# MCx Hardware Manual

**Release 2.2/1.3**

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# Scope of Changes

- Version 1.0
  - Added:
    - First version issued.
- Version 1.1
  - Added:
    - Heatsink voltage in Electrical Specifications section.
  - Fixed:
    - Motor voltage range in Electrical Specifications section.
- Version 1.2
  - Added:
    - 'Important' about the independent power supply of the heatsink fan in Electrical Specifications section.
  - Fixed:
    - MCx weight in Mechanical Specifications section.
- Version 1.3
  - Fixed:
    - Power switching technology (SiC MOSFET instead of IGBT) in Introduction section.

# Introduction



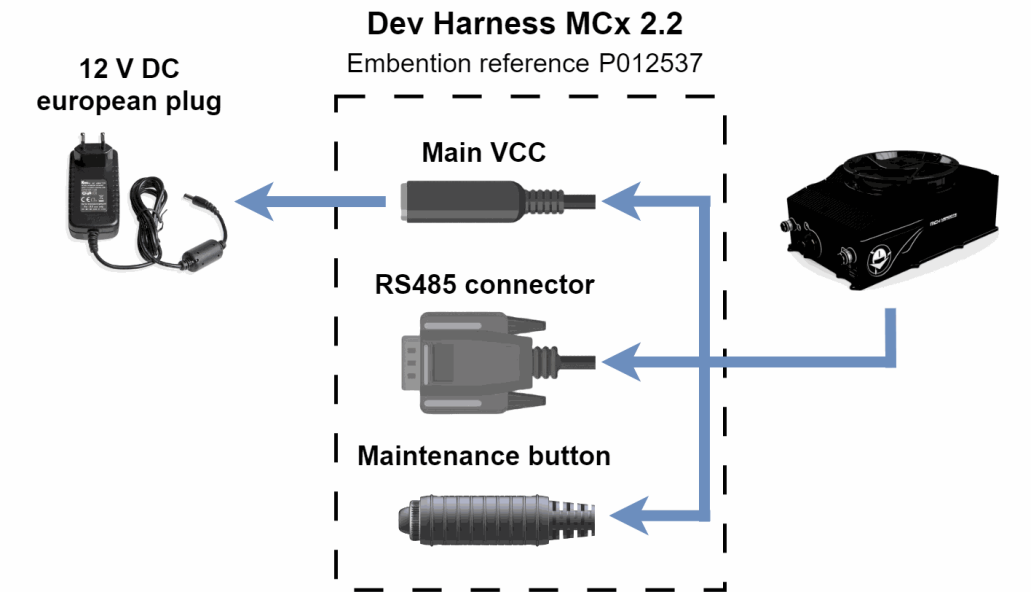
**Veronte MCx** speed controller is capable of driving any type of 3-phase PMSM motor. It can be used with a wide variety of UAVs or eVTOL vehicles. **MCx** uses FOC algorithm for motor control together with SiC Mosfet.

# Quick Start

## First Steps

To connect the **MCx** to a PC, use the RS-485 port. If the computer has not a serial port, a RS-485 to USB converter can be employed. The serial pins are explained in the Pinout section

## Basic Connection Diagram




For further information on the **Dev Harness MCx** connectors, refer to the Dev Harness MCx - Hardware Installation section of the present manual.

## Warnings

When installing the MCx speed controller in the vehicle, the following limitations shall be considered:

- It is highly recommended to reduce the distance between the MCx and the motor in order to reduce the high rate of voltage changes (dV/dt) and the electromagnetic radiation. Additionally it is highly recommended to shield the phase cables and connect this shield to the motor stator and to the MCx metal case.

- Wire connections between power devices must be crimped not soldered.
- PID tuning is an extremely delicate operation that requires specific technical expertise. Performing this procedure without the necessary skills poses a concrete risk of irreversibly damaging or burning the motor controllers. Should the customer decide to proceed independently with tuning, the **company shall assume NO liability** for any resulting damage to the unit. To ensure optimal performance and maximum safety, professional integration and custom tuning services are available. Please contact the support team by creating a Ticket.
- An unappropriated use of the MCx exempts Embention from responsabilities related to any damage.
- Embention shall have no responsibility, obligation or liability in any manner for and in respect of any inappropriate use by the client.

# Technical

## Main Features

The following diagram summarizes the architecture of the MCx. The unit filters the incoming DC power (hw_Input Filter), uses a microcontroller (hw_MCC) to execute the motor-control algorithms and safety functions, and drives the three-phase motor through the switching stage (hw_PWRMOS).

## Mechanical Specifications

- Weight: 3.0 kg without heatsink; 5.6 kg with heatsink.
- Dimensions:

Dimensions in mm

## Electrical Specifications

- Input voltage (low voltage): 6.5 to 36 V
- Input voltage (motor): 100 to 800 V
- Input voltage (heatsink fan): 24 V

> **Important**
>
> The heatsink fan is **not** powered through the MCx. Therefore, the fan must be connected to an independent 24 V supply.

- Maximum battery current (RMS): 120 A (continuous)
- Maximum phase current (RMS): 110 A (25º)
- Switching frequency: 5 to 24 kHz
- Regenerative brake: Enabled during motor deceleration
- Startup protection: Inrush control for high-voltage and low-voltage lines

## Control and Performance

- Control modes: Torque, thrust, speed, and PWM
- Startup logic: Open-loop or closed-loop supported

- Motor types: Sensorless and sensored
- Encoder support: Hall, incremental, SinCos, and Back-EMF
- Maximum speed: Up to 120,000 eRPM
- Custom profiles: User-defined motor behavior presets
- Telemetry: Voltage, current, RPM, and temperature
- Protection logic: Overvoltage, overcurrent, sensor loss, and inrush current
- Safety features: Ground fault, short-circuit, and current imbalance

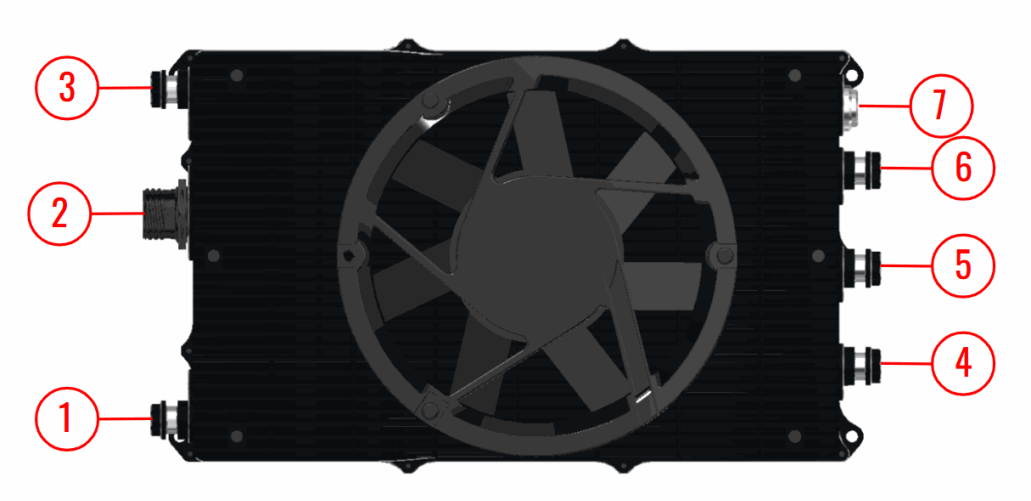
## Thermal and Environmental Specifications

- Cooling: Air
- Cooling plate: Custom heatsink
- Operating temperature: -40 to +80ºC
- Humidity: Up to 95% RH

## Interfaces

- PWM input: 1 opto-isolated PWM input
- CAN interfaces: 1 CAN FD and 1 CAN 2.0
- Serial ports: RS-485
- Digital I/O: Fault and status indicators
- Configuration tools: CAN and RS-485

### Connector Layout



| | Index | Connector |
|---|---|---|
| **Power** | 1 | HV negative |
| | 3 | HV positive |
| | 4 | Phase U Connector |
| | 5 | Phase V Connector |
| | 6 | Phase w Connector |
| **Electronic** | 2 | User Connector |
| | 7 | Signal Connector |

## Mating Connectors

| | Index | MC110 Connector | Mating Connector |
|---|---|---|---|
| **Power** | 1 | HV negative | M6 Cable lug<br>Wire gauge: 16 $mm^2$<br>Ref: LCMA 16-6-C |
| | 3 | HV positive | |
| | 4 | Phase U Connector | |
| | 5 | Phase V Connector | |
| | 6 | Phase W Connector | |

| | Index | MC110 Connector | Mating Connector |
|---|---|---|---|
| **Electronic** | 2 | User Connector | Mating harnesses available on demand:<br>• Veronte Motor Controllers: Dev Harness MCX 2.2 (Embention reference **P012537**)<br>• Veronte Harness - 22P MIL-DTL-38999 - Male - 50cm (Embention reference **P016323**) |
| | 7 | Signal Connector | Mating harness available on demand: Veronte Connector 16P (Embention reference **P006993**) |

# Hardware Installation

## Mechanical

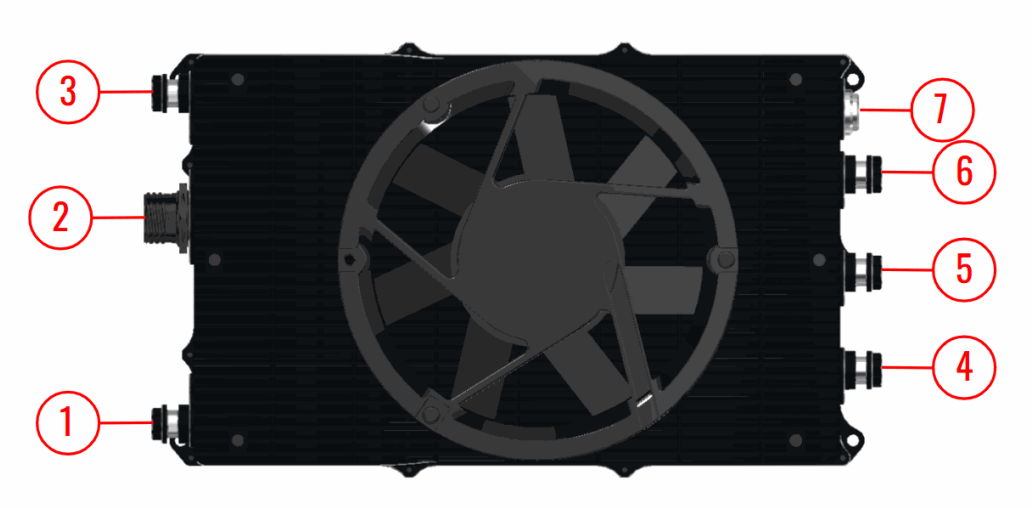
To fix the **MCx** to an aircraft frame, take a look to the dimensions and screws positions in Mechanical Specifications. Screw holes must be deeper than 6 mm with M6

## Electrical

### Power Wiring

> ⚠ **Warning**
>
> The input power polarity must be respected; otherwise, a short circuit may occur.

The polarity and connections are indicated in the following image and table.




| | Index | Connector | Description |
|---|---|---|---|
| **Power** | 1 | HV negative | HV DC input power 100 to 800 V DC |
| | 3 | HV positive | |

| | Index | Connector | Description |
|---|---|---|---|
| | 4 | Phase U Connector | Output power to motor |
| | 5 | Phase V Connector | |
| | 6 | Phase W Connector | |
| **Electronic** | 2 | User Connector | Communications, telemetry and control signals |
| | 7 | Signal Connector | Encoders and sensor temperature signals |

> ⓘ **Note**
>
> The **section** of the cables must be dimensioned according to the **maximum** power that will be used

## Cable installation

Install each cable as follows:

1. Open the bottom enclosure. Keep the enclosure seal in place.

Cable installation - Step 1.

1. Remove the cable gland nuts from the cable entries to be used.

Cable installation - Step 2

1. Prepare and connect the cable:

Cable installation - Step 3a

a. Install the shielding, pass the cable through the cable gland nut and O-ring, and feed it into the enclosure through the hole.

b. Crimp the cable to the cable lug.

c. Position the cable lug over its terminal by bringing the screw closer to the hole, then tighten the screw.

Cable installation - Step 3b and 3c

d. Tighten the cable gland nut to the enclosure and secure the cable shielding to the cable gland.

Cable installation - Step 3d

> ⓘ **Note**
>
> Fix the cable shielding to the cable nut where the surface has no anodize protection, Using a metal clamp like the one shown in the image is recommended.

1. Close the enclosure, ensuring that the enclosure seal remains correctly seated.

Cable installation - Step 5

## Pinout

There are two pinouts: one for the User Connector and one for the Signal Connector.

User Connector




| Pin | Signal | Type | Description |
|---|---|---|---|
| 1 | IN_485_P | INPUT | RS-485 input positive |
| 2 | IN_485_N | INPUT | RS-485 input negative |
| 3 | OUT_485_N | OUTPUT | RS-485 output negative |
| 4 | OUT_485_P | OUTPUT | RS-485 output positive |
| 5 | GND | GROUND | Ground |
| 6 | CN_VIN | POWER | |

| Pin | Signal | Type | Description |
|---|---|---|---|
| | | | Positive Power Rail of the Battery |
| 7 | CN_VIN | POWER | Positive Power Rail of the Battery |
| 8 | CN_GND | GROUND | Negative Power Rail of the Battery |
| 9 | CN_GND | GROUND | Negative Power Rail of the Battery |
| 10 | GND_CAN | GROUND | Ground reference for CAN and CAN FD |
| 11 | CANFD_P | BIDIRECTIONAL | CAN FD positive pin |
| 12 | CANFD_N | BIDIRECTIONAL | CAN FD negative pin |
| 13 | GND_CAN | GROUND | Ground reference for CAN and CAN FD |
| 14 | CANB_P | BIDIRECTIONAL | CAN B positive pin |

| Pin | Signal | Type | Description |
|---|---|---|---|
| 15 | CANB_N | BIDIRECTIONAL | CAN B negative pin |
| 16 | GND_CAN | GROUND | Ground reference for CAN and CAN FD |
| 17 | ISO_PWM | INPUT | Positive PWM Control Input |
| 18 | FAN | OUTPUT | Output Power Signal for External Fan |
| 19 | SYNC_OUT | OUTPUT | Sync Out GPIO Signal |
| 20 | SYNC_IN | INPUT | Sync In GPIO Signal |
| 21 | HEARTBEAT | OUTPUT | Heartbeat Signal |
| 22 | Digital_GND | GROUND | Negative Power Rail of the Battery |

Signal Connector

| Pin | Signal | Type | Description |
|---|---|---|---|
| 1 | ENC_Z | INPUT | |

| Pin | Signal | Type | Description |
|---|---|---|---|
| | | | Input signal from encoder - Z |
| 2 | ENC_B | INPUT | Input signal from encoder - B |
| 3 | ENC_A | INPUT | Input signal from encoder - A |
| 4 | GND_ISO | GROUND | Isolated negative power rail |
| 5 | ISO_TEMP | INPUT | Motor temperature sensor |
| 6 | +1V | POWER | +1 V isolated voltage supply |
| 7 | GND_ISO | GROUND | Isolated negative power rail |
| 8 | +5V | POWER | +5 V isolated voltage supply |
| 9 | +5V | POWER | |

| Pin | Signal | Type | Description |
|---|---|---|---|
| | | | +5 V isolated voltage supply |
| 10 | ENC_COS | INPUT | Cosine signal from SinCos encoder |
| 11 | ENC_SIN | INPUT | Sine signal from SinCos encoder |
| 12 | GND_ISO | GROUND | Isolated negative power rail |
| 13 | GND_ISO | GROUND | Isolated negative power rail |
| 14 | GND_ISO | GROUND | Isolated negative power rail |
| 15 | GND_ISO | GROUND | Isolated negative power rail |
| 16 | GND_ISO | GROUND | Isolated negative power rail |

## Compatible Connectors

The following connectors are compatible with the User and Signal Connectors.

| Compatible with | Connector | Description | Embention Reference |
|---|---|---|---|
| User Connector | Veronte Motor Controllers: Dev Harness MCX 2.2 | Development harness with connectors. | P012537 |
| | Veronte Harness - 22P MIL-DTL-38999 - Male - 50 cm | Amphenol connector with loose wires for aircraft integration. | P016323 |
| Signal Connector | Veronte Connector 16P | LEMO connector with crimp contacts for aircraft integration. | P006993 |

User Connector Harnesses

### Dimensions

- Cables length: 50 cm

## Pinout




Veronte Harness - 22P MIL-DTL-38999 - Male - 50cm

The pinout of the Veronte Harness is the same as the pinout above. The color code of the harness wires is given below.

| Pin | Color code | Pin | Color code |
|---|---|---|---|
| 1 | White | 12 | Red - Blue |
| 2 | Brown | 13 | White - Green |
| 3 | Green | 14 | Brown - Green |
| 4 | Yellow | 15 | White - Yellow |
| 5 | Gray | 16 | Yellow - Brown |
| 6 | Pink | 17 | White - Gray |
| 7 | Blue | 18 | Gray - Brown |
| 8 | Red | 19 | White - Pink |
| 9 | Black | 20 | Pink - Brown |

| Pin | Color code | Pin | Color code |
|---|---|---|---|
| 10 | Violet | 21 | White - Blue |
| 11 | Gray - Pink | 22 | Brown - Blue |

Veronte Motor Controllers: Dev Harness MCX 2.2

The pinout of this harness is the same as the pinout above. In addition, this harness has some connectors already implemented for easy operation. Below is detailed information on which pins these connectors are connected to:

| Connector | PIN | Signal |
|---|---|---|
| **RS-485** | 1 | IN_485_P |
| | 2 | IN_485_N |
| | 3 | OUT_485_N |
| | 4 | OUT_485_P |
| | 5 | GND |
| **Power Input** | 6 and 7 | CN_VIN |
| | 8 and 9 | CN_GND |
| **Maintenance button** | 19 | SYNC_OUT |
| | 20 | SYNC_IN |

## Electrical Diagram of CAN Bus

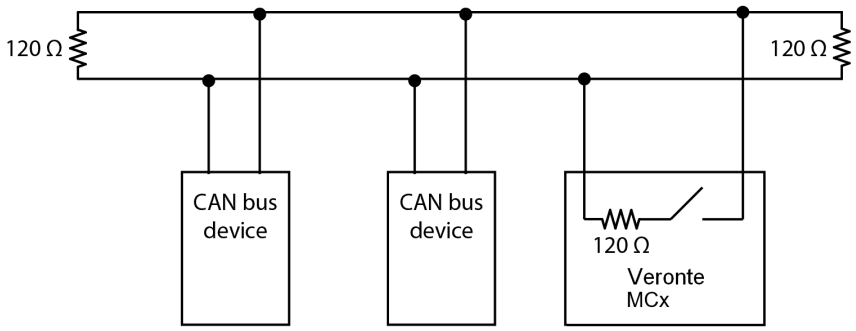
Like any other CAN device, **Veronte MCx** requires a termination resistor to allow the connection of multiple **MCxs** or other CAN bus devices to the same

line. For this termination resistor, users can add an external resistor or simply activate the 120 Ω resistor that MCx has **internally** (this is activated via software).

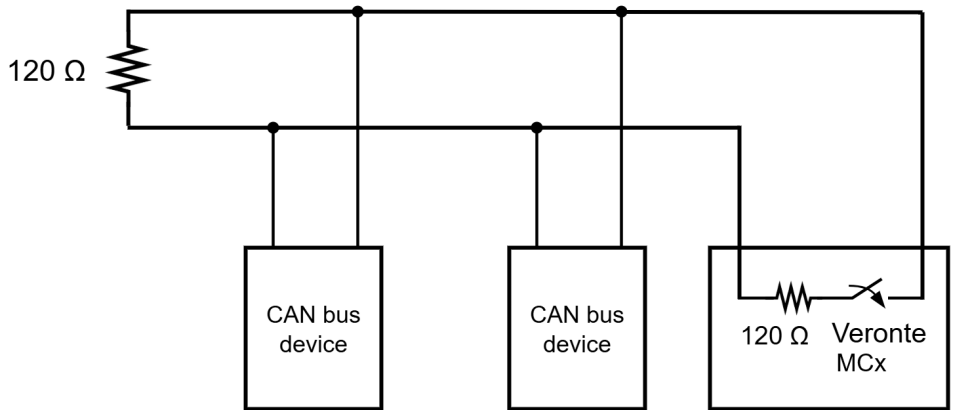
Below are some of the different configurations according to users preference.

> **Important**
>
> The scenarios described below are provided as examples of common setups. Users are free to implement custom wiring configurations that best suit their vehicle's design.
>
> The critical principle for any valid setup is that the CAN bus line must be terminated with a 120 Ω resistor at its two physical ends: one at the beginning and one at the end. As long as this rule is followed, any combination of internal or external resistors may be used.

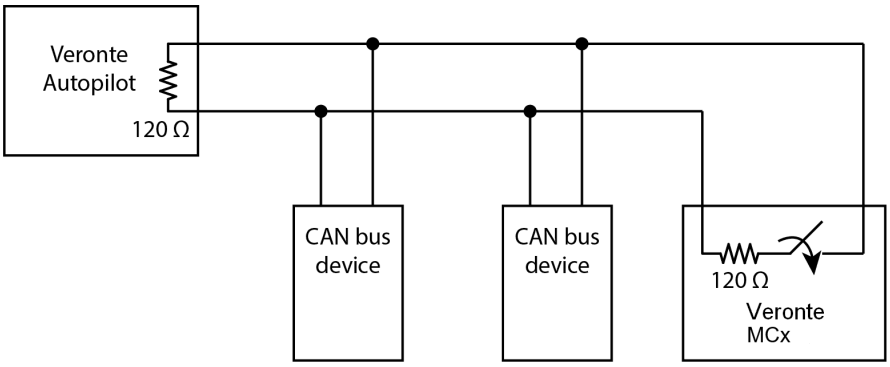
In this setup, the **MCx's internal resistor is not used**. Instead, **two external 120 Ω resistors** are placed at the physical ends of the CAN bus to provide termination. The MCx can be located anywhere on the bus, including at the end, but its internal resistor must remain disabled in the software.



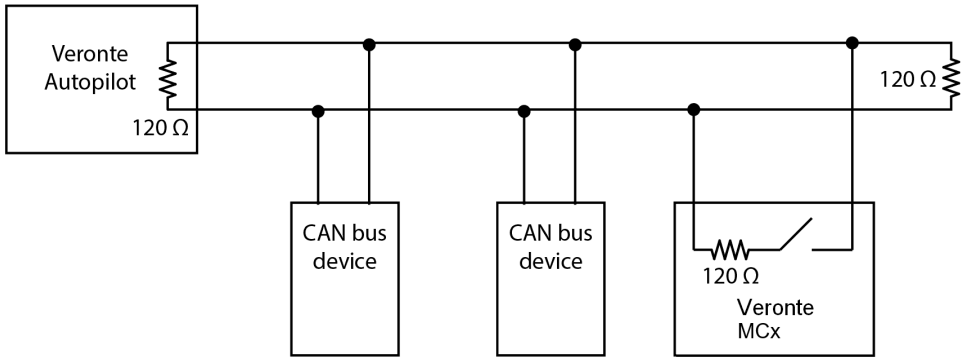

This configuration uses the MCx's built-in termination feature for one end of the bus. The Veronte MCx is placed at one physical end of the line, and its **internal 120 Ω resistor is enabled** via software. **A single external 120 Ω resistor** is then installed at the opposite end of the bus to complete the termination.




Considering **Veronte Autopilot** includes one entrance resistor of 120 Ω, for the simplest wiring, this configuration uses the internal resistors of both the Veronte Autopilot and the Veronte MCx. The Veronte Autopilot, which includes a 120 Ω resistor, is placed at one end of the bus. The Veronte MCx is placed at the other end, and its internal 120 Ω resistor is enabled via software. This setup provides full bus termination without requiring any external components.




In this latter case, the 120 Ω internal resistor of the Veronte Autopilot is placed at one end of the bus and an external 120 Ω resistor is installed at the end of the CAN bus, leaving the internal resistor of the Veronte MCx disabled, as shown in below:



# Software Installation

In order to configure **Veronte MCx**, connect it to a computer via USB (through an RS485-USB converter) with the DEV harness MCx 2.2 (Embention reference: P012537).

To install the required software and configure **MCx**, read the MCx Software Manual.

# Maintenance

In order to clean **Veronte MCx** properly, follow the guidelines below:

- Turn off the device before cleaning.
- Use a clean, soft, damp cloth to clean the unit.
- Do not immerse the unit in water to clean it.

# Acronyms and Definitions

| Acronym | Description |
|---|---|
| Back-EMF | Back Electromotive Force |
| CAN | Controller Area Network |
| CAN FD | Controller Area Network Flexible Data-Rate |
| DC | Direct Current |
| eVTOL | electric Vertical Take-Off and Landing |
| eRPM | electrical Revolutions Per Minute |
| FOC | Field-Oriented Control |
| GND | Electrical Ground |
| GPIO | General-Purpose Input/Output |
| HV | High Voltage |
| I/O | Input/Output |
| IGBT | Insulated Gate Bipolar Transistor |
| MIL-DTL | Military Detail Specification |
| PC | Personal Computer |
| PID | Proportional-Integral-Derivative |
| PMSM | |

| Acronym | Description |
|---|---|
| | Permanent Magnet Synchronous Motor |
| PWM | Pulse-Width Modulation |
| RH | Relative Humidity |
| RMS | Root Mean Square |
| RPM | Revolutions Per Minute |
| RS-485 | Recommended Standard 485 |
| SinCos | Sine/Cosine |
| UAV | Unmanned Aerial Vehicle |
| USB | Universal Serial Bus |

# Contact Data

For support-related inquiries, customers have access to a dedicated portal through the Joint Collaboration Framework. This platform facilitates communication and ensures traceability of all support requests, helping us to address your needs efficiently.

For other questions or general inquiries, you can reach us via email at sales@embention.com or by phone at (+34) 965 115 421