation method. The digital halls are not used in this case as a feedback measurement device. The actual motor control is done with an incremental encoder.*
2. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

3.5.8.8 Digital Hall Connection for direct motor control without an encoder

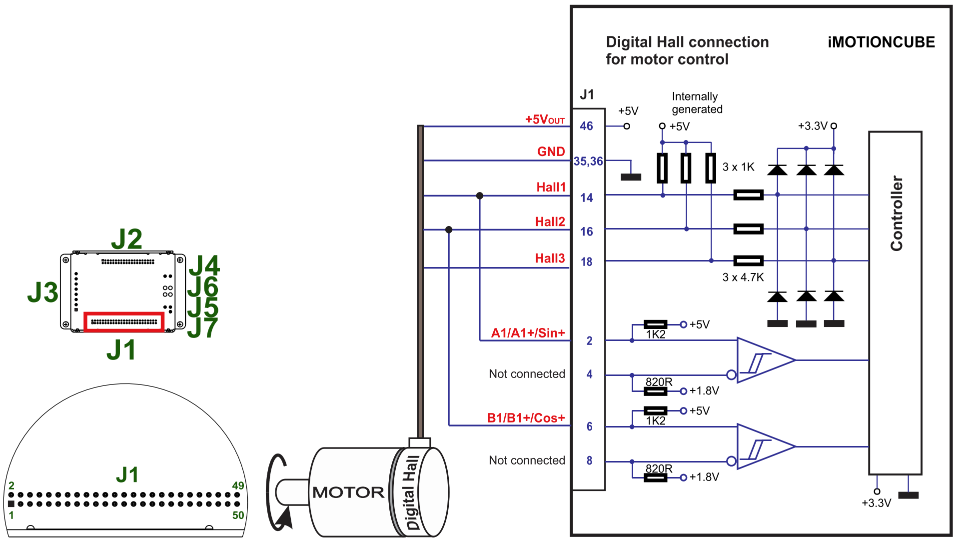


Figure 3.27. **Digital Hall connection**

Remarks:

1. *This connection is required when using only Digital hall signals as the main feedback device for motor control. In this case, no incremental encoder is needed.*
2. *The length of the cables must be up to 30m, reducing the exposure to voltage surges in industrial environment.*

3.5.8.9 Linear Hall Connection

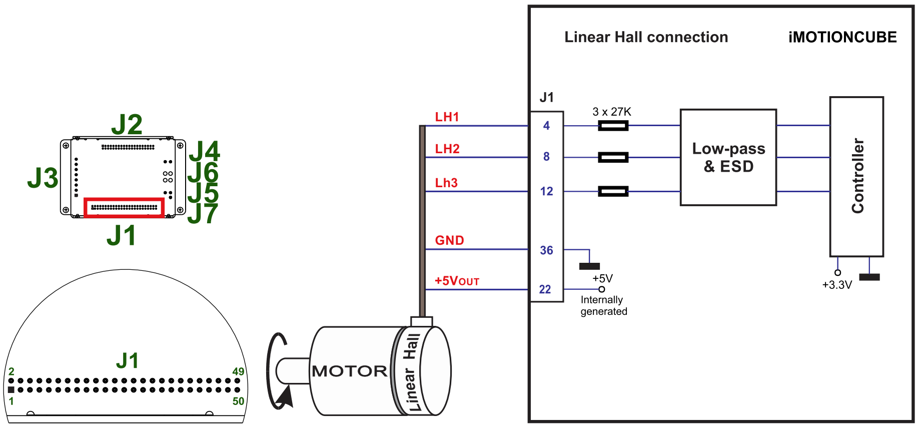


Figure 3.28. **Linear Hall connection**

3.5.8.10 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-, B+/Cos+ with B-/Cos-, Z+ with Z-. 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 iMOTIONCUBE (using the GND pin) or the encoder / motor. Do not connect the shield at both ends.

c) If the iMOTIONCUBE 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.

3.5.9 Power Supply Connection

3.5.9.1 Supply Connection (non STO version)

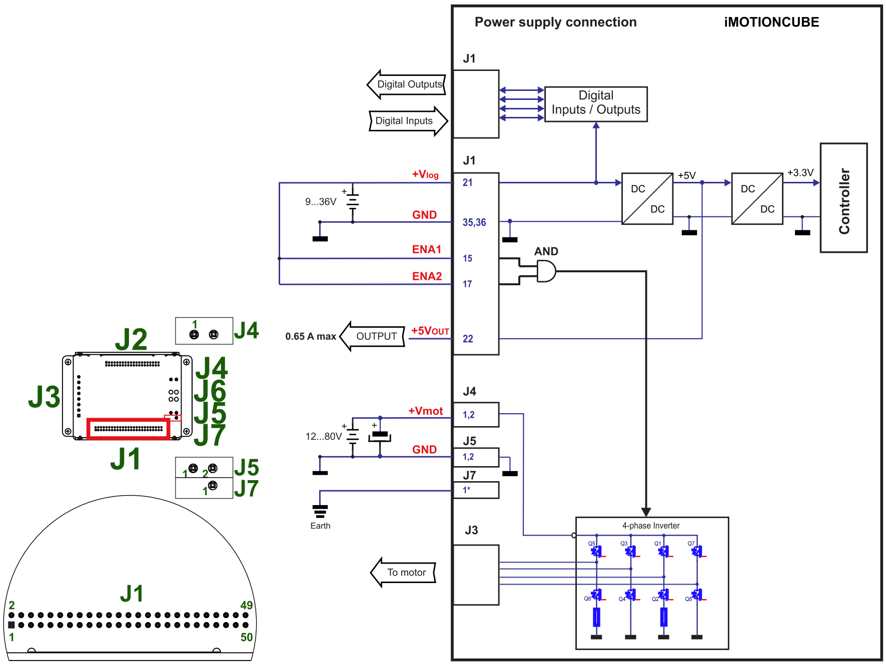


Figure 3.29. **Supply connection for the non-STO version**

Remark: Connector J7 is not available on previous versions of iMOTIONCUBE v2.0

3.5.9.2 Supply Connection (STO version)

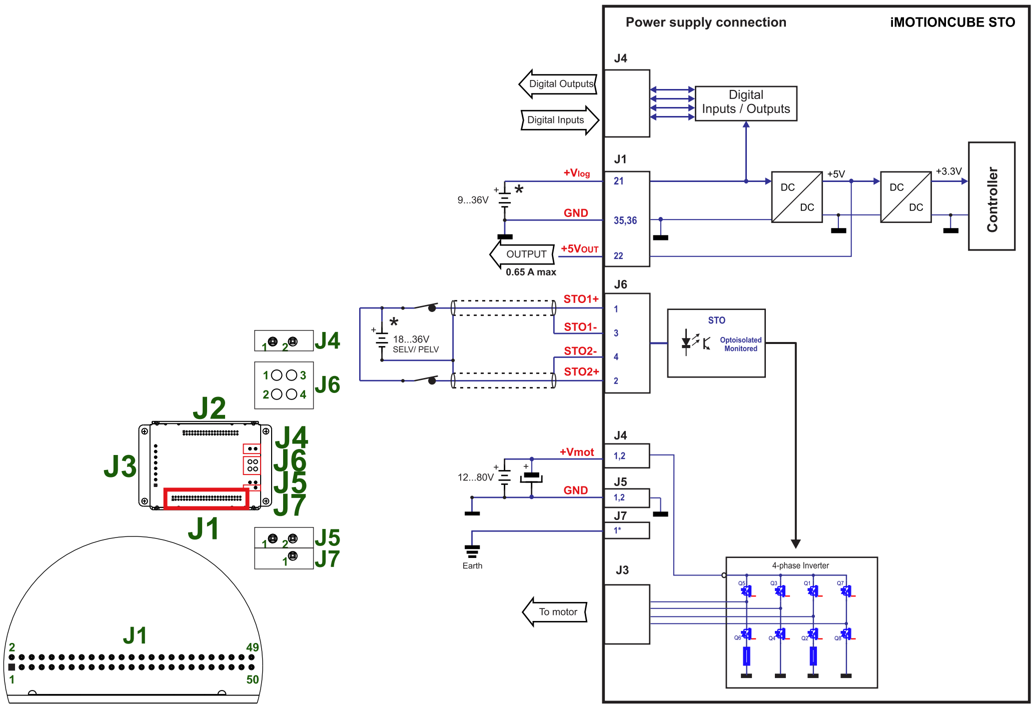


Figure 3.30. **Supply connection for STO versions**

3.5.9.3 Recommendations for Supply Wiring

The iMOTIONCUBE always requires two supply voltages: V_{log} and V_{mot}.

Use short, thick wires between the iMOTIONCUBE 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 iMOTIONCUBE.

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

3.5.9.4 Recommendations to limit over-voltage during energy regeneration

During abrupt motion decelerations 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 81V, 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} = 28V 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]

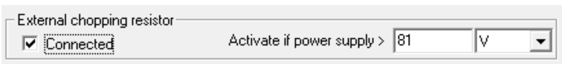
T_F – total friction torque as seen at motor shaft [Nm] – includes load and transmission

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 chopping resistor R_{CR} between phase CR/B- and ground, and activate the software option of dynamic braking (see below).

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

The chopping resistor option can be found in the Drive Setup dialogue within EasyMotion / EasySetup :



The chopping will occur when DC bus voltage increases over U_{CHOP}. This parameter (U_{CHOP}) should be adjusted depending on the nominal motor supply. Optimally (from a braking point of view), U_{CHOP} should be a few volts above the maximum nominal supply voltage. This setting will activate the chopping resistor earlier, before reaching dangerous voltages – when the over-voltage protection will stop the drive. Of course, U_{CHOP} 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 chopping resistor size.*

Chopping resistor selection

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

1. to limit the maximum current below the drive peak current I_{PEAK} = 0.9A

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

2. to sustain the required *braking power*:

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

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

$$R_{CR} < \frac{U_{CHOP}^2}{2 \times P_{CR}}$$

3. to limit the average current below the drive nominal current I_{NOM}=0.9A

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

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

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

Remarks:

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

	WARNING!	***THE CHOPPING RESISTOR MAY HAVE HOT SURFACES DURING OPERATION.***

3.5.10 Serial RS-232 connection

3.5.10.1 Serial RS-232 connection

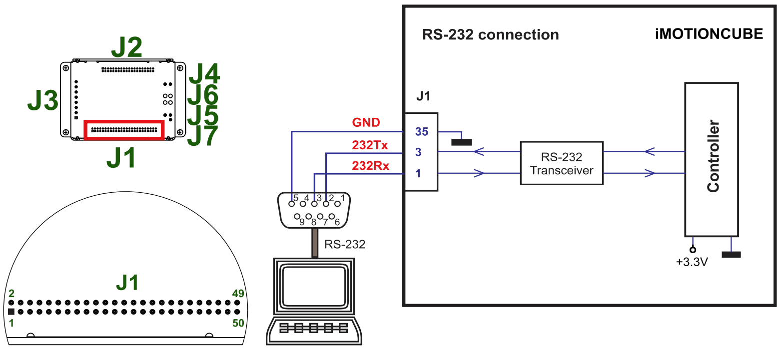


Figure 3.31. **Serial RS-232 connection**

3.5.10.2 Recommendation for wiring

a) If you build the serial cable, you can use a 3-wire shielded cable with shield connected to BOTH ends. Do not use the shield as GND. The ground wire must be included inside the shield, like the 232Rx and 232Tx signals
b) Always power-off all the iMOTIONCUBE supplies before inserting/removing the RS-232 serial connector
c) Do not rely on an earthed PC to provide the iMOTIONCUBE GND connection! The drive must be earthed through a separate circuit. Most communication problems are caused by the lack of such connection

3.5.11 CAN-bus connection (for CAN drives only)

3.5.11.1 CAN connection

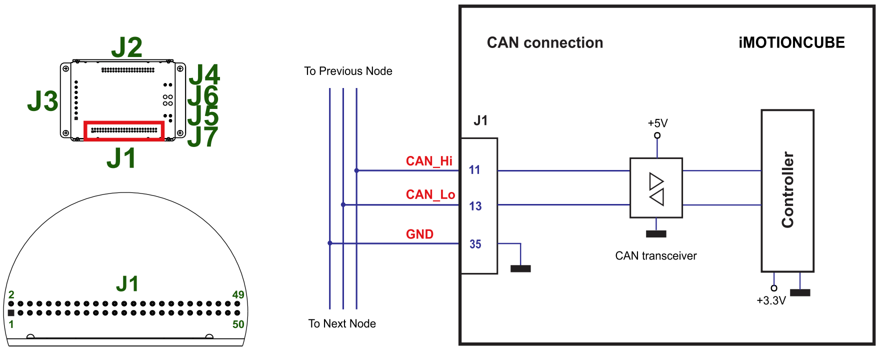


Figure 3.32. **CAN connection**

Remarks:

1. *The CAN network requires a 120-Ohm terminator. This is not included on the board. Figure 3.33 shows how to connect it on your network*
2. *CAN signals are not insulated from other iMOTIONCUBE circuits.*

3.5.11.2 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) When using a printed circuit board (PCB) motherboard based on FR-4 material, build the CAN network using a pair of 12mil (0.012”) tracks, spaced 8 to 10mils (0.008”…0.010”) apart, placed over a local ground plane (microstrip) which extends at least 1mm left and right to the tracks.
c) Whenever possible, use daisy-chain links between the CAN nodes. Avoid using stubs. A stub is a "T" connection, where a derivation is taken from the main bus. When stubs can’t be avoided keep them as short as possible. For 1 Mbit/s (worst case), the maximum stub length must be below 0.3 meters.
d) The 120Ω termination resistors must be rated at 0.2W minimum. Do not use winded resistors, which are inductive.

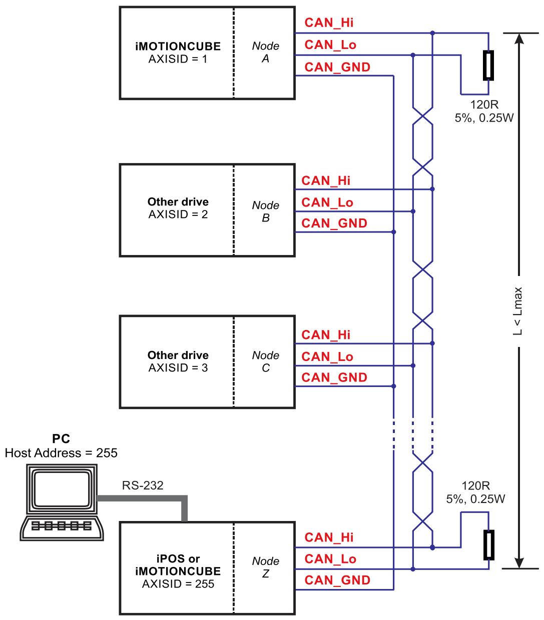


Figure 3.33. **Multiple-Axis CAN network**

3.5.12 EtherCAT bus connection (for CAT drives)

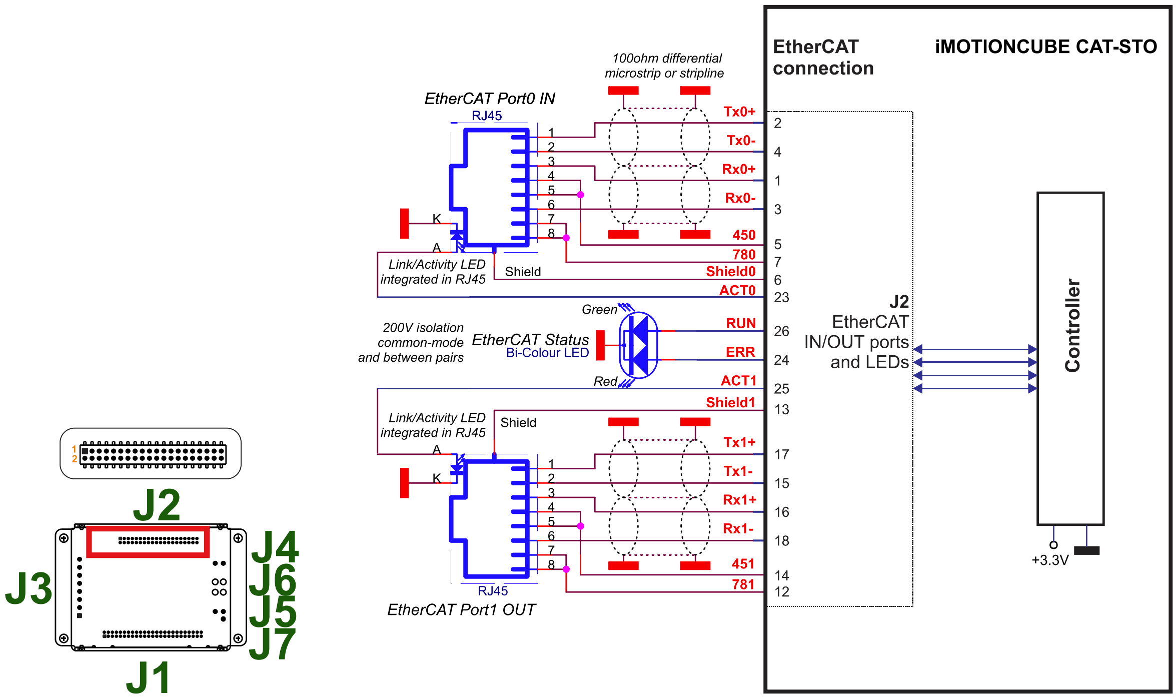


Figure 3.34. **EtherCAT bus connection to RJ45 connectors**

3.5.13 Removal from Autorun Mode

When the iMOTIONCUBE is set in TMLCAN operation mode, it enters by default after power on in *Autorun* mode, if the drive has in its local EEPROM a valid TML application (motion program), this is automatically executed as soon as the motor supply V_{MOT} is turned on.

In order to remove the drive from *Autorun*, you have 2 ways:

a) Software - by writing value 0x0001 in first EEPROM location, from address 0x4000;

b) Hardware – by temporary connecting all digital Hall inputs to GND, during the power on for about 1s (until the green led is turned on), as shown in *Figure 3.35*. 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 TML application from the EEPROM. On next power on, in absence of a valid TML application, the drive enters in the *non-Autorun/slave* mode independently of the digital Hall inputs status.

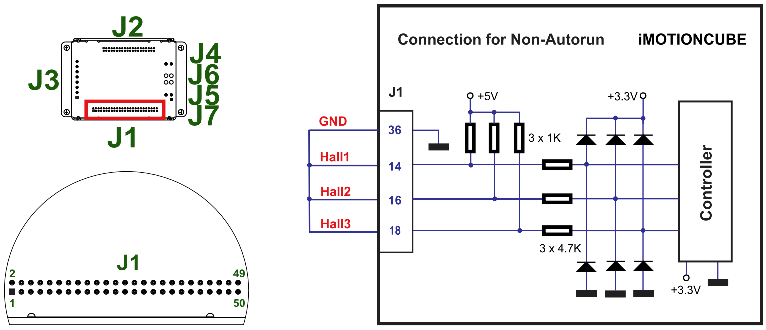


Figure 3.35. **Temporary connection during power-on to remove the drive from** Autorun **mode**

3.6 CAN Operation Mode and Axis ID Selection for CAN drives

3.6.1 Selection Levels on Axis ID Inputs

On iMOTIONCUBE the selection of the operation mode: CANopen or TMLCAN as also of the axis ID number is done by setting different voltage levels on the inputs AxisID 0 (J1 pin 5), AxisID 1(J1 pin 7) and AxisID 2 (J1 pin 9). Each input can be set to one of the following 7 levels:

Level	Connection needed
L0	Connect input directly to ground
L1	Connect input through a 4.7KΩ resistor to ground
L2	Connected input through a 22KΩ resistor to ground
L3	Nothing connected – leave input open
L4	Connect input through a 22KΩ resistor to +5Vdc
L5	Connect input through a 4.7Kohm resistor to +5Vdc
L6	Connect input directly to +5V

The operation mode selection is done via AxisID 2:

- CANopen mode, if the input levels are: L0, L1 or L2
- TMLCAN mode, if the input levels are L3, L4, L5, L6

Figure ***3.36*** shows how to set the 7 levels on the AxisID 0 input and the resulting axis ID values when AxisID 2 input level is set for **CANopen** operation. Paragraph **3.6.2.1** shows how to set all possible values for axis ID in this mode of operation.

Remarks:

1. *AxisID value is computed with formula: 49 x AxisID2 + 7 x AxisID1 + AxisID0, where each AxisID can have one of the integer values: 0 to 6 (0 for L0, 1 for L1, 2 for L2, etc.)*
2. *If the resulting AxisID value is 0 (all 3 inputs are connected to GND), the axis ID will be set to 127. If the resulting AxisID is greater than 127, the axis ID will be set to 255.*
3. *If the AxisID is set to 255, the drive remains "non-configured" 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 messages (including boot-up) is disabled.* The Ready (green) LED will flash at 1 second time intervals while in this mode.

Figure ***3.37*** shows how to set the 7 levels on the AxisID 0 input and the resulting axis ID values when AxisID 2 input level is set for **TMLCAN** operation. Paragraph **3.6.2.2** shows how to set all possible values for axis ID in this mode of operation.

Remarks:

1. *AxisID is computed with formula: 49 x (AxisID2 - 3) + 7 x AxisID1 + AxisID0, where each AxisID can have one of the integer values: 0 to 6 (0 for L0, 1 for L1, 2 for L2, etc.)*
2. *If the resulting AxisID value is 0, the axis ID will be set to 255 and the drive will be in LSS "non-configured" mode.*
3. All pins are sampled at power-up, and the drive is configured accordingly
4. *If CANopen mode is selected and the AxisID is set to 255, the drive remains "non-configured" 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 messages (including boot-up) is disabled.* The Ready (green) LED will flash at 1 second time intervals while in this mode

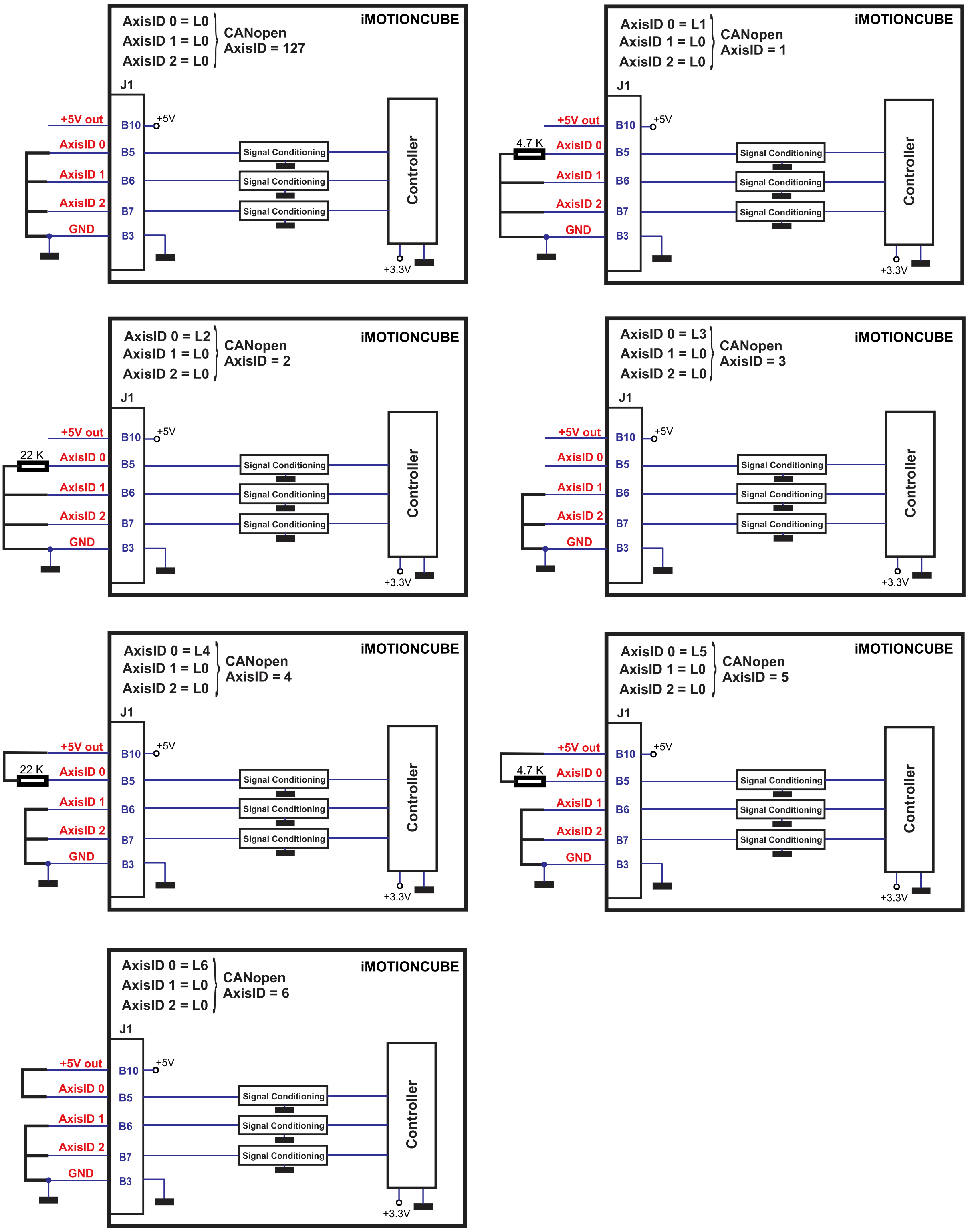


Figure 3.36. **Axis ID Setting Examples. CANopen mode or EtherCAT drive**

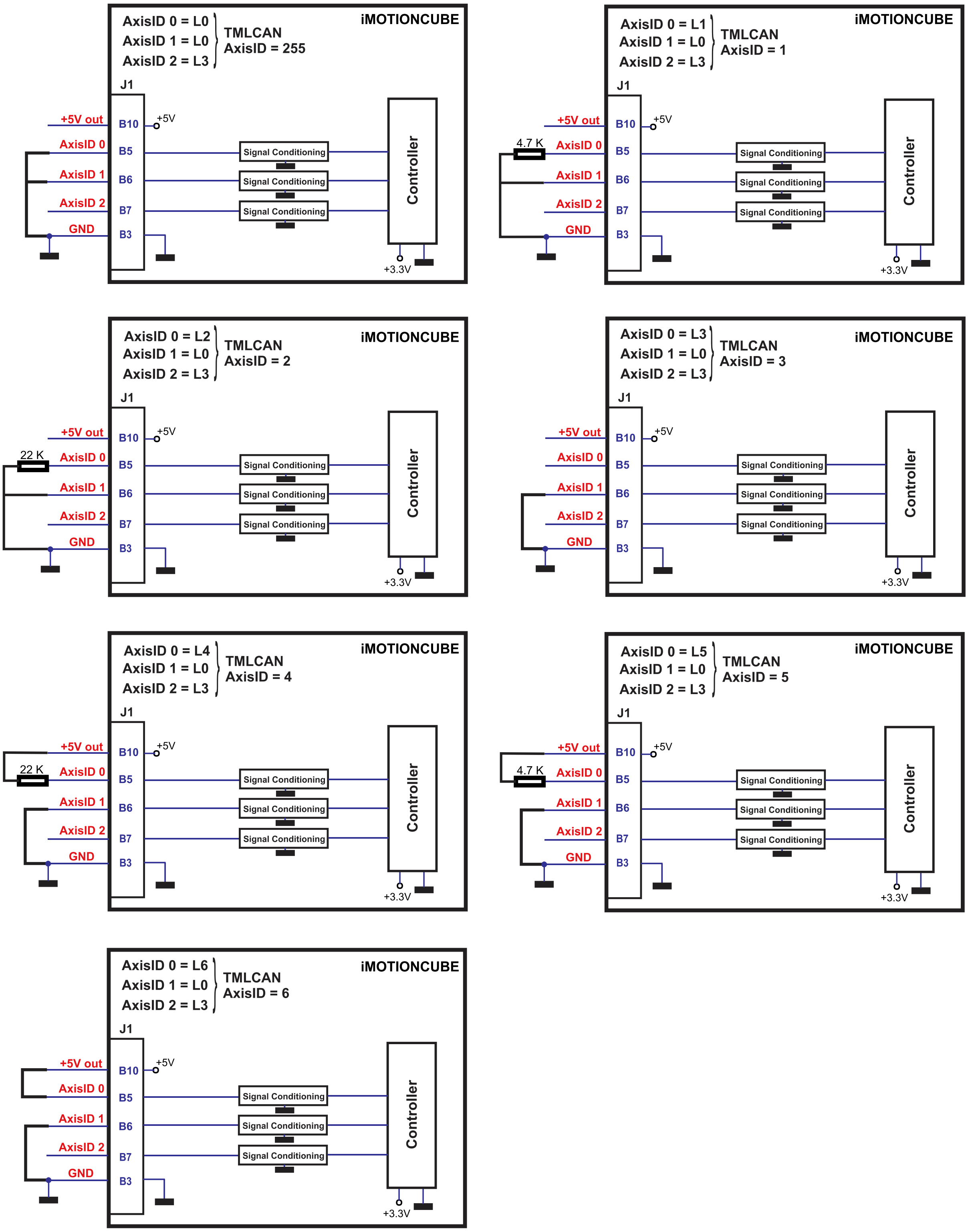


Figure 3.37. **Axis ID Setting Examples. TMLCAN mode**

3.6.2 Axis ID Settings (possible values)

3.6.2.1 Axis ID Settings for CANopen mode or for EtherCAT drives

Axis ID 2	Axis ID 1	Axis ID 0	ID CANopen
L0	L0	L0	127
L0	L0	L1	1
L0	L0	L2	2
L0	L0	L3	3
L0	L0	L4	4
L0	L0	L5	5
L0	L0	L6	6
L0	L1	L0	7
L0	L1	L1	8
L0	L1	L2	9
L0	L1	L3	10
L0	L1	L4	11
L0	L1	L5	12
L0	L1	L6	13
L0	L2	L0	14
L0	L2	L1	15
L0	L2	L2	16
L0	L2	L3	17
L0	L2	L4	18
L0	L2	L5	19
L0	L2	L6	20
L0	L3	L0	21
L0	L3	L1	22
L0	L3	L2	23
L0	L3	L3	24
L0	L3	L4	25
L0	L3	L5	26
L0	L3	L6	27
L0	L4	L0	28
L0	L4	L1	29
L0	L4	L2	30
L0	L4	L3	31
L0	L4	L4	32
L0	L4	L5	33
L0	L4	L6	34
L0	L5	L0	35
L0	L5	L1	36
L0	L5	L2	37
L0	L5	L3	38
L0	L5	L4	39
L0	L5	L5	40
L0	L5	L6	41
L0	L6	L0	42
L0	L6	L1	43
L0	L6	L2	44
L0	L6	L3	45
L0	L6	L4	46
L0	L6	L5	47
L0	L6	L6	48
L1	L0	L0	49
L1	L0	L1	50
L1	L0	L2	51
L1	L0	L3	52
L1	L0	L4	53
L1	L0	L5	54
L1	L0	L6	55
L1	L1	L0	56
L1	L1	L1	57
L1	L1	L2	58
L1	L1	L3	59
L1	L1	L4	60
L1	L1	L5	61
L1	L1	L6	62
L1	L2	L0	63
L1	L2	L1	64
L1	L2	L2	65
L1	L2	L3	66
L1	L2	L4	67
L1	L2	L5	68
L1	L2	L6	69
L1	L3	L0	70
L1	L3	L1	71
L1	L3	L2	72
L1	L3	L3	73
L1	L3	L4	74
L1	L3	L5	75
L1	L3	L6	76
L1	L4	L0	77
L1	L4	L1	78
L1	L4	L2	79
L1	L4	L3	80
L1	L4	L4	81
L1	L4	L5	82
L1	L4	L6	83
L1	L5	L0	84
L1	L5	L1	85
L1	L5	L2	86
L1	L5	L3	87
L1	L5	L4	88
L1	L5	L5	89
L1	L5	L6	90
L1	L6	L0	91
L1	L6	L1	92
L1	L6	L2	93
L1	L6	L3	94
L1	L6	L4	95
L1	L6	L5	96
L1	L6	L6	97
L2	L0	L0	98
L2	L0	L1	99
L2	L0	L2	100
L2	L0	L3	101
L2	L0	L4	102
L2	L0	L5	103
L2	L0	L6	104
L2	L1	L0	105
L2	L1	L1	106
L2	L1	L2	107
L2	L1	L3	108
L2	L1	L4	109
L2	L1	L5	110
L2	L1	L6	111
L2	L2	L0	112
L2	L2	L1	113
L2	L2	L2	114
L2	L2	L3	115
L2	L2	L4	116
L2	L2	L5	117
L2	L2	L6	118
L2	L3	L0	119
L2	L3	L1	120
L2	L3	L2	121
L2	L3	L3	122
L2	L3	L4	123
L2	L3	L5	124
L2	L3	L6	125
L2	L4	L0	126
L2	L4	L1	255
L2	L4	L2	255
L2	L4	L3	255
L2	L4	L4	255
L2	L4	L5	255
L2	L4	L6	255
L2	L5	L0	255
L2	L5	L1	255
L2	L5	L2	255
L2	L5	L3	255
L2	L5	L4	255
L2	L5	L5	255
L2	L5	L6	255
L2	L6	L0	255
L2	L6	L1	255
L2	L6	L2	255
L2	L6	L3	255
L2	L6	L4	255
L2	L6	L5	255
L2	L6	L6	255

3.6.2.2 Axis ID Settings for TMLCAN mode

Axis ID 2	Axis ID 1	Axis ID 0	ID TMLCAN
L3	L0	L0	255
L3	L0	L1	1
L3	L0	L2	2
L3	L0	L3	3
L3	L0	L4	4
L3	L0	L5	5
L3	L0	L6	6
L3	L1	L0	7
L3	L1	L1	8
L3	L1	L2	9
L3	L1	L3	10
L3	L1	L4	11
L3	L1	L5	12
L3	L1	L6	13
L3	L2	L0	14
L3	L2	L1	15
L3	L2	L2	16
L3	L2	L3	17
L3	L2	L4	18
L3	L2	L5	19
L3	L2	L6	20
L3	L3	L0	21
L3	L3	L1	22
L3	L3	L2	23
L3	L3	L3	24
L3	L3	L4	25
L3	L3	L5	26
L3	L3	L6	27
L3	L4	L0	28
L3	L4	L1	29
L3	L4	L2	30
L3	L4	L3	31
L3	L4	L4	32
L3	L4	L5	33
L3	L4	L6	34
L3	L5	L0	35
L3	L5	L1	36
L3	L5	L2	37
L3	L5	L3	38
L3	L5	L4	39
L3	L5	L5	40
L3	L5	L6	41
L3	L6	L0	42
L3	L6	L1	43
L3	L6	L2	44
L3	L6	L3	45
L3	L6	L4	46
L3	L6	L5	47
L3	L6	L6	48
L4	L0	L0	49
L4	L0	L1	50
L4	L0	L2	51
L4	L0	L3	52
L4	L0	L4	53
L4	L0	L5	54
L4	L0	L6	55
L4	L1	L0	56
L4	L1	L1	57
L4	L1	L2	58
L4	L1	L3	59
L4	L1	L4	60
L4	L1	L5	61
L4	L1	L6	62
L4	L2	L0	63
L4	L2	L1	64
L4	L2	L2	65
L4	L2	L3	66
L4	L2	L4	67
L4	L2	L5	68
L4	L2	L6	69
L4	L3	L0	70
L4	L3	L1	71
L4	L3	L2	72
L4	L3	L3	73
L4	L3	L4	74
L4	L3	L5	75
L4	L3	L6	76
L4	L4	L0	77
L4	L4	L1	78
L4	L4	L2	79
L4	L4	L3	80
L4	L4	L4	81
L4	L4	L5	82
L4	L4	L6	83
L4	L5	L0	84
L4	L5	L1	85
L4	L5	L2	86
L4	L5	L3	87
L4	L5	L4	88
L4	L5	L5	89
L4	L5	L6	90
L4	L6	L0	91
L4	L6	L1	92
L4	L6	L2	93
L4	L6	L3	94
L4	L6	L4	95
L4	L6	L5	96
L4	L6	L6	97
L5	L0	L0	98
L5	L0	L1	99
L5	L0	L2	100
L5	L0	L3	101
L5	L0	L4	102
L5	L0	L5	103
L5	L0	L6	104
L5	L1	L0	105
L5	L1	L1	106
L5	L1	L2	107
L5	L1	L3	108
L5	L1	L4	109
L5	L1	L5	110
L5	L1	L6	111
L5	L2	L0	112
L5	L2	L1	113
L5	L2	L2	114
L5	L2	L3	115
L5	L2	L4	116
L5	L2	L5	117
L5	L2	L6	118
L5	L3	L0	119
L5	L3	L1	120
L5	L3	L2	121
L5	L3	L3	122
L5	L3	L4	123
L5	L3	L5	124
L5	L3	L6	125
L5	L4	L0	126
L5	L4	L1	127
L5	L4	L2	128
L5	L4	L3	129
L5	L4	L4	130
L5	L4	L5	131
L5	L4	L6	132
L5	L5	L0	133
L5	L5	L1	134
L5	L5	L2	135
L5	L5	L3	136
L5	L5	L4	137
L5	L5	L5	138
L5	L5	L6	139
L5	L6	L0	140
L5	L6	L1	141
L5	L6	L2	142
L5	L6	L3	143
L5	L6	L4	144
L5	L6	L5	145
L5	L6	L6	146
L6	L0	L0	147
L6	L0	L1	148
L6	L0	L2	149
L6	L0	L3	150
L6	L0	L4	151
L6	L0	L5	152
L6	L0	L6	153
L6	L1	L0	154
L6	L1	L1	155
L6	L1	L2	156
L6	L1	L3	157
L6	L1	L4	158
L6	L1	L5	159
L6	L1	L6	160
L6	L2	L0	161
L6	L2	L1	162
L6	L2	L2	163
L6	L2	L3	164
L6	L2	L4	165
L6	L2	L5	166
L6	L2	L6	167
L6	L3	L0	168
L6	L3	L1	169
L6	L3	L2	170
L6	L3	L3	171
L6	L3	L4	172
L6	L3	L5	173
L6	L3	L6	174
L6	L4	L0	175
L6	L4	L1	176
L6	L4	L2	177
L6	L4	L3	178
L6	L4	L4	179
L6	L4	L5	180
L6	L4	L6	181
L6	L5	L0	182
L6	L5	L1	183
L6	L5	L2	184
L6	L5	L3	185
L6	L5	L4	186
L6	L5	L5	187
L6	L5	L6	188
L6	L6	L0	189
L6	L6	L1	190
L6	L6	L2	191
L6	L6	L3	192
L6	L6	L4	193
L6	L6	L5	194
L6	L6	L6	195

3.7 Axis ID Selection for CAT drives

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

- Software, setting via EasySetUp a specific AxisID value in the range 1-255.
- Hardware, by setting different voltage levels on the inputs AxisID 0 (J1 pin 5), AxisID 1(J1 pin 7) and AxisID 2 (J1 pin 9). Each input can be set to one of the following 7 levels:

Level	Connection needed
L0	Connect input directly to ground
L1	Connect input through a 4.7KΩ resistor to ground
L2	Connected input through a 22KΩ resistor to ground
L3	Nothing connected – leave input open
L4	Connect input through a 22KΩ resistor to +5Vdc
L5	Connect input through a 4.7Kohm resistor to +5Vdc
L6	Connect input directly to +5V

Figure ***3.36*** shows how to set the 7 levels on the AxisID 0 input. Paragraph **3.6.2.1** shows how to set all 127 possible values for the axis ID.

Remarks:

1. *AxisID value is computed with formula: 49 x AxisID2 + 7 x AxisID1 + AxisID0, where each AxisID can have one of the integer values: 0 to 6 (0 for L0, 1 for L1, 2 for L2, etc.)*
2. *If the resulting AxisID value is 0 (all 3 inputs are connected to GND), the axis ID will be set to 127. If the resulting AxisID is greater than 127, the axis ID will be set to 255.*
3. *If the drive Axis ID will be 255, the configured station alias will be 0. Some EtherCAT masters can work with multiple drives in a network having the same configured station alias only if it is 0.*

3.8 Electrical Specifications

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

T_{amb} = 0…40°C, V_{LOG} = 24 V_{DC}; V_{MOT} = 80V_{DC}; Supplies start-up / shutdown sequence: -*any*-
Load current (sinusoidal amplitude / continuous BLDC,DC,stepper) = 20A

3.8.1 Operating Conditions

		Min.	Typ.	Max.	Units
Ambient temperature[1]		0		+40	ºC
Heat sink temperature		0		+75	ºC
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

3.8.2 Storage Conditions

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

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

[2] iMOTIONCUBE 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.

3.8.3 Mechanical Mounting

		Min.	Typ.	Max.	Units
Airflow		natural convection[1], closed box			
Heat sink	mounted	Full current capability			
	not mounted	max 5A output current			

3.8.4 Environmental Characteristics

			Min.	Typ.	Max.	Units
Size (Length x Width x Height)	Global size	iMOTIONCUBE CAN	60 x 40 x 28.2			mm
			~2.36 x 1.58 x 1.11			inch
Weight		iMOTIONCUBE CAN	45			g
Cleaning agents	Dry cleaning is recommended		Only Water- or Alcohol- based			
Protection degree	According to IEC60529, UL508		IP20			-

3.8.5 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
	+V_{LOG} = 12V		250		mA
	+V_{LOG} = 24V		150	280	
	+V_{LOG} = 36V		100		

3.8.6 Motor Supply Input (+V_{MOT})

		Min.	Typ.	Max.	Units
Supply voltage	Nominal values	12	80	90	V_{DC}
	Absolute maximum values, drive operating but outside guaranteed parameters	11		94	V_{DC}
	Absolute maximum values, surge (duration ≤ 10ms) †	-1		95	V
Supply current	Idle		1	5	mA
	Operating	-40	±20	+40	A
	Absolute maximum value, short-circuit condition (duration ≤ 10ms) †			45	A

3.8.7 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				20	A
	for PMSM motors with FOC sinusoidal control (sinusoidal amplitude value)				20	
	for PMSM motors with FOC sinusoidal control (sinusoidal effective value)				14.2	
Motor output current, peak	maximum 2.5s		-40		+40	A
Short-circuit protection threshold	measurement range				±45	A
Short-circuit protection delay			5	10		μs
On-state voltage drop	Nominal output current; including typical mating connector contact resistance			±0.3	±0.5	V
Off-state leakage current				±0.5	±1	mA
Motor inductance (phase-to-phase)	Recommended value, for ripple ±5% of measurement range; +V_{MOT} = 48 V	F_{PWM} = 20 kHz	330			μH
		F_{PWM} = 40 kHz	150			
		F_{PWM} = 60 kHz	120			
		F_{PWM} = 80 kHz	80			
		F_{PWM} = 100 kHz	60			
	Absolute minimum value, limited by short-circuit protection; +V_{MOT} = 48 V	F_{PWM} = 20 kHz	120			μH
		F_{PWM} = 40 kHz	40			
		F_{PWM} = 60 kHz	30			
		F_{PWM} = 80 kHz	15			
		F_{PWM} = 100 kHz	8			
Motor electrical time-constant (L/R)	Recommended value, for ±5% current measurement error due to ripple	F_{PWM} = 20 kHz	250			μs
		F_{PWM} = 40 kHz	125			
		F_{PWM} = 60 kHz	100			
		F_{PWM} = 80 kHz	63			
		F_{PWM} = 100 kHz	50			

[1] It is mandatory to mount the IMOTIONCUBE on a metallic support using the provided mounting holes, in order to achieve rated current capability

Current measurement accuracy	FS = Full Scale		±5	±8	%FS

3.8.8 Digital Inputs (IN0, IN1, IN2/LSP, IN3/LSN)[1]

		Min.	Typ.	Max.	Units
Mode compliance		PNP			
Default state	Input floating (wiring disconnected)	Logic LOW			
Input voltage	Logic "LOW"	-10	0	2.2	V
	Logic "HIGH"	6.3		36	
	Floating voltage (not connected)		0		
	Absolute maximum, continuous	-10		+39	
	Absolute maximum, surge (duration ≤ 1s) †	-20		+40	
Input current	Logic "LOW"; Pulled to GND		0		mA
	Logic "HIGH"		6	6	
		Min.	**Typ.**	**Max.**	**Units**
Mode compliance		NPN			
Default state	Input floating (wiring disconnected)	Logic HIGH			
Input voltage	Logic "LOW"	-10		2.2	V
	Logic "HIGH"	6.3		36	
	Floating voltage (not connected)		Vlog-1		
	Absolute maximum, continuous	-10		+36	
	Absolute maximum, surge (duration ≤ 1s) †	-20		+40	
Input current	Logic "LOW"; Pulled to GND		6	8	mA
	Logic "HIGH"; Pulled to +24V		0		

Input frequency		0		150	kHz
Minimum pulse width		3.3			µs
ESD protection	Human body model	±2			kV

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

			Min.	Typ.	Max.	Units
Mode compliance	All outputs (OUT0, OUT1, OUT2/Error, OUT3/Ready)		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	Logic "HIGH"			
		OUT3/Ready	Logic "LOW"			
Output voltage	Logic "LOW"; output at nominal current = 0.5A				0.8	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 "HIGH", leakage current; external load to +V_{LOG}; V_{OUT} = V_{LOG} max = 39V				0.2	mA
Minimum pulse width			2			µs
ESD protection	Human body model		±15			kV

3.8.10 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"	1.8			
	Floating voltage (not connected)		4.5		
	Absolute maximum, surge (duration ≤ 1s) †	-10		+15	
Input current	Logic "LOW"; Pull to GND		5	3	mA
	Logic "HIGH"; Internal 1KΩ pull-up to +5	0	0	0	
Minimum pulse width		2			µs
ESD protection	Human body model	±5			kV

[1] The digital inputs are software selectable as PNP or NPN

3.8.11 Encoder #1 Inputs (A1+, A1-, B1+, B1-, Z1+, Z1-,)[1]

		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)		4.5		
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		2.5	3	mA
	Logic "HIGH"; Internal 2.2KΩ pull-up to +5	0	0	0	
Differential mode compliance	For full RS422 compliance, see [2]	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-	4.2	4.7		kΩ
	Z1+ to Z1-	6.1	7.2		
Input frequency	Single ended mode	0		5	MHz
	Differential mode	0		10	
Minimum pulse width	Single ended mode, Open-collector / NPN	1			μs
	Differential mode, or Single-ended driven by push-pull (TTL / CMOS)	50			ns
ESD protection	Human body model	±2			kV

3.8.12 Encoder #2 Inputs (A2, B2, Z2)

		Min.	Typ.	Max.	Units
Single ended mode compliance		TTL / CMOS / Open-collector			
Input voltage, single-ended mode A2, B2, Z2	Logic "LOW"			0.8	V
	Logic "HIGH"	2			
Input current, single-ended mode A2, B2, Z2	Logic "LOW"			0.1	mA
	Logic "HIGH"			0.1	

3.8.13 Linear Hall Inputs (LH1, LH2, LH3)

		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

3.8.14 Sin-Cos Encoder Inputs (Sin+, Sin-, Cos+, Cos-)[3]

		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
	Common-mode, to GND		2.2		kΩ
Resolution with interpolation	Software selectable, for one sine/cosine period	2		10	bits
Frequency	Sin-Cos interpolation	0		450	kHz
	Quadrature, no interpolation	0		10	MHz
ESD protection	Human body model	±2			kV

[1] Encoder #1 differential input pins do not have internal 120Ω termination resistors connected across

[2] For full RS-422 compliance, 120Ω termination resistors must be connected across the differential pairs, as close as possible to the drive input pins. See *Figure 3.18. Differential incremental encoder #1 connection*

[3] For many applications, a 120Ω termination resistor should be connected across SIN+ to SIN-, and across COS+ to COS-. Please consult the feedback device datasheet for confirmation.

3.8.15 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		8		kΩ
Resolution			12		bits
Integral linearity				±2	bits
Offset error			±2	±10	bits
Gain error			±1%	±3%	% FS[1]
Bandwidth (-3dB)	Software selectable	0		1	kHz
ESD protection	Human body model	±2			kV

3.8.16 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

3.8.17 CAN-Bus (for CAN drives)

		Min.	Typ.	Max.	Units
Compliance		ISO11898, CiA-301v4.2, CiA 305 v2.2.13, 402v3.0			
Bit rate	Software selectable	125		1000	125
Bus length	1Mbps			25	m
	500Kbps			100	
	≤ 250Kbps			250	
Resistor	Between CAN-Hi, CAN-Lo	none on-board			
Node addressing	Hardware: by H/W pins	1 ÷ 127 & 255 (LSS non-configured) (CANopen); 1-127 & 255 (TMLCAN)			
	Software	1 ÷ 127 (CANopen); 1- 255 (TMLCAN)			
ESD protection	Human body model	±15			kV

3.8.18 Supply Output (+5V)

			Min.	Typ.	Max.	Units
+5V output voltage	Current sourced = 250mA		4.8	5	5.2	V
+5V output current		iMOTIONCUBE CAN	600	650		mA
Short-circuit protection			Yes			
Over-voltage protection			NOT protected			
ESD protection	Human body model		±2			kV

3.8.19 Ethernet ports (for CAT drives)

		Min.	Typ.	Max.	Units
Standard Compliance		EtherCAT (IEC61158-3/4/5/6-12)			
		Fast Ethernet 100BASE-TX (IEEE802.3u)			
		Auto-negotiation for 100Mbps/s full-duplex			
		Auto-detect MDI/MDI-X			
Power over Ethernet	NOT used by the iMOTIONCUBE, requires separate +Vlog SELV/ PELV supply	compliant to IEEE802.3af mode A "Mixed DC & Data"			
		NOT compliant to IEEE802.3af mode B "DC on Spares"			
Isolation GND0,GND1	Requirement for motherboard PCB routing	500			V_{rms}
		1.5			kV_{peak}
Maximum cable length	2-pair UTP Cat5	100	150		m
ESD protection	Human body model	±4			kV

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

3.8.20 ECAT LED signals (CAT drives)

		Min.	Typ.	Max.	Units
LED connection		Common anode to 3.3V output Direct, no series resistor			
LED current			8	10	mA
3.3 output voltage		3.15	3.3	3.45	V
3.3 output current				60	mA

3.8.21 Safe Torque OFF (STO1+; STO1-; STO2+; STO2-)

		Min.	Typ.	Max	Units
Safety function	According to EN61800-5-2	STO (Safe Torque OFF)			
EN 61800-5-1/ -2 and EN 61508-5-3/ -4 Classification	Safety Integrity Level	safety integrity level 3 (SIL3)			
	PFHd (Probability of Failures per Hour - dangerous)	$8*10^{-10}$	$hour^{-1}$ (0.8 FIT)		
EN13849-1 Classification	Performance Level	Cat3/PLe			
	MTTFd (meantime to dangerous failure)	377	years		
Mode compliance		PNP			
Default state	Input floating (wiring disconnected)	Logic LOW			
Input voltage	Logic "LOW" (PWM operation disabled)	-20		5.6	V
	Logic "HIGH" (PWM operation enabled)	18		36	V
	Absolute maximum, continuous	-20		+40	V
Input current	Logic "LOW"; pulled to GND		0		mA
	Logic "HIGH", pulled to +Vlog		5	13	mA
Repetitive test pulses (high-low-high)	Ignored high-low-high			5	ms
				20	Hz
Fault reaction time	From internal fault detection to register DER bit 14 =1 and OUT2/Error high-to-low			30	ms
PWM operation delay	From external STO low-high transition to PWM operation enabled			30	ms
ESD protection	Human body model	±2			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.

4 Memory Map

iMOTIONCUBE has 2 types of memory available for user applications: 16K×16 SRAM and up to 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 TML 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 TML programs, the cam tables and the drive setup information.

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

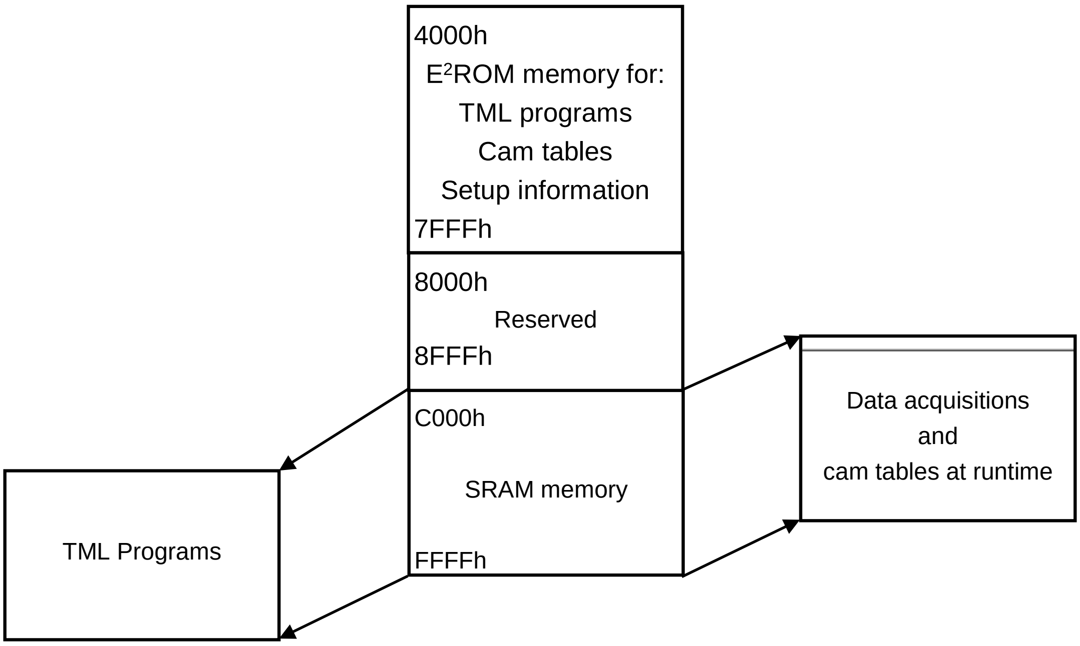


Figure 7.1. *iMOTIONCUBE Memory Map*