MC110 Hardware Manual

Release 2.0/1.0

Embention Sistemas Inteligentes, S.A.

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Scope of Changes

- Version 1.0
  - Added:
    - First version issued.

Introduction

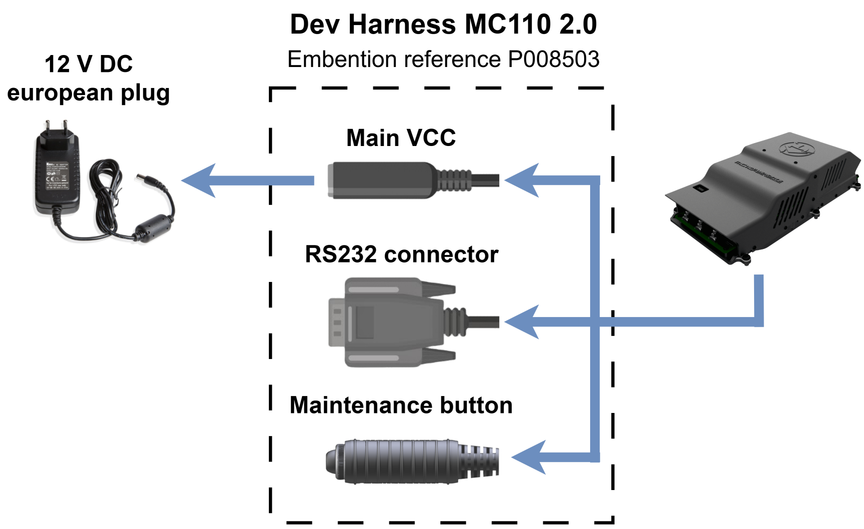
Veronte MC110 speed controller is capable of driving any type of 3-phase PMSM motor. It can be used with a wide variety of UAVs or eVTOL vehicles. **MC110** uses FOC algorithm for motor control together with IGBTs.

Quick Start

First steps

To connect the **MC110** to a PC, use the RS-232 or RS-485 port. If the computer has not a serial port, a RS-232 or 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 MC110** connectors, refer to the Dev Harness MC110 2.0 - Hardware Installation section of the present manual.

Warnings

When installing the MC110 speed controller in the vehicle, the following limitations shall be considered:

- It is highly recommended to reduce the distance between the MC110 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 MC110 metal case.
- Wire connections between power devices must be crimped not soldered.

- The cold plate is integrated with the **MC110**, but it requires the rest of refrigeration elements. To know how to choose them, read the Cooling Circuit Sizing - Integration examples section of this manual.
- PID tuning is strongly not recommended, since it nullifies the warranty.
- An unappropriated use of the MC110 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, such as (including but not limited to) not implementing an appropiate cooling circuit, applying according to the indications given by Embention.

Requirements

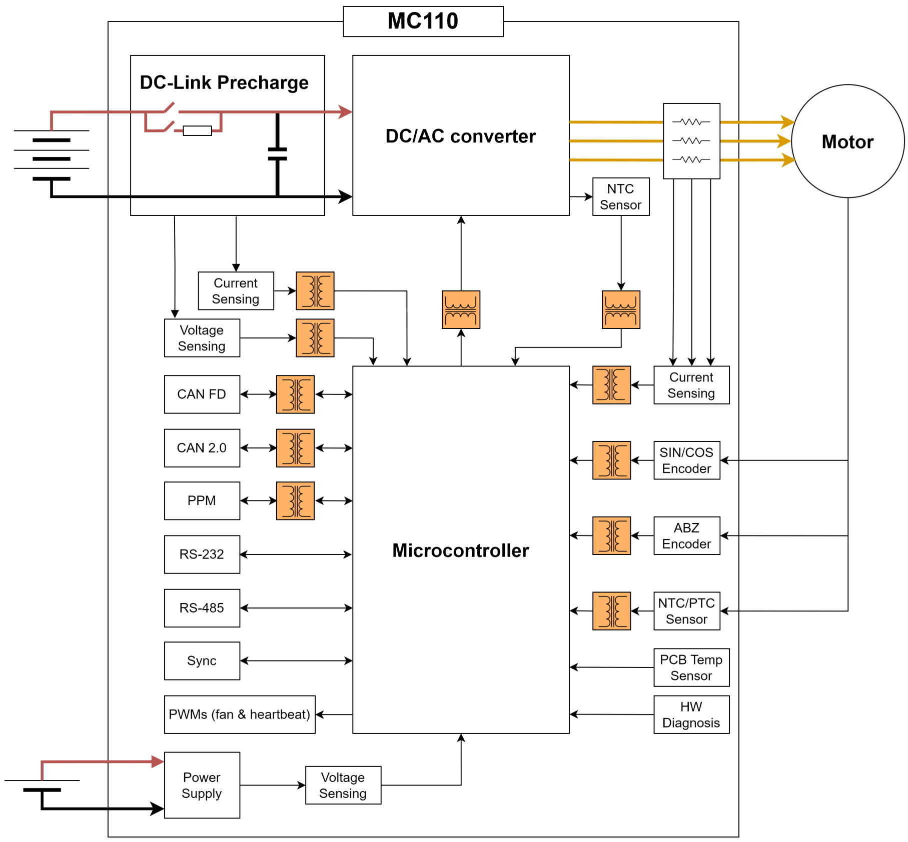
A cooling circuit is required to refrigerate the **MC110**, since the cold plate is integrated, but not the rest of elements.

Technical

Main Features

- **Configuration parameters**: for reduced power consumption.

The block diagram of the system is shown below.



Peripheral used for motor control:

- PWM signal, optocupled inside the **MC110**
- CAN bus
- CAN FD bus

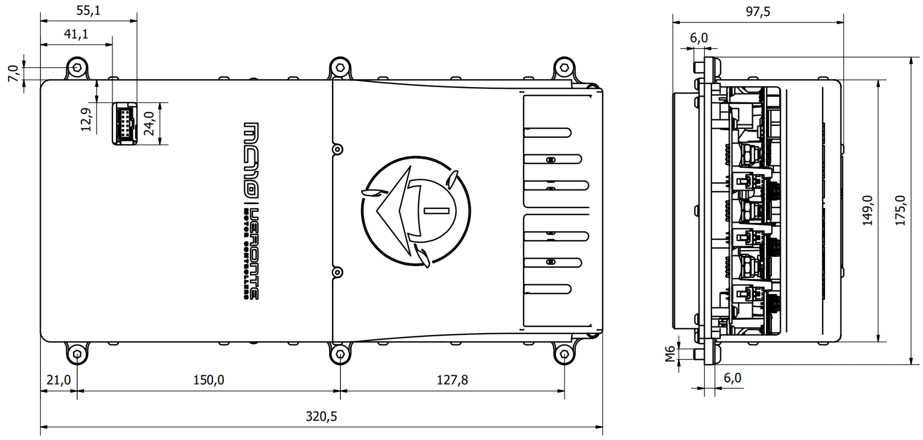
Peripheral use for ESC telemetry:

- Serial RS-232
- Serial RS-485

Any of the serial interfaces can be used to configure the internal variables of the **MC110**.

Mechanical Specifications

- **Weight**: 2680 g
- **Maximum speed (for 1 pair of poles)** 50,000 RPM (depending on the acquisition frequency)
- **Dimensions**:



Dimensions in mm

Electrical Specifications

- **Power**: up to 110 kW *
- **Maximum continous current**: Up to 200A*
- **Peak current**: 250A (as long as MC110 is not overheated by the input power)
- **PWM Frequency**: 5-24 kHz
- **HV range**: 100 V to 800 V
- **LV range**: 8 V to 36 V
- **Minimum temperature**: - 30 ºC
- **Maximum temperature**: 150 ºC * (for IGBT module)
- **Regenerative brake**: 60 A maximum
- **Sensorless mode**: MC110 is able to operate with sensorless motors with maximum efficiency.

  The sensorless mode does not require a minimum speed to measure it and operate, as long as **MC110** provides current to the motor phases (since the speed is measured with the current).

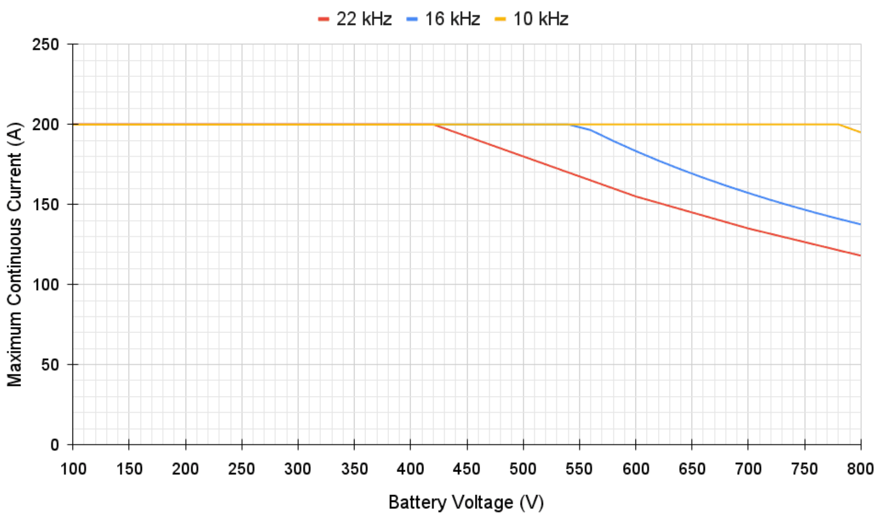
> **Note**
> Features with * depend on voltage and switching frequency. To know more, read the Maximum continuous current section below.

- **Protections**:
    - Protection agains in-rush current when turned on (at low and at high voltage sides)
    - Ground fault detection
    - Protection against overcurrent at power input and phases
- **Sensored motors**:
    - Hall sensors
    - Digital incremental encoders
    - Analog SIN/COS
- **Reverse rotation**: MC110 can operate in any direction of rotation without additional configuration.
- **Configurable**:
    - Type of Observer
    - Programmable acceleration curve
    - Motor direction
    - Overvoltage threshold
    - Overcurrent threshold
    - Overtemperature threshold
    - Max. RPM (limit)
    - Braking force
    - Duty Cycle
- **Communications**:
    - CAN Bus
    - CAN FD Bus
    - PWM optocupled inside the **MC110**
    - RS-232
    - RS-485
- **Redundant control**
- **Telemetry**:
    - Motor & ESC temperature

- RPM
- Input voltage
- Input and output current

Maximum continuous current

The relationship between maximum input current and battery voltage depends on the switching frequency of the DC/AC converter. The following figure shows this relationship for different switching frequencies.



Maximum Continuous Current vs Battery Voltage

Interfaces

HALL Inputs

> ⚠ **Warning**
>
> The employed hall sensors must not exceed 5 V.

These inputs are used to add to the system a feedback in sensored mode (incremental type, usually magnetic).

The 3 Hall effect sensors must be placed at 120° (electrical degrees) from each other. The following is a simple formula for obtaining the mechanical degrees of separation when installing the sensors:

$$Electrical\ Degrees = Pole\ Pairs \times Mechanical\ Degrees$$

So the sensors must be placed one of each other at:

$$Mechanical\ Degrees\ (^{\circ}) = \frac{120^{\circ}}{Pole\ Pairs}$$

For example, for 10 pole pairs:

$$\frac{120^{\circ}}{Pole\ Pairs} = \frac{120^{\circ}}{10} = 12^{\circ}$$

Example diagram

> **Tip**
>
> The arc length between sensors can be calculated as follows:
>
> $$Arc\ Length = \frac{2\pi \times Motor\ Radius \times Mechanical\ Degrees\ (^{\circ})}{360}$$

FAN_PWM

This Open-Drain output is used to control an external fan if needed. External power for the fan and an aditional pull-up resistor is required. Maximum voltage in this signal is 60 V and 360 mA for maximum sink current. It is important that the GND connection of this supply is the same as the GND connection for the supply of the control group (user connector).

Opto PWM Input

This input is an optocoupled control digital signal.

The input is interpreted as 0-100 % of the maximum RPM. An initial dead band can be configured to prevent the engine from starting.

Type	Specification
Input voltage range	0-5 V
	2.5 mA

Type	Specification
Minimum input current	
Pulse length	1-2 ms
Frequency	40-250 Hz

NTC/PTC Input (External Temperature Sensing)

A PTC or NTC can be integrated. The PTC or NTC must not exceed 2 V.

The PTC/NTC should be connected on the low side of an external resistor divider. This is the configuration by default. A high side connection can be used too, but a custom modification is needed.

The isolated Voltage_ref output should be left floating in default mode. The iso_ground is the return path of the NTC/PTC sensor.

SIN/COS_SIGNAL

These signals are those dedicated to the SIN / COS type analog sensor.

> ⚠ **Warning**
>
> SIN/COS signals must not exceed 5 V.

RS-232

Single ended serial type protocol:

Type	Specification
ESD Protection	±15 kV (HBM)
Requirements	TIA/EIA-232-F and ITU v.28

Type	Specification
Speed	Max. 250 kbit/s
Input Voltage	-25 to 25 V
Output Voltage	-13.2 to 13.2 V

RS-485

Differential serial type protocol:

Type	Specification
ESD Protection	±15 kV (HBM)
Requirements	TIA/EIA-485-A
Speed	Max. 25 Mbit/s
Input Voltage (D)	-0.5 to 7 V
Output Voltage (D)	1.5 to 2.4 V

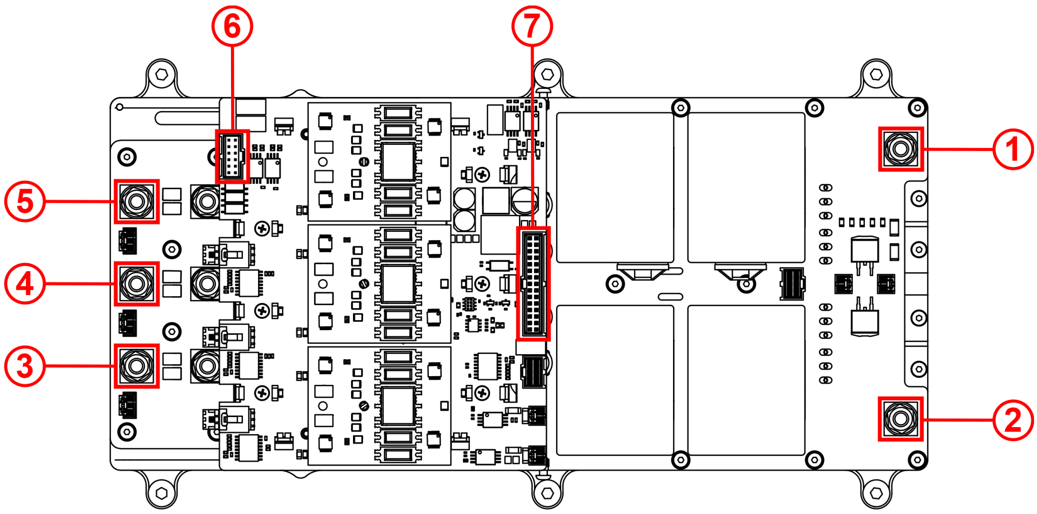
Isolated CAN FD and Isolated CAN 2.0

Differential communication protocol with flexible data rate:

Type	Specification
ESD Protection	±4 kV (HBM)
Requirements	ISO11898-2
Speed	Max. 5 Mbit/s
Max CAN 2.0 Speed	1 Mbit/s

Type	Specification
Input Voltage (D)	-12 to 12 V
CAN H Voltage	2.75 to 4.5 V
CAN L Voltage	0.5 to 2.25 V

Connector Layout



	Index	Connector
Power	1	HV negative
	2	HV positive
	3	Phase U Connector
	4	Phase V Connector
	5	Phase W Connector
Electronic	6	Sensor Connector

	Index	Connector
	7	User Connector

Mating Connectors

	Index	MC110 Connector	Mating Connector
Power	1	HV negative	Tubular cable lugs of Würth with M6. The recommended reference depends on wire section: • 10 mm²: 5580610 • 16 mm²: 5580616 • 25 mm²: 5580625 • 35 mm²: 5580635
	2	HV positive	
	3	Phase U Connector	
	4	Phase V Connector	
	5	Phase W Connector	
Electronic	6	Sensor Connector Molex: 90130-1312	Mating connector - Molex: 90142-0012 Mating harness available on demand: Conn

	Index	MC110 Connector	Mating Connector
			Harness MC110 2.0 (Embention reference **P008609**)
	7	User Connector Molex: 90130-1130	Mating connector - Molex: 90142-0030 Mating harnesses available on demand: • Dev Harness MC110 2.0 (Embention reference **P008503**) • Conn Harness MC110 2.0 (Embention reference **P008609**)

Hardware Installation

> **Danger**
>
> The dc-link capacitors may remain charged with hazardous voltage after the power source is disconnected. Wait at least **5 minutes** for the internal passive resistors to fully discharge the capacitors before handling the connections.

> **Note**
>
> When working voltage is higher than 60 V, use of insulating gloves are mandatory for installation and the system **must have** a chassis fault detection system.

Mechanical

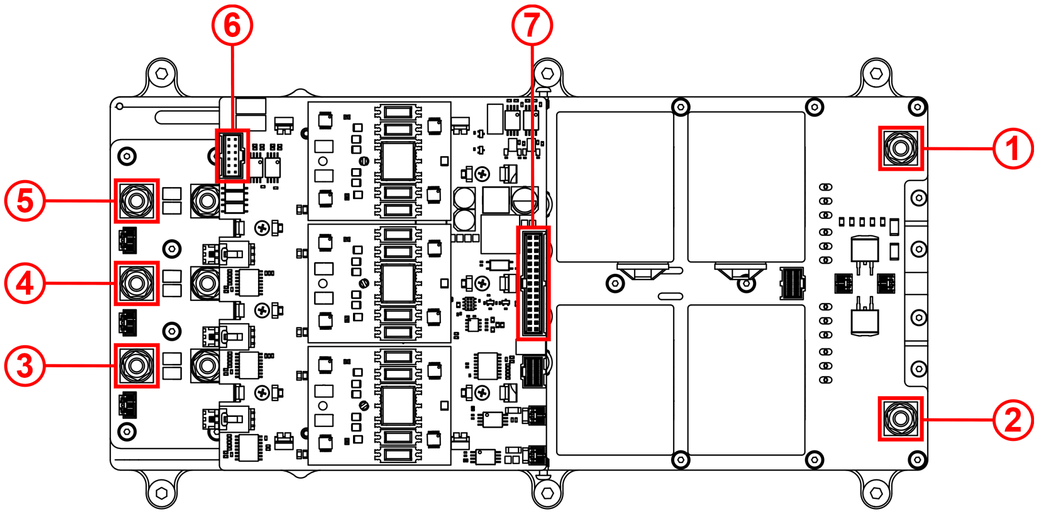
To fix the **MC110** to an aircraft frame, take a look to the dimensions and screws positions. Screw holes must be deeper than 6 mm with M6.

Electrical

ESC-Motor Wiring

> **Warning**
>
> The polarity connection of the input must be respected, otherwise a short circuit may occur.

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



<table>
<tr><th>Index</th><th>Connector</th><th>Description</th></tr>
<tr><td>1</td><td>HV negative</td><td rowspan="2">Input power from DC current
100 to 800 V DC</td></tr>
<tr><td>2</td><td>HV positive</td></tr>
<tr><td>3</td><td>Phase U Connector</td><td rowspan="3">Output power to motor</td></tr>
<tr><td>4</td><td>Phase V Connector</td></tr>
<tr><td>5</td><td>Phase W Connector</td></tr>
<tr><td>6</td><td>Sensor Connector</td><td>Encoders and sensor temperature signals</td></tr>
<tr><td>7</td><td>User Connector</td><td>Communications, telemetry and control signals</td></tr>
</table>

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

> **Warning**
>
> When using a power supply that does not have sink capabilities (cannot absorb current), the regenerative functions of the MC110 **must be turned OFF** to prevent damage to the power supply. For additional protection, it is recommended to install a diode in series between the positive terminal of the power supply and the HV positive input of the MC110.

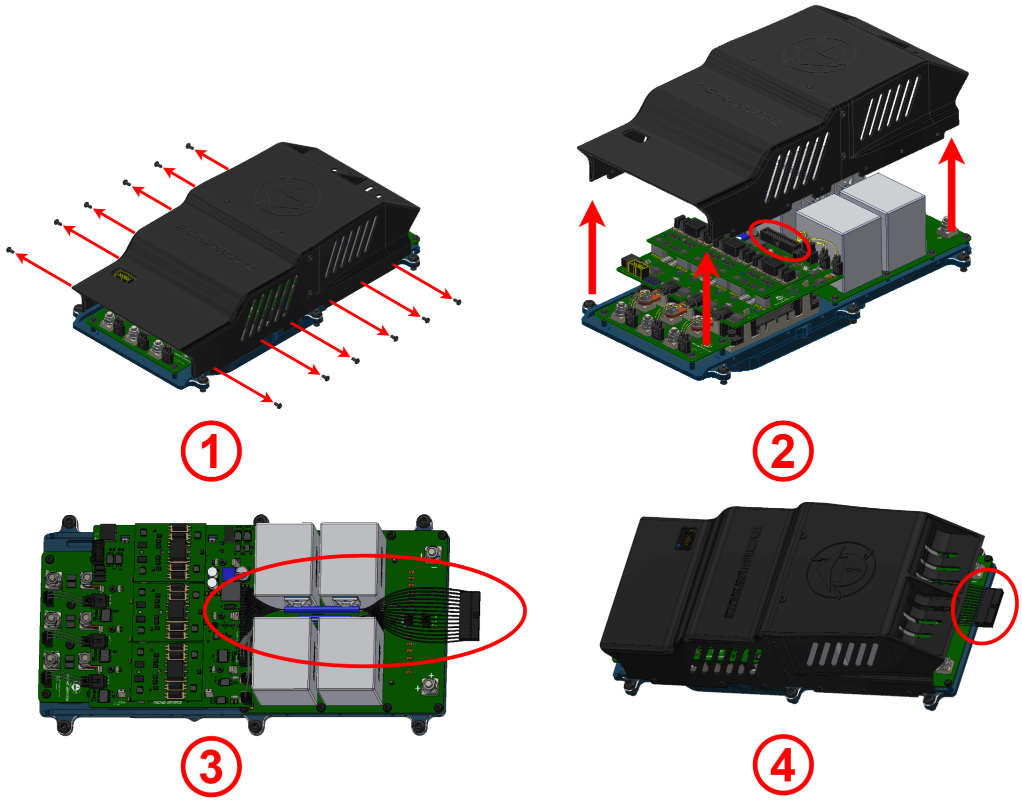
Battery cables between MC and battery should be as short as possible. If the distance between battery and motor is long, please extend phase cables in order to shorten battery cables.

> **Tip**
>
> Connection of the phases can be done freely, however, it will affect the direction of rotation of the motor. Hence, if the motor is spinning in the opposite direction, switch any 2 phases around.

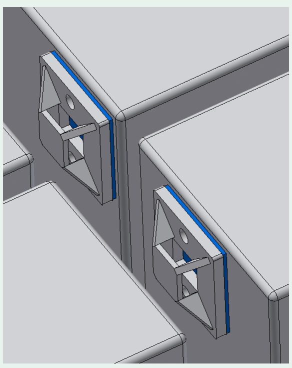
User Connector Wiring

> **Note**
>
> The user must not remove the screws that hold the two casings together.

To access and wire the user connector, follow the next steps:



1. Unscrew the enclosure.
2. Pull up the enclosure and plug the user connector.
3. Pass the wires between the capacitors. Heat shrinkable cover is recommended to protect wires and keep them together.

> **Tip**
>
> The capacitors have two cable tie mounts, so wires can be fixed with cable ties.
>
> 

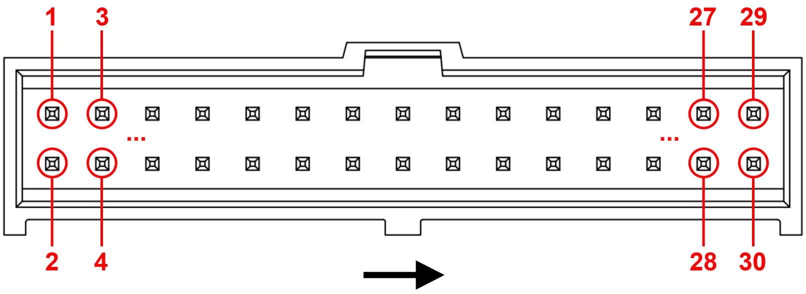
4. Screw back the enclosure, such that wires protrudes from **MC110**.

> **Important**
> When reinstalling the housing, apply a medium-strength fastener to these screws and tighten to a torque of 0.2 Nm.

Pinout

User Connector pinout

The user connector pinout is shown in the following figure and table:



User connector for MC110 - Molex: 90130-1130 (frontal view)

PIN	Signal	Description	PIN	Signal	Description
1	HRBT_OUT *	Output PWM Heartbeat signal to synchronize multiple MC110 units	2	HRBT_IN *	Input PWM Heartbeat signal to synchronize multiple MC110 units
3	GND	Ground	4	GND	Ground
5	SYNC_OUT *	Output PWM to synchronize multiple MC110 units	6	SYNC_IN *	Input PWM to synchronize multiple MC110 units
7	GND	Ground	8	RS232_TX	RS-232 transmitter

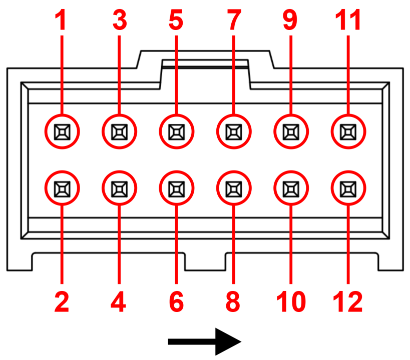
PIN	Signal	Description	PIN	Signal	Description
9	OUT_485_P	RS-485 output positive	10	RS232_RX	RS-232 receiver
11	OUT_485_N	RS-485 output negative	12	FAN_PWM	Digital PWM output for fan control
13	IN_485_N	RS-485 input negative	14	GPIO_AUX	Auxiliar GPIO signal
15	IN_485_P	RS-485 input positive	16	GND_485	Ground for RS-485
17	OPTO_PWM	Digital Input for motor speed. Optocoupled inside MC110	18	OPTO_RTN	Return of pin 17
19	CANFD_N	CAN FD negative pin	20	CANFD_P	CAN FD positive pin
21			22		
23	GND_CAN **	Isolated ground for CAN	24	GND_CAN **	Isolated ground for CAN
25	CANB_N	CAN B negative pin	26	CANB_P	CAN B positive pin
27			28		

PIN	Signal	Description	PIN	Signal	Description
29	GND	Ground	30	VCC	Digital power supply 8 - 36 V

> ⓘ **Note**
>
> * : Synchronization between MC110s optimizes battery management.
>
> ** : Ground for CAN is not necessary, but it can be used in case of having issues with CAN signals.

Sensor Connector pinout

The sensors connector pinout is shown in the following figure and table:



Sensor connector for MC110 - 90130-1312 (frontal view)

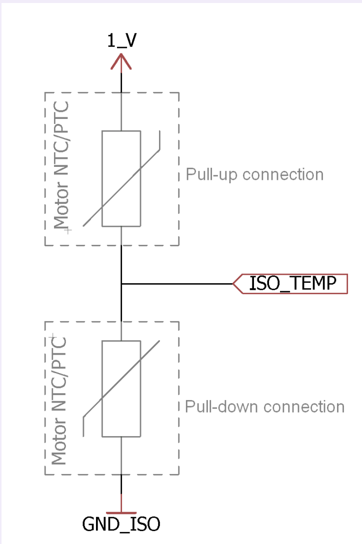
PIN	Signal	Description	PIN	Signal	Description
1	ENC_SIN	Sine input from encoder	2	ENC_COS	Cosine input from encoder
3	GND_ISO	Isolated ground	4	5_V_HALL	Isolated 5 V

<table>
<tr><th>PIN</th><th>Signal</th><th>Description</th><th>PIN</th><th>Signal</th><th>Description</th></tr>
<tr><td>5</td><td>ENC_A *</td><td>Encoder A</td><td>6</td><td></td><td></td></tr>
<tr><td>7</td><td>ENC_B *</td><td>Encoder B</td><td>8</td><td>ENC_Z *</td><td>Encoder Z</td></tr>
<tr><td>9</td><td rowspan="2">GND_ISO</td><td rowspan="2">Isolated ground</td><td>10</td><td>ISO_TEMP</td><td>External temperature sensor measurement</td></tr>
<tr><td>11</td><td>12</td><td>1_V</td><td>Power supply for external temperature sensor (1 V)</td></tr>
</table>

> **Note**
>
> * : These inputs are digital, incremental and optocoupled inside MC110.

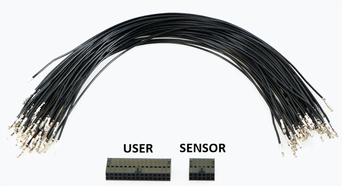
Important

- If the temperature sensor is connected as a pull-up resistor, pin `1_V` (12) will be the voltage reference.
- If the temperature sensor is connected as a pull-down resistor, pin `GND_ISO` (3, 9 or 11) will be the voltage reference.



Harnesses

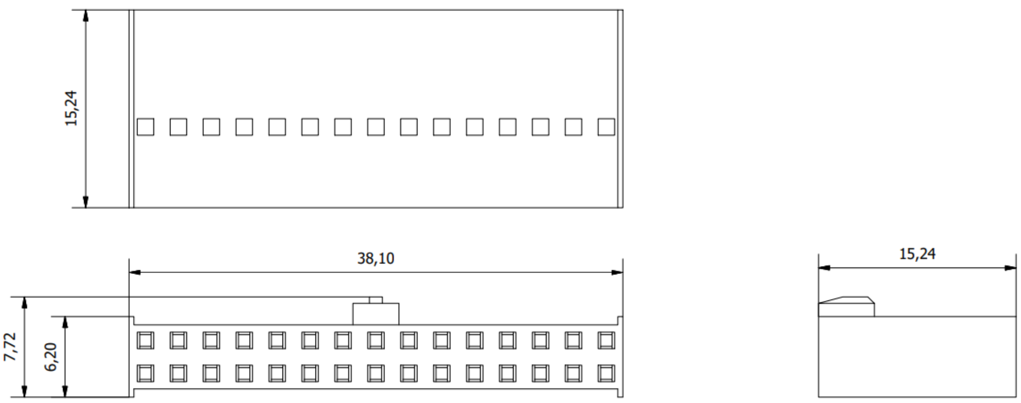
A wire harness is a structured assembly of cables and connectors used to organize and manage wiring in electrical and electronic systems. It is designed to ensure a tidy and secure installation of cables, preventing tangles, electromagnetic interference, and facilitating maintenance.

<table>
<tr><th rowspan="2">Dev Harness MC110 2.0 for User Connector</th><th colspan="2">Conn Harness MC110 2.0</th></tr>
<tr><td>User Connector Harness</td><td>Sensor Connector Harness</td></tr>
<tr><td></td><td colspan="2">
</td></tr>
</table>

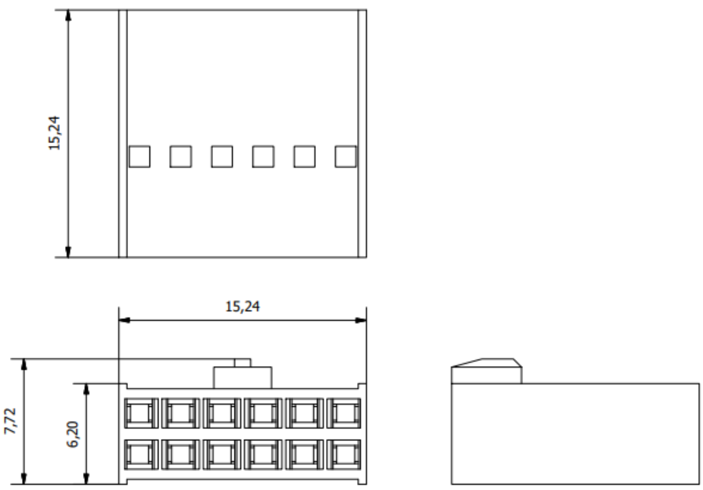
Harness available on demand with the Embention reference **P008503**	Harness available on demand with the Embention reference **P008609**

Dimensions

- **Dev Harness MC110 2.0 wire gauge:** 22-24 AWG
- **Cables length:** 30 cm
- **Harness plug dimensions:**

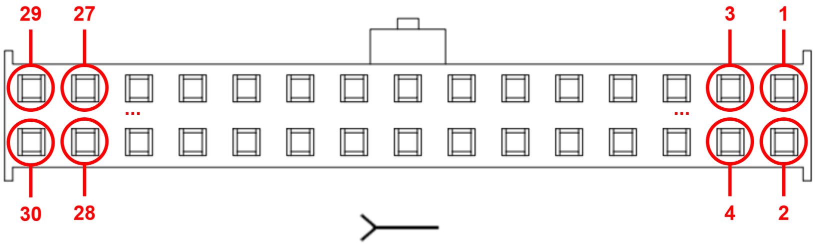


User Connector Harness - Molex: 90142-0030 dimensions (mm)

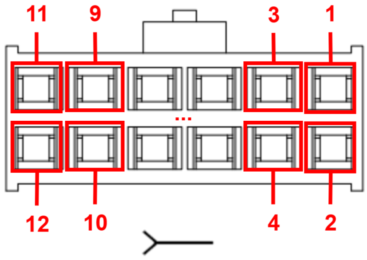


Sensor Connector Harness - Molex: 90142-0012 dimensions (mm)

Pinout



Harness plug (user connector) - Molex: 90142-0030 (frontal view)



Harness plug (sensor connector) - Molex: 90142-0012 (frontal view)

Conn Harness MC110 2.0

- The pinout of the Conn Harness MC110 2.0 - **User** Connector is the same as the User Connector pinout above.
- The pinout of the Conn Harness MC110 2.0 - **Sensor** Connector is the same as the Sensor Connector pinout above.

Dev Harness MC110 2.0

The pinout of this harness is the same as the User Connector 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
Main VCC	30	VCC
	29	GND
RS232 connector	8	RS232_TX
	10	RS232_RX

Connector	PIN	Signal
	7	GND
Maintenance button	2	HRBT_IN
	6	SYNC_IN

How to Turn On and Off

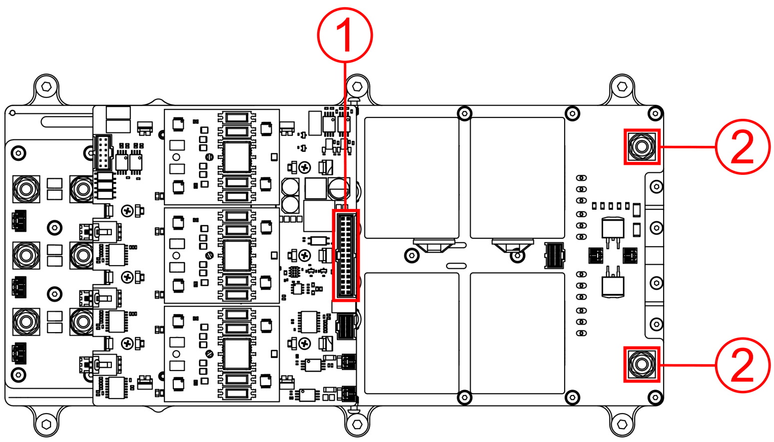
> **Note**
>
> **Grounding:** The MC110 uses two separate ground circuits to prevent interference: One for the low voltage supply and another for the high voltage supply. It is vital that these circuits remain isolated. Optionally, the equipment enclosure can be connected to the chassis for added safety and protection.

MC110 has two electric circuits: **control** (1) and **power** (2).

To **turn on** the voltage supply (with devices such as switches, relays or MOSFETs), it is mandatory to do it with the following order:

1. **Control** circuit (1): **User** connector.
2. **Power** circuit (2): HV negative and HV positive cables.

The following figure illustrates the connection order:



To **turn off** the **MC110**, reverse the order:

1. **Power** circuit (2): HV negative and HV positive cables.
2. **Control** circuit (1): **User** connector.

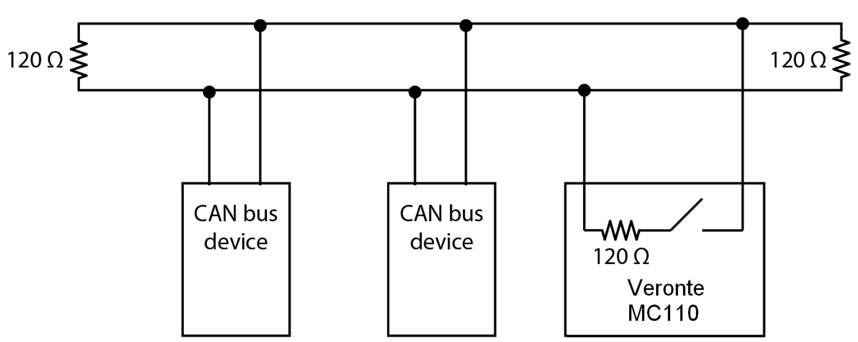
Electrical Diagram of CAN Bus

Like any other CAN device, **Veronte MC110** requires a termination resistor to allow the connection of multiple **MC110s** 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 MC110 has **internally** (this is activated via software).

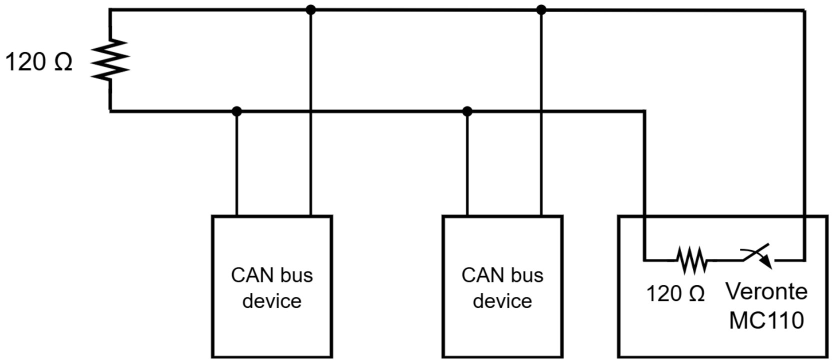
Below are some of the different configurations according to users preference.

> **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.

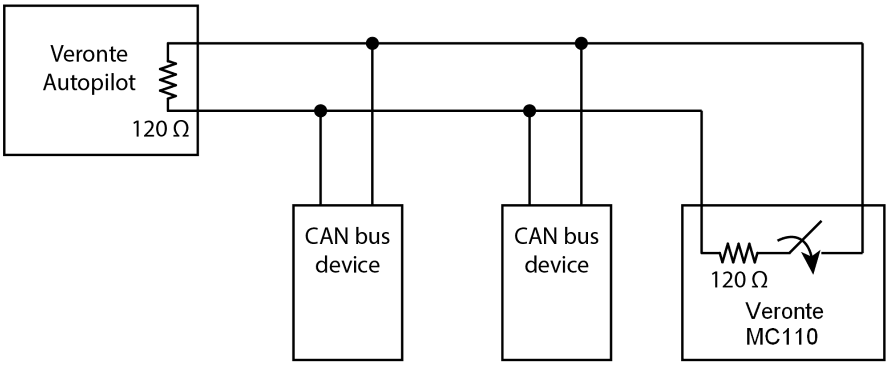
In this setup, the **MC110's internal resistor is not used**. Instead, **two external 120 Ω resistors** are placed at the physical ends of the CAN bus to provide termination. The MC110 can be located anywhere on the bus, including at the end, but its internal resistor must remain disabled in the software.



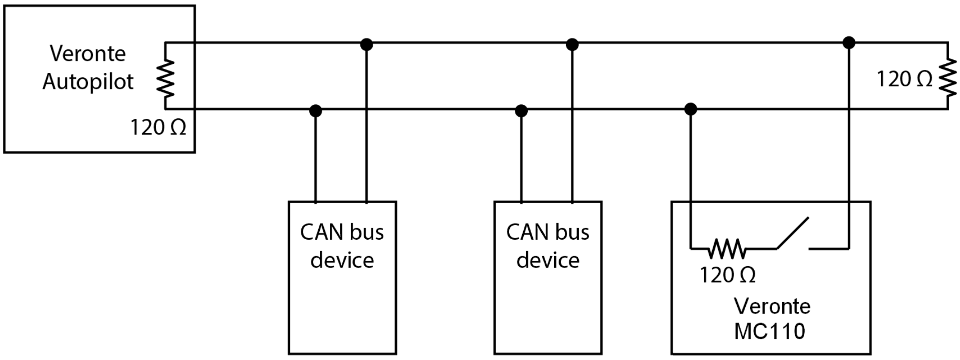
This configuration uses the MC110's built-in termination feature for one end of the bus. The Veronte MC110 is placed at one physical end of the line, and its **internal 120 Ω resistor is enabled** via software. **A single external 120 Ω resistor** is then installed at the opposite end of the bus to complete 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 MC110. The Veronte Autopilot, which includes a 120 Ω resistor, is placed at one end of the bus. The Veronte MC110 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 MC110 disabled, as shown in below:

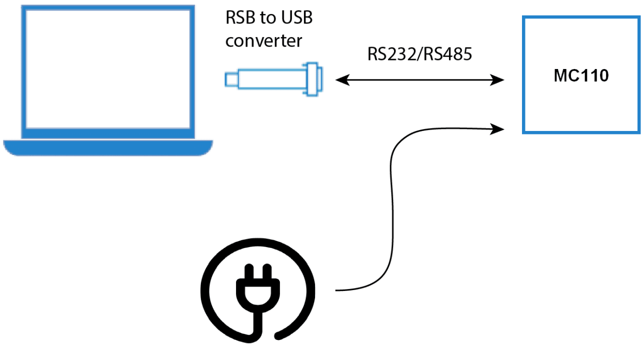


Note

To enable or disable the resistor, refer to the Mailboxes - Input/Output section of **MC110 PDI Builder** user manual.

Software Installation

In order to configure **Veronte MC110**, connect it to a computer via USB (through an RS232/485-USB converter) with the harness cable.



Then, to install the required software and configure **MC110**, read its software manual.

> **Note**
>
> Users can find detailed information on how to perform Tuning of the MC110 in the Tuning section of the **MC110 PDI Builder** user manual.

Maintenance

Once a year, the coolant should be replaced with new one, to ensure it works properly.

In order to clean **Veronte MC110** properly follow the next recommendations.

- 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.

Compatible Devices

Radiators

Company	Comments
	• Tube-Fin Heat Exchangers • Flat Tube Oil Coolers • Plate-Fin Heat Exchangers • Liquid to Liquid Brazed Plate Heat Exchangers

Integration examples

Cooling Circuit Design

> ⚠ **Warning**
>
> Do not place the **MC110** or its cooling circuit close to another heat source, since it would be counterproductive for the refrigeration, compromising its performance and safety.

> ⓘ **Note**
>
> The following explanations assume there are not phase changes on the coolant, since it is not necessary to use a refrigeration system with phase changes.

MC110 is able to control motors up to 110 kW due to liquid refrigeration systems. The motor controller only includes the cold plate, requiring the rest of the refrigeration system (pump, pipes, radiator, expansion tank and coolant).

> ⓘ **Note**
>
> In the Compatible Devices section of this manual, the user can find **recommended radiators** to install with the **MC110**.

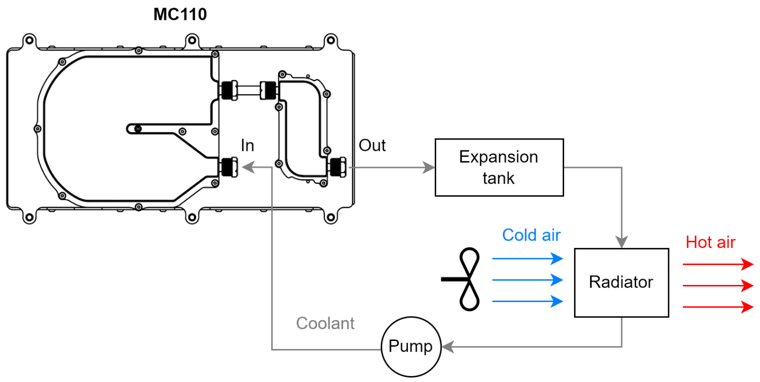
This manual explains two ways to design a cooling circuit, click on the desired one:

- Simplified. For one MC110 with a specific type of cooling circuit.
- Advanced. Generic indications to design a completely custom application.

Simplified Cooling Circuit Design

This subsection explains how to size a specific layout of cooling design, so the user does not have to calculate any parameters.

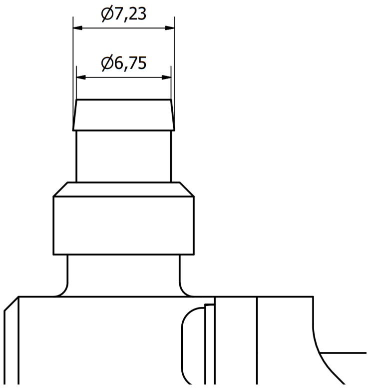
This layout is intended for one single **MC110**. In case of desiring to use a different layout or to refrigerate multiple controllers with a single circuit, read the Advanced Cooling Circuit Design.



Basic diagram of cooling circuit

Each cooling element must accomplish the following requirements:

- **Pump**
  - Flow rate: 6 l/min.
  - Minimum pressure: 0.5 bar.
  - Activity: always on (while **MC110** is on).
- **Pipes connected to cold plate**
  - Water-glicol resistant
  - Able to join with the following ports:



Port diamaters (mm)

> **Tip**
>
> For cold plate connections, it is recommended to use fluoropolymer tubing with 8 mm of outside diameter and 6 mm of internal diameter.

- **Coolant**
  - Mixture water-glycol at 50 %, in order to have a freezing temperature below operating conditions.
- **Radiator**

  Radiator thermal conductivity (which is related to size) depends on motor power, switching frequency and battery voltage.

  Depending on each situation, the following tables show the minimum heat transfer of the required radiator.

Heat transfer for 10 kHz switching frequency (W/ºC)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V
15	50	50	150
30	100	100	*
45	100	150	*
60	150	150	*
75	150	200	*
95	200	200	*
110	200	200	*

Heat transfer for 16 kHz switching frequency (W/ºC)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V

Heat transfer for 16 kHz switching frequency (W/ºC)			
15	50	50	150
30	100	100	*
45	150	150	*
60	150	150	*
75	200	200	*
95	200	200	*
110	250	250	*

Heat transfer for 22 kHz switching frequency (W/ºC)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V
15	100	100	150
30	100	150	*
45	150	150	*
60	200	200	*
75	200	200	*
95	250	*	*
110	*	*	*

⚠ **Warning**

* : These situations involve an intensity higher to 250 A or overheating.

Tip

- The generated heat by the **MC110** increases with switching frequency and motor power. But it decreases with battery voltage.
- Be careful with the change of tube sections. If the coolant transitions from a small to a large section, air bubbles may remain.

Advanced Cooling Circuit Design

The power electronics of the **MC110** will produce heat and its temperature will increase. To prevent overheating, the heat will be absorbed by a liquid coolant according to the following equation:

$$Q = m \cdot c \cdot (T_{out} - T_{in})$$

- Q : heat produced by one single **MC110**.
- m : coolant mass flow.
- c : coolant specific heat.
- T_{out} : temperature of the coolant at the output of the coldplate and at the input of the radiator.
- T_{in} : temperature of the coolant at the input of the coldplate.

Q is assumed to be completely absorbed by the coolant, this assumption is considering the worst case scenario (adiabatic environment, which does not help at all).

The value of Q depends strongly on the switching frequency, input voltage (from battery) and motor power (hence intensity consumption). It can be obtained from the following tables, which assume an input coolant of water at 30 ºC (T_{in}) and 6 l/min:

Q for 10 kHz switching frequency (W)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V
15	200	250	950
30	400	450	*
45	600	750	*
60	850	1000	*
75	1100	1350	*
95	1350	1700	*
110	1750	2200	*

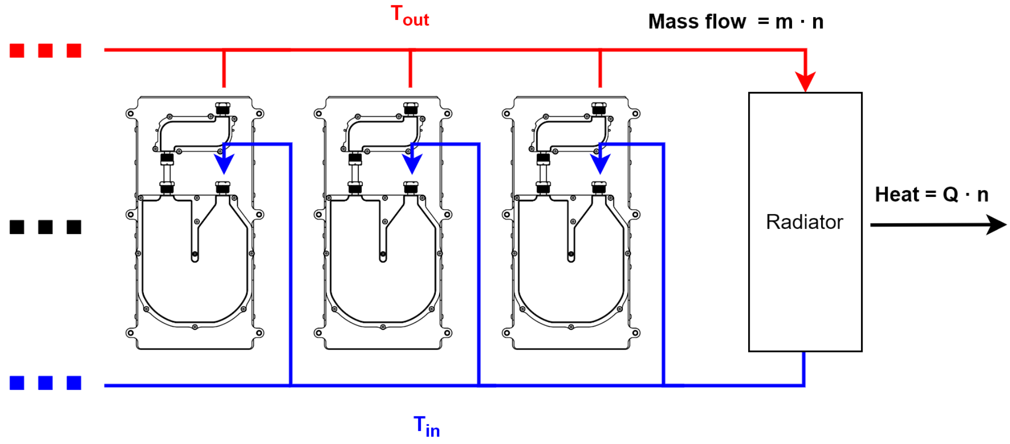
Q for 16 kHz switching frequency (W)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V
15	300	300	1000
30	550	600	*
45	850	950	*
60	1150	1300	*
75	1500	1750	*
95	2050	2250	*

Q for 16 kHz switching frequency (W)			
110	2550	3000	*

Q for 22 kHz switching frequency (W)			
Motor power (kW)	Battery voltage		
	800 V	550 V	100 V
15	350	350	1050
30	700	750	*
45	1100	1200	*
60	1550	1650	*
75	2050	2250	*
95	2650	*	*
110	*	*	*

> ⚠ **Warning**
>
> * : These situations involve an intensity higher to 250 A or overheating.

Once the heat transfer has been defined, the radiator can be chosen according to the required heat transfer capacity. Considering that each radiator dissipates the heat of several motor controllers.



Simplified diagram for multiple controllers

$$H = Q \cdot n / (T_{out} - T_{amb})$$

- H : heat transfer capacity.
- n : number of motor controllers for the radiator.
- T_{amb} : ambient temperature.

$$H = \frac{Q \cdot n}{T_{in} + Q/(m \cdot c) - T_{amb}}$$

By applying the previous equation to one **MC110** unit, users obtain the tables of the Simplified Cooling Circuit Design.

Troubleshooting

How to confirm that the MC110 is able to read a PWM signal

> ⚠ **Warning**
>
> For safety reasons, it is better to do this test without the motor connected or powered.

Power up the controller via user cable, without connecting the motor or the input power. If the input command is higher than the deadband, the MC will start to control (even though there is no motor connected). Then, a noise of 16 kHz will sound due to the PWM switching. If the input command is reduced to below the deadband, the MC and its noise will stop.

FAQ

Is it possible to use a standard PWM servo tester to control the MC110?

MC110 is thought to be controlled via CAN. PWM signal should be used for testing purposes. In case to desire using a transmitter, connect a receiver and use just one control channel (just one PWM signal).

Acronyms and Definitions

Acronym	Description
ATP	Acceptance Test Report
CAN	Controller Area Network
CAN FD	Controller Area Network Flexible Data-Rate
COC	Certificate Of Compliance
COM	COMmunications
ESC	Electronic Speed Control
ESD	ElectroStatic Discharge
ESS	Environmental Stress Screening
eVTOL	electric Vertical Take-Off and Landing
FAQ	Frequently Asked Questions
FOC	Field Oriented Control
GND	Electrical Ground
HBM	Human Body Model
HV	High Voltage Range
IGBT	Insulated Gate Bipolar Transistor

Acronym	Description
LV	Low Voltage Range
MC	Motor Controller
MTBF	Mean Time Between Failure
NTC	Negative Temperature Coefficient thermistor
OPTO PWM	OPTO-coupled PWM
PMSM	Permanent Magnet Synchronous Motor
PTC	Positive Temperature Coefficient thermistor
PWM	Pulse Width Modulation signal
RPM	Revolutions Per Minute
RS-232	Recommended standard 232
RS-485	Recommended standard 485
SIN/COS	Sine/Cosine
SN	Serial Number
UAV	Unmanned Aerial Vehicle
VCC	Voltage Continuous Current
VDC	Voltage Direct Current

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