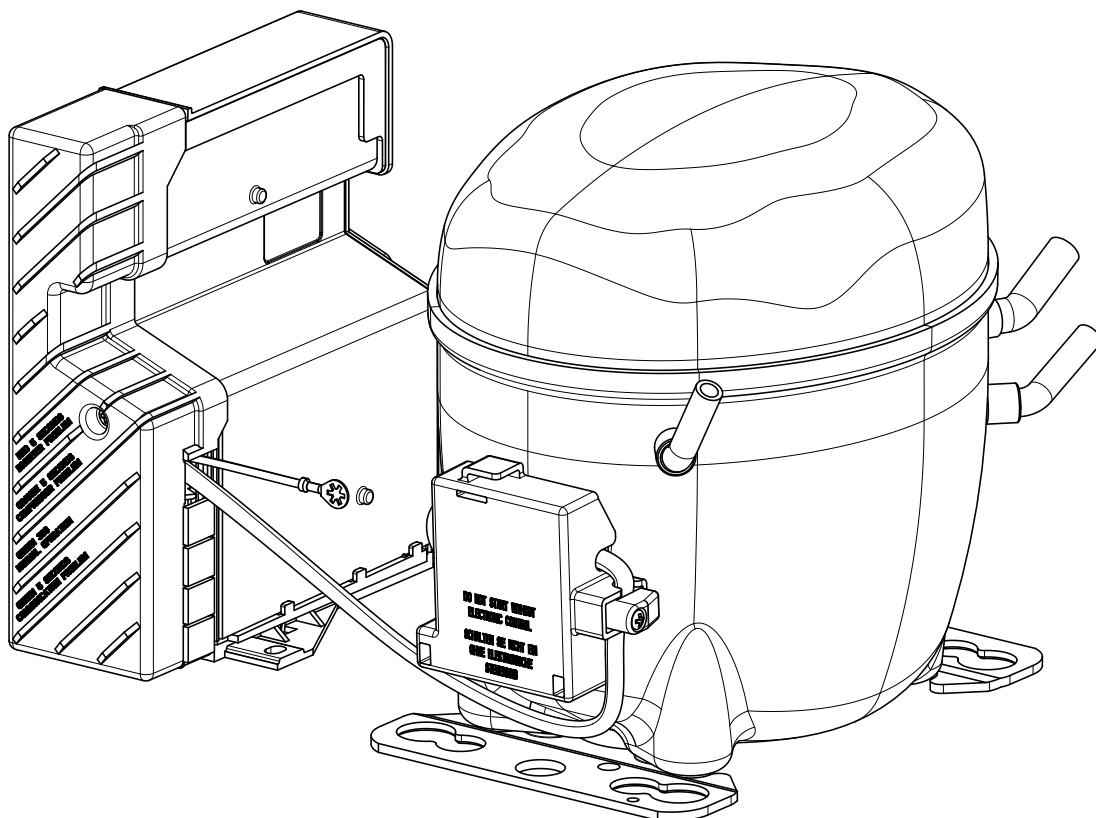# embraco

POWER **IN.**
CHANGE **ON.**

VARIABLE CAPACITY COMPRESSORS
ELECTRONIC INVERTER

Product Manual
Fullmotion
MP 2.0 Family

BEFORE YOU BEGIN

⚠ WARNING	Incorrect operation could result in bodily injury or death due to electrical hazard.
⚠ CAUTION	Incorrect operation could cause bodily injure or could result in equipment damage.
NOTICE	Contain helpful suggestions or references to material not covered in this document.

Contents

CONTENTS

GENERAL PRECAUTIONS

WARNING

- This product must be grounded. The low resistance test described on standard IEC 60335-1 Article 27.5 shall be performed in the final appliance to assure ground connection.

- Make sure that Fullmotion MP 2.0 Inverter will not be in direct contact with flames during assembly.

- The location where the Inverter will be installed must be protected against splashed water from all directions.

- Permanent damage will occur if the Compressor is directly connected to the AC power supply.

- Fullmotion MP 2.0 Inverter is classified as ambient pollution degree 2 according to UL60730-1, meaning that cares shall be taken about temporary conductivity caused by condensation.

- Do not open the Inverter box. For installation, remove only the Inverter Cover to make the electrical connections.

CAUTION

- This inverter is for use only with the Fullmotion Embraco compressors.

- Read this material carefully before you begin the Fullmotion MP 2.0 Inverter installation and start up procedure.

- To prevent damage to your inverter during and after assembly, avoid contacting with the following substances: Hydrocarbons; Ester based oils (e.g.: compressor oil); Phenols; Amines; Ketenes; Automotive fluids such as grease, except glycol and heavy alcohol.

Chapter 1

INTRODUCTION

Embraco's Variable Capacity Compressors MP 2.0 is ideal for commercial applications where wide voltage range, fast pull down, better performance, fine temperature control, lower power consumption and very low noise and vibration levels are required. This is possible thanks to the use of an electronic inverter capable of driving the compressor at different speeds and consequently, controlling its refrigeration capacity.

Efficiency	Variable Capacity Compressors technology allows the compressor to operate at different speeds, adjusting itself according to demand. When side by side with a conventional compressor, the energy consumption is up to 45%.
Flexible	Indicated for commercial refrigeration system, provides more flexibility in customized solutions through inclusion of even smaller products and the use of electronics already coupled to the compressor.

1.1 Product description

1.1.1 Stand alone

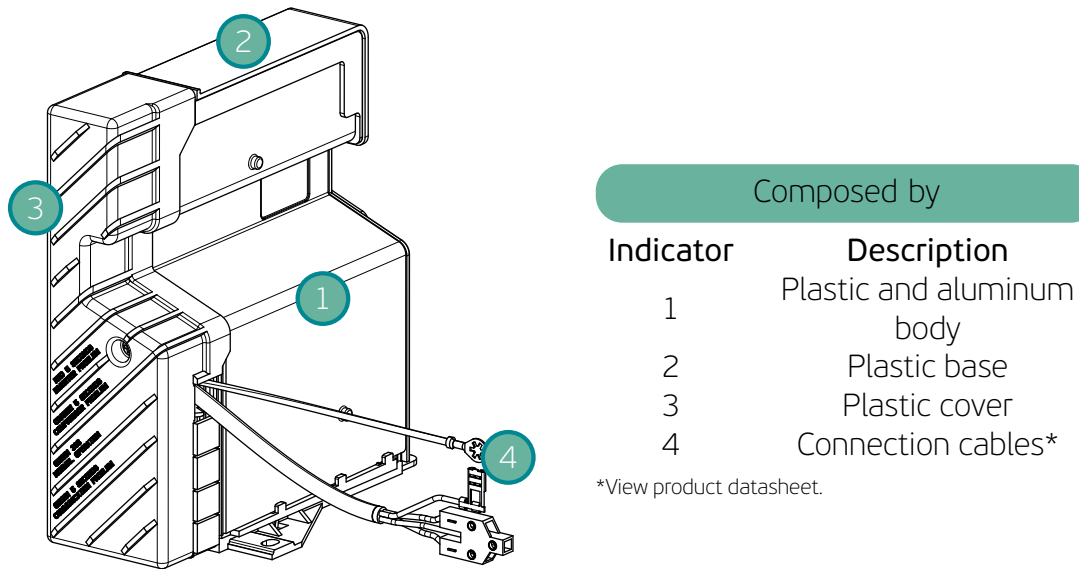| Composed by	
Indicator	**Description**
1	Plastic and aluminum body
2	Plastic base
3	Plastic cover
4	Connection cables*

*View product datasheet.

Figure 1.1: Stand alone view.

1.2 Package information

The inverters are packed in a carton paper box. Figure 1.2 shows the used box to pack the product. The quantity of products inside the box may change due to internal or external requirements. Box dimensions can be changed without previous information.
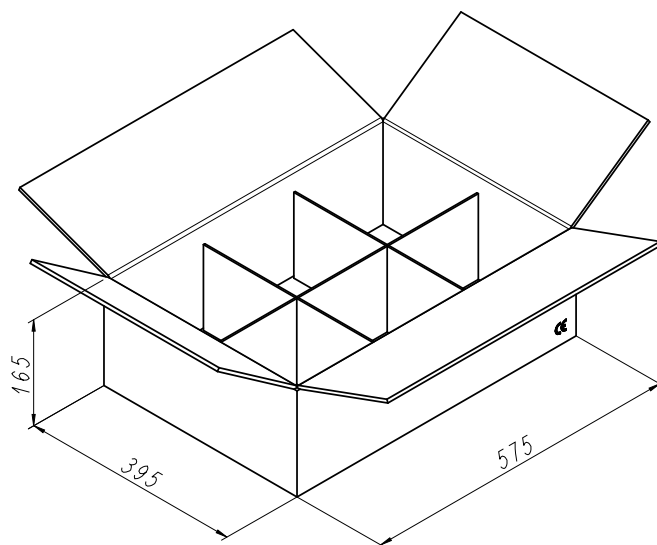

Figure 1.2: Product package.

- Before you begin your installation observe technical specifications and proper connections.

- Check if product is properly identified and if it's enclosure is without cracks.

CAUTION

1.3   Product handling

- Inverter is sensitive to Electrostatic Discharges. Take care with product handling until final assembly.

- Special care must be taken to avoid mechanical impacts on the inverter during assembly process.

- The environment must be properly protected against ESD.

- The workers that handle the inverter must be grounded through adequate ESD wrist strap and must wear ESD gloves.

- Do not hold by the wiring.

- Do not use if drop the inverter.

CAUTION

1.4   Institute approval

Institute approval		
Fullmotion MP 2.0 Inverter	c ᴿᵁ® US	Approved according to UL60730-1 ed. 4. File ref. E222315, Volume 3, Section 3.

Chapter 2

TECHNICAL SPECIFICATIONS

2.1   Nomenclature

MP	2.0	B	KK	XX.WW	Y	ZZ

MP	Family of the inverter	
2.0	Product version	
B	Power supply:	120 V / 50-60 Hz
KK	Software version	
XX.WW	PEC/Hardware version	
Y	Enclosure version	
ZZ	Cables and peripherals	

Example: MP 2.0 B 00 AA.AA A AA

MP	MP Family
2.0	Product version
B	120 V / 50-60 Hz
00	Software version 00
AA.AA	PEC/Hardware version AA
A	Stand alone
AA	Cable configuration type*

*View product datasheet.

2.1.1 Label information

Next image shows the product label description.
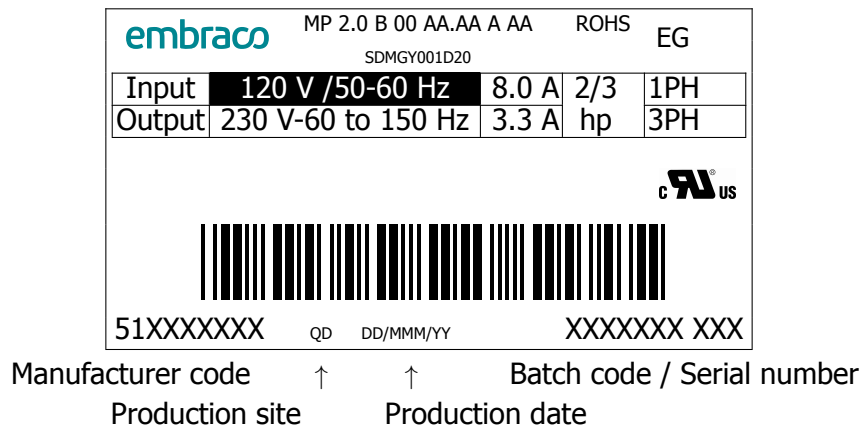
Electrical	
Voltage rating	120 V
Voltage range	70 to 140 V
Input frequency range	50 Hz to 60 Hz
Maximum input current	8 A
Maximum input power	540 W
Stand by consumption	< 0.9 W
Output frequency range	60 Hz to 150 Hz
Maximum output current	3.3 A
Maximum output power	500 W
Control modes	Frequency, Drop-In and Serial
Compressor	
Compressor*	VEGT11HB or VEGT8U
Compressor speed range*	1800 rpm to 4500 rpm
Ambient and Storage	
Air forced ventilation (min)	2 m/s
Ambient temp. range	-20 ºC to 60 ºC
Ambient humidity	< 85%
Storage temp. range	-40 ºC to 85 ºC
Storage humidity	Less than 85%

*View product datasheet.

2.2 Product Specifications

WARNING

- Do not connect the Fullmotion MP 2.0 Inverter to 220V – 240V power supply.

CAUTION

- Exposure of the product to voltages over 140 V may affect its reliability. Also, when operating under 120 V input, the maximum compressor cooling capacity is reduced as consequence of speed limitation.

- Confirm compressor type and speed rotation at product datasheet.

NOTICE

- Voltage range is only for product functionality but not according to institute approval.

- Maximum power is not reached under all input voltage range.

- Maximum power is only achieved with minimum forced ventilation of 2 m/s over the heat sink.

- Output frequency and motor speed may have reduced range based on maximum working conditions of the respective compressor.
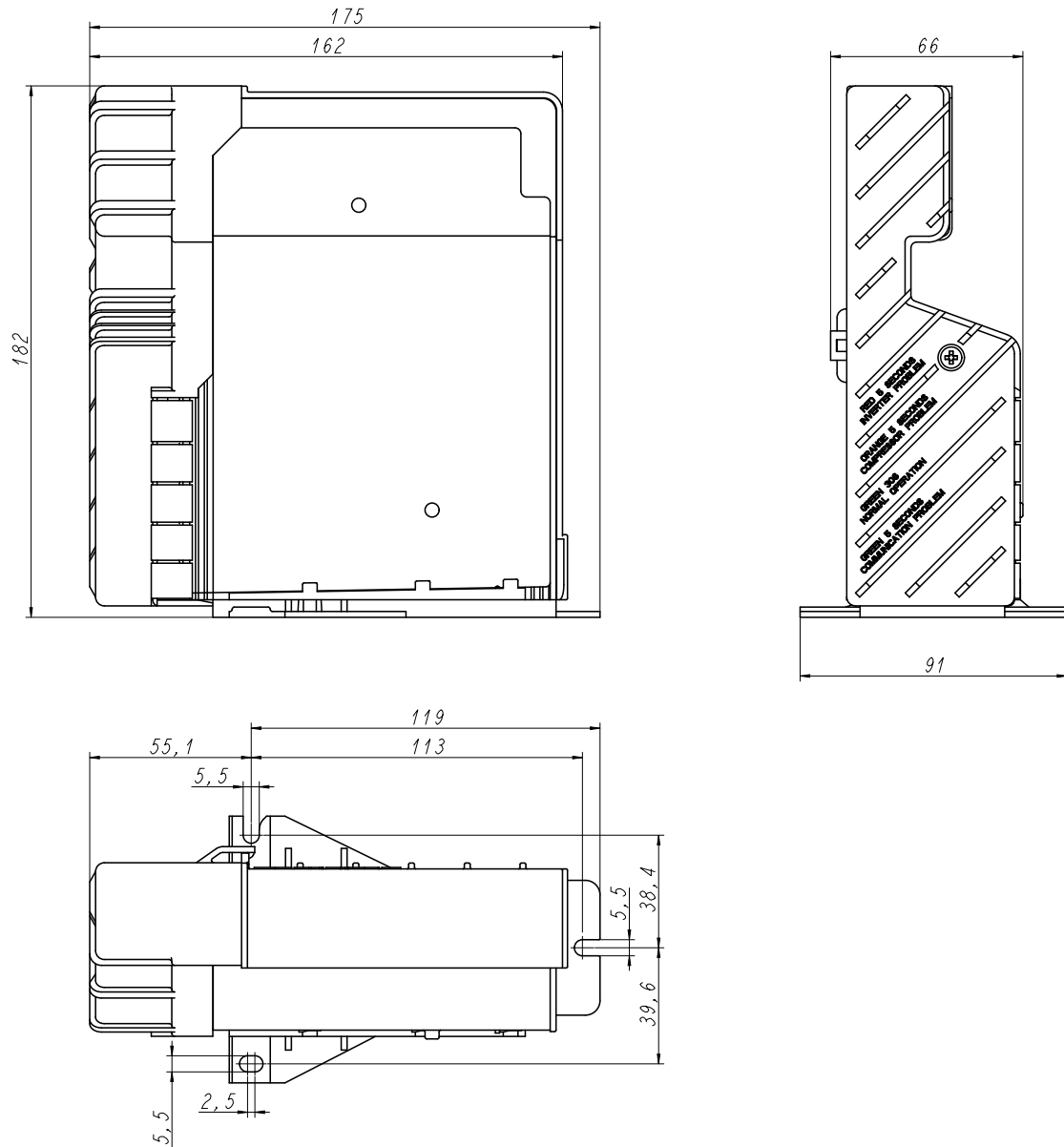
2.3 Enclosure

2.3.1 Product dimensions

Figure 2.1: Stand alone dimensions

Stand alone dimensions	
Dimensions	182 mm x 175 mm x 91 mm

2.3.2 Connectors

This section shows the available connectors of Fullmotion MP 2.0 Inverter, as well as their propper connections. The final enclosure without plastic cover is presented

to improve understanding. The manufacturer part number of each connector can be found bellow.
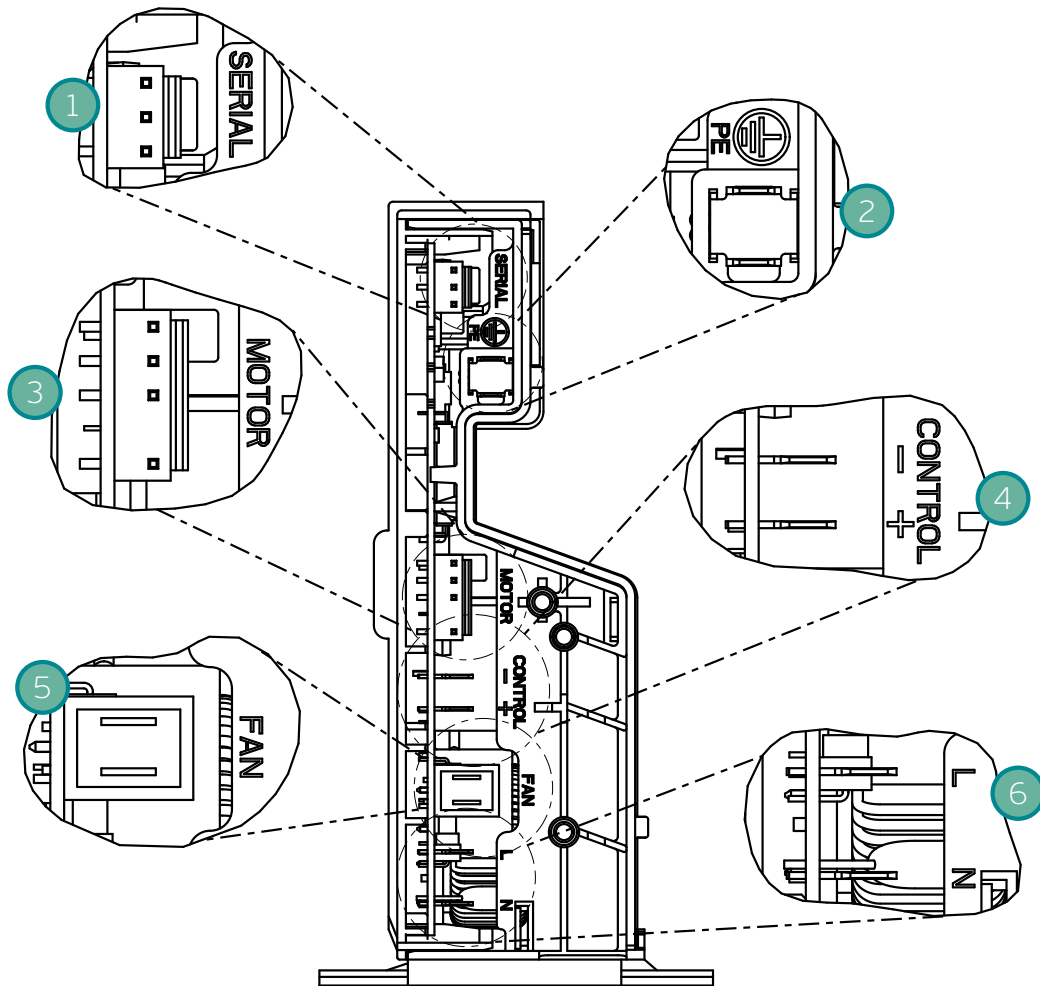

Figure 2.2: Connectors.

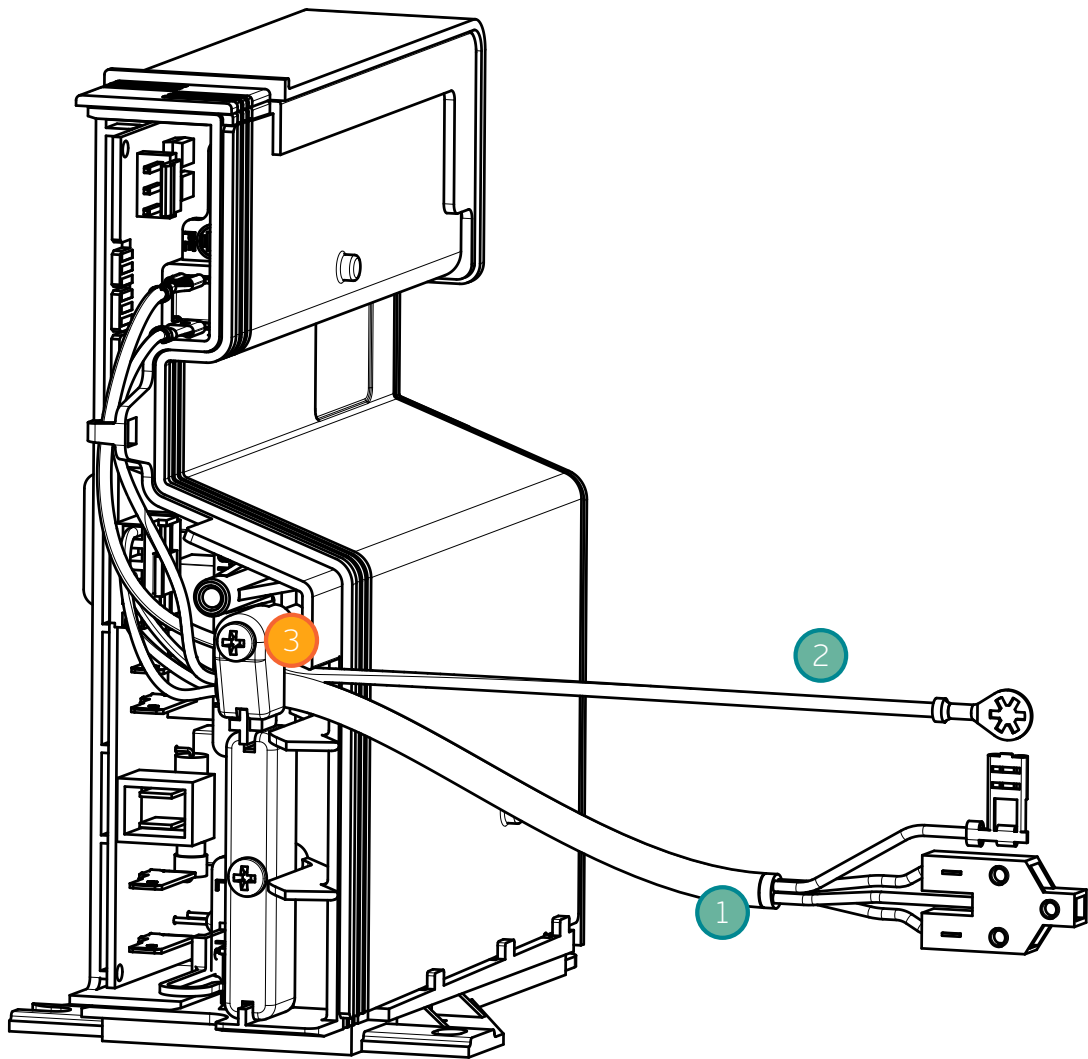| Connectors part numbers				
Indicator	**Description**	**Part number**	**Manufacturer**	**Insulation**
1	Serial Communication	S3P-VH (LF)(SN)	JST	Reinforced
2 & 3	Cables provided by Embraco			
4 & 6	Control and AC input (L+N)	1217754-1	Tyco	Functional
5	AC Fan*	MSLO 9402 - 002 - 00A - 960 - 000 - 00	Stocko	--

*Mates with 1/4" faston receptacle.

Figure 2.3: Connection cables.

Cable Specification		
Indicator	Description	Part Specification
1	Motor Cable	UL Style 2517 105 ºC 300 V
2	Ground Cable	UL Style 1028 105 ºC 600 V

NOTICE	• Do not disassemble the fixing clip indicated on the item 3 on Figure 2.3.

2.3.3 Product discards

> **! CAUTION**
>
> - Do not open the inverter box.
>
> - Do not incinerate any inverter. Contact your local authorities, if you need to incinerate this product for disposal.
>
> - Inverters should not be mixed with general waste.

> **NOTICE**
>
> - If you wish to discard this product, please contact your local authorities or dealer for the correct method of disposal, for proper treatment, recovery and recycling.
>
> - This device is RoHS compliant, nevertheless the correct disposal of this product will help to save valuable resources and prevent any potential negative effects on human health and the environment (e.g.: to avoid ground disperse) which could otherwise arise from inappropriate handling.

Chapter 3

INSTALLATION

3.1 Assembly instructions

3.1.1 Inverter
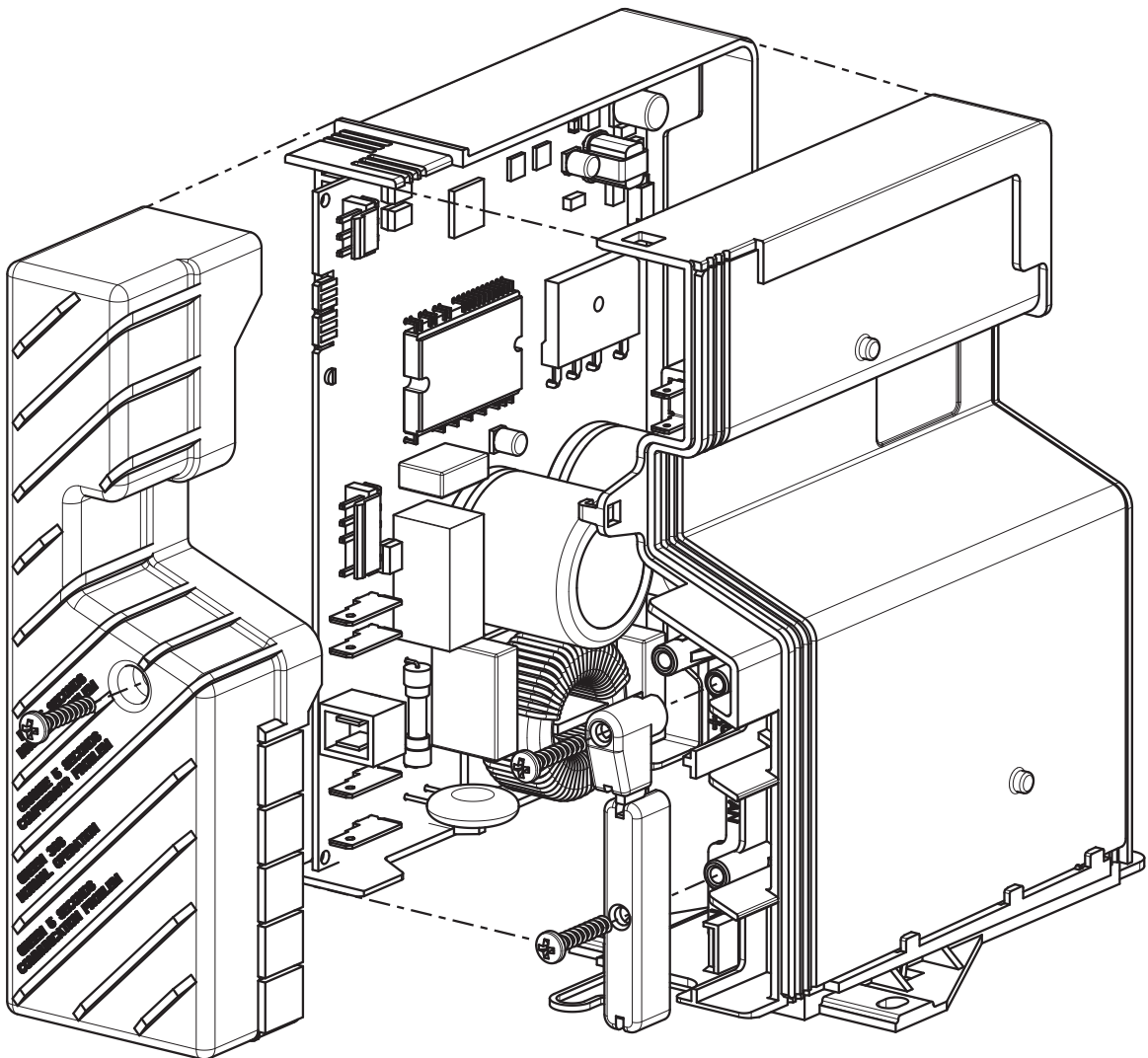
3.1.2   Motor cable connection

The Fullmotion MP 2.0 Inverter has a quick and easy assembly method. To connect to the compressor the following sequence must be addopted.

1. Connect the motor cable on the hermetic compressor terminal;

2. Connect the Ground connector on the compressor ground terminal.
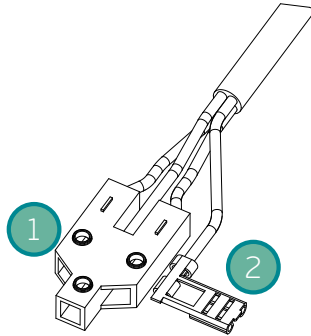

Figure 3.1: Compressor (1) and Ground (2) connectors
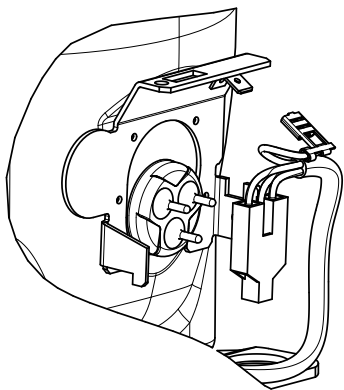

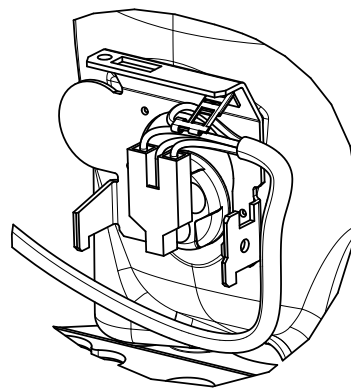Figure 3.2: Step 1   Figure 3.3: Step 2

After performing the connections, assemble compressor fence cover as shown in the following sequence (Step 3 and 4).

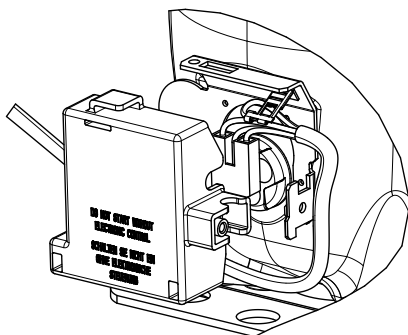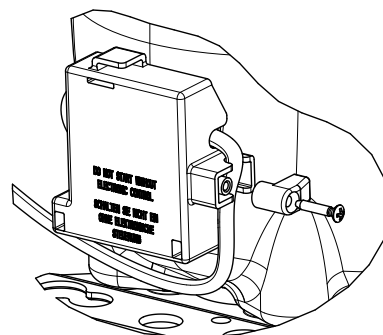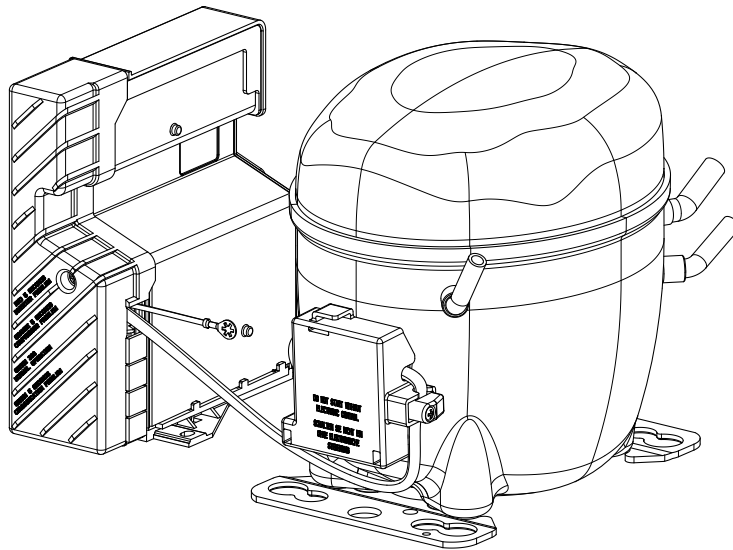Figure 3.4: Step 3   Figure 3.5: Step 4

Figure 3.6: Perspective view of Inverter and Compressor assembled system.

To disassemble the fence conver, the following sequence must be addopted.

1. Introduce a screwdriver into the clip in the top of the fence cover and push it down;

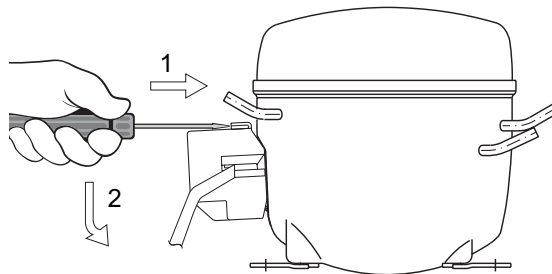2. To remove the cover, push it down and pull out of the compressor.
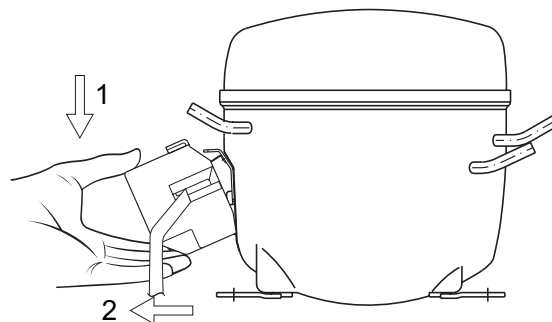

Figure 3.7: Step 1

Figure 3.8: Step 2

WARNING

- Before obtain access to connectors, disconnect the AC power supply.

- Avoid contact of the Control Input Cable (low voltage) with high voltage or power supply cables, due to electrical hazard and potential equipment damage.

CAUTION

- Motor connector must be properly mounted on the 3 pins of compressor hermetic terminal. Bad connection will cause bad compressor functioning.

- The screws shown in Figure 3.5 must be fixed with a torque within 0.8 – 1.2 Nm range.

- The handling of Inverter box must be careful to avoid contact with the internal electronic board, in order to prevent possible electrostatic discharges.

- Make sure all necessary connections are properly done before connecting the Inverter to AC supply line.

- The electronic Inverter must be installed in the vertical position.

- When using Serial or Frequency communication mode, the inverter has reinforced isolation. Neverthless, in the Drop-In mode (energized or dry-contact) this functionality is not available.

- Ground connector must be properly assembled until the terminal locks.

- To disconnect the motor cable, insert a screwdriver between the connector and the compressor terminal to make a lever and then pull it back.

> **NOTICE**
>
> • It is necessary to read the Embraco compressor documents that contain technical information about the Fullmotion compressors, not covered in this material. Please, contact the compressor technical assitant.

3.1.3 Forced ventilation

The direction of the air flow must be as shown in Figure 3.9.
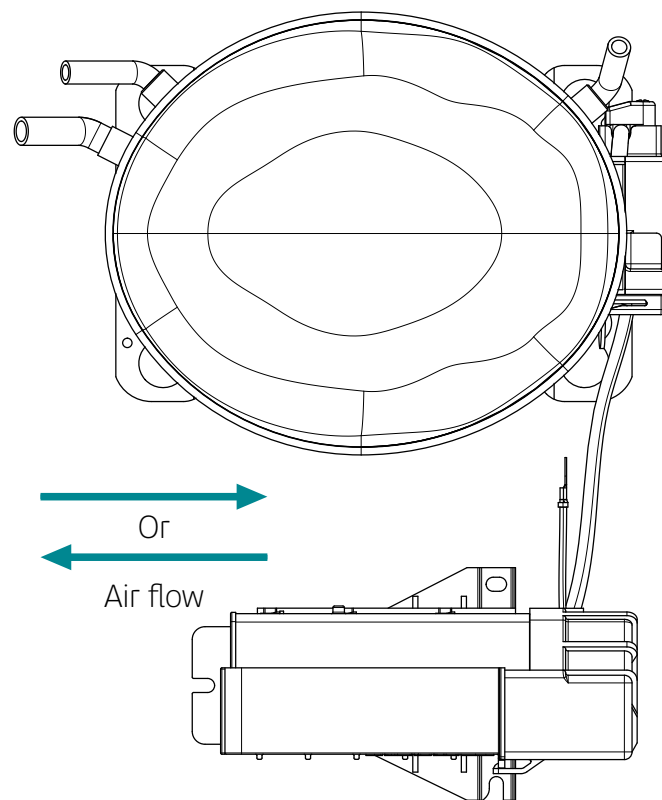

Or

Air flow

Figure 3.9: Air flow direction.

> **! CAUTION**
>
> • In order to avoid loss of performance, make sure that the heat sink is not obstructed from the air ventilation.

3.1.4 Fan connection (optional)

The fan must be connected to the Inverter board according to the following image, where the indicators are referenced to Figure 2.2.
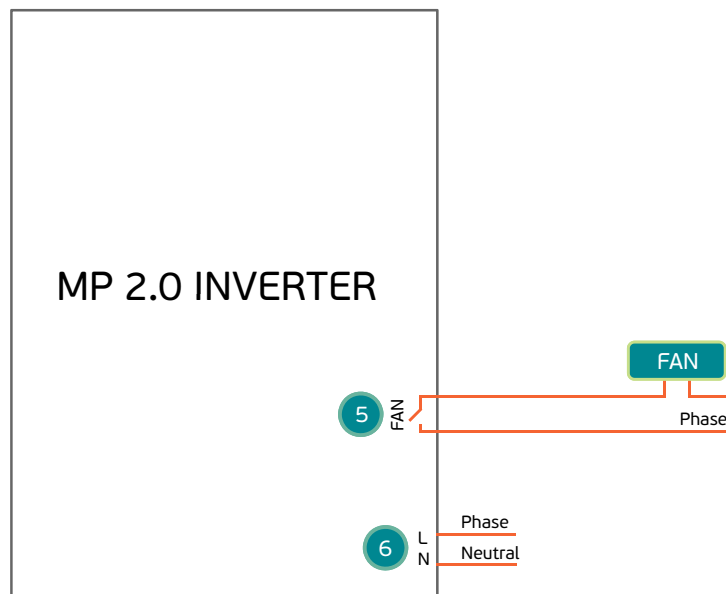
Figure 3.10: Fan connection.

> ⚠ **CAUTION**
> - The maximum voltage of the inverter relay is 250 V.
> - The maximum current of the inverter relay is 1.5 A.

3.1.5 Input, Fan and Communication cables arrangement

The input, fan and communication cables are not provided by Embraco. Furthermore, the customer must arrange the cables according to the following instructions.

1. Break the plastic protection as much as necessary to pass the cables. The cables must pass through the cord relief as shown in Figure 3.11

2. Assemble the fixing clip as shown in Figure 3.12.

Routing Description	
Indicator	**Description**
1	Input Cable
2	Fan Cable
3	Communication Cable
4	Fixing Screw

Figure 3.11: Step 1

Figure 3.12: Step 2

CAUTION

- Avoid routing cables over the cord relief, otherwise the product may damage due to mechanical stress.

- The screw shown in Figure 3.12 must be fixed with a torque within 0.8 - 1.2 Nm.

- After concluded the routing, the plastic cover must be reassembled, fixing the scew with a torque between 0.8 - 1.2 Nm.
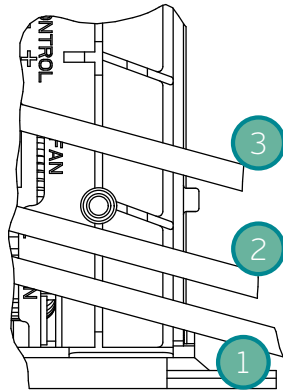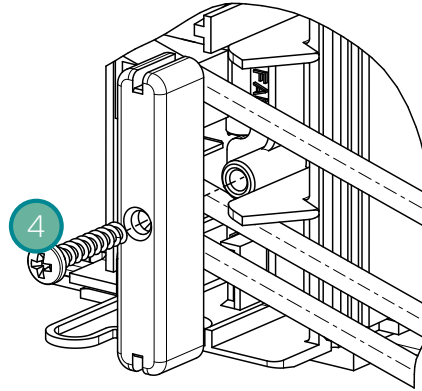
Chapter 4

OPERATION

The Fullmotion MP 2.0 Inverter has 3 communication mode available: Drop-In, Frequency and Serial. For all the available control modes, the fan relay is turned on automaticaly, whenever the compressor is running.

> ⚠️ **CAUTION**
>
> - The Control Mode is chosen by the customer and configured at the EMBRACO ELECTRONICS manufacturing line.

4.1   Frequency control mode

In this mode of operation the compressor speed is controled through a frequency signal sent to the inverter. Usually this signal is provided by an electronic thermostat.

The frequency signal is a digital square wave and its characteristics are described on Signal specification table and Figure below.

Signal specifications	
Voltage range	-5 V to +15 V
OFF state	-5 V to +0.7 V
ON state	+5 V to +15 V
Maximum duty-cycle	70%
Minimum duty-cycle	30%
Maximum current	15 mA @ 15 V
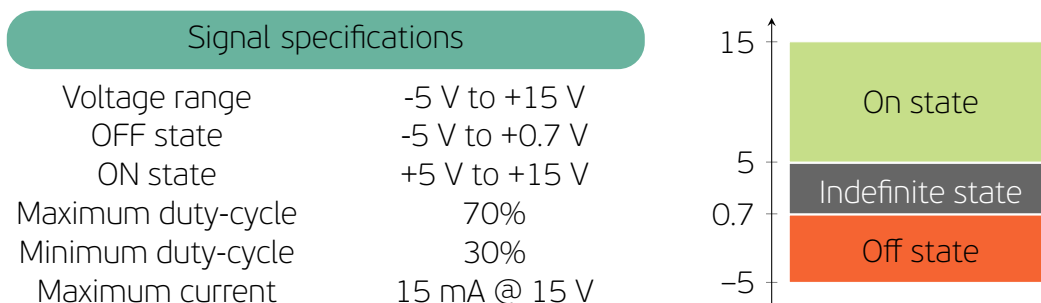
Once the range from 0.7 V to 4.5 V is an indefinite state, it's recommended to avoid it. The following graphic shows an example of an input frequency signal of 100 Hz sent to the inverter. The duty-cycle of the digital frequency wave can vary from 30% to 70%.

Signal control shape
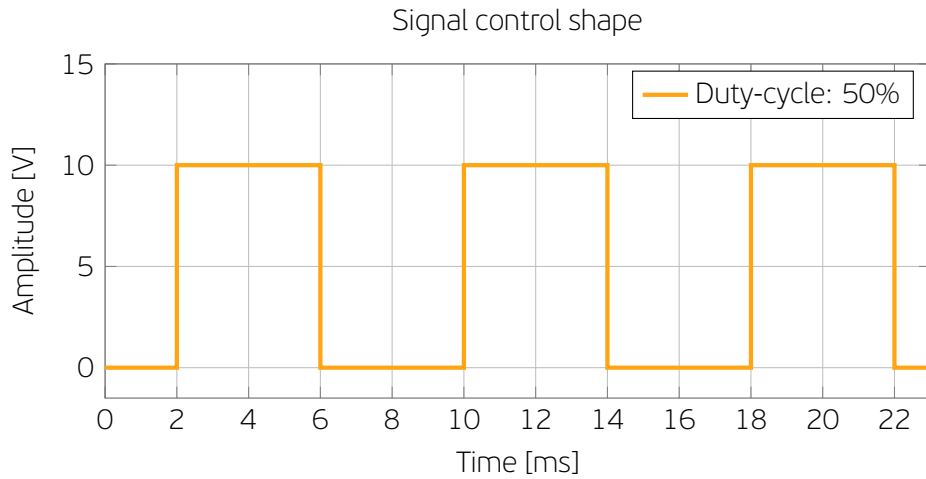
The compressor will follow frequency signal sent to the inverter according to the relation described on the following table and illustrated on the graph.

Input Frequency Signal [Hz]	Compressor speed [RPM]
0 to 50	0
50.1 to 59.9	1800
60 to 150	30 x Hz
>150	4500

Compressor speed versus Frequency signal
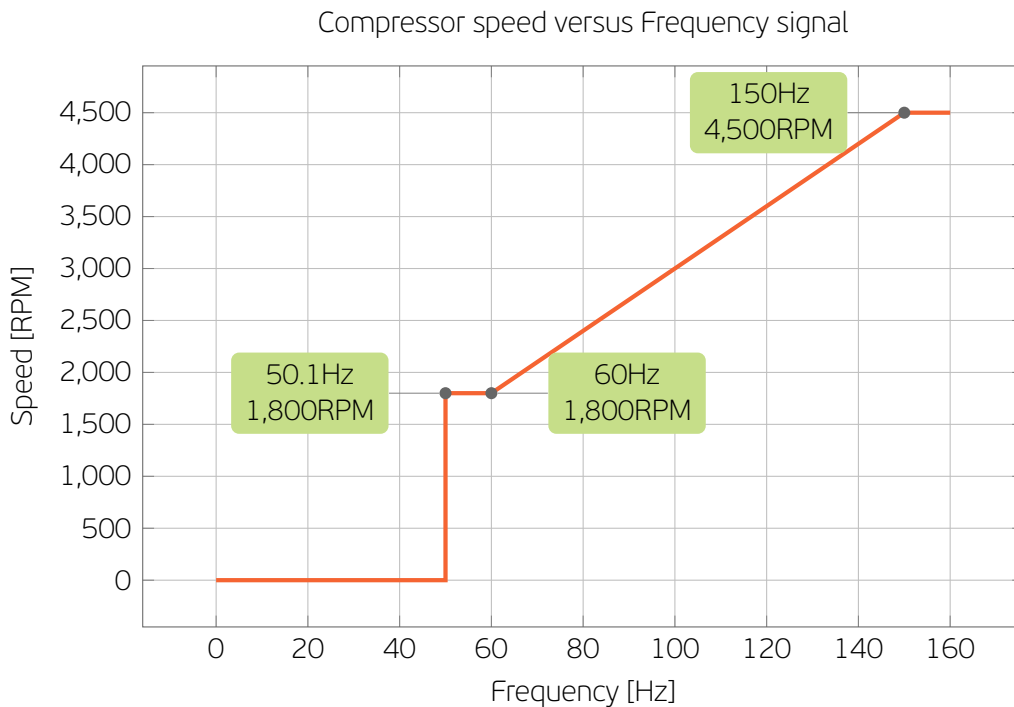
The following figure shows the right way to perform the Frequency Control Mode connection according to the connectors described in Figure 2.2.
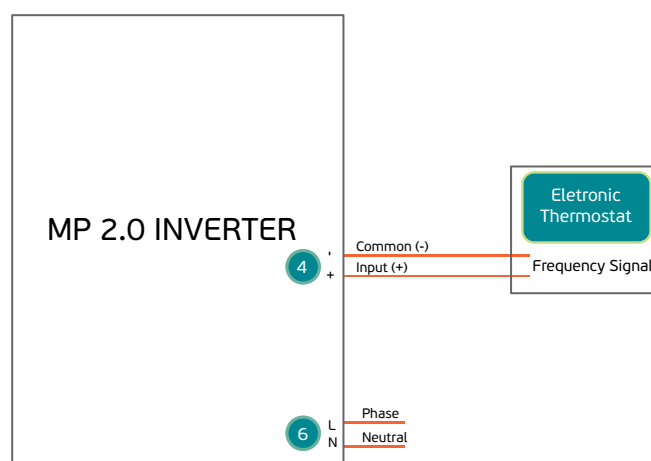
Figure 4.1: Frequency control mode connetion

> **NOTICE**
>
> • For Frequency Control Mode, the input resistance is 1.2 kΩ.

4.2   Drop-In control mode

The Drop-In mode is a Fullmotion MP 2.0 Inverter control mode, where single thermostat contact is used to set the compressor running conditions. Drop-In mode allows the application to any refrigeration system with a simple ON/OFF thermostat, without needing a control signal coming from an electronic thermostat. The compressor speed will be adjusted automatically by the Inverter, in accordance to the thermal load variation.

4.2.1   First time Pull-down

After 7 minutes of intermediary speed, the speed is increased to maximum and it is kept at this rotation until the thermostat opens, switching the compressor off.

4.2.2   Normal cycling

Compressor speed increases and decreases proportional to thermal load variation during compressor running time. Minimum speed will be targeted to minimize energy consumption.

4.2.3   Stabilization

If thermal load remains constant for a period longer than 20 minutes, the compressor speed is increased.

Compressor speed versus thermostat behavior
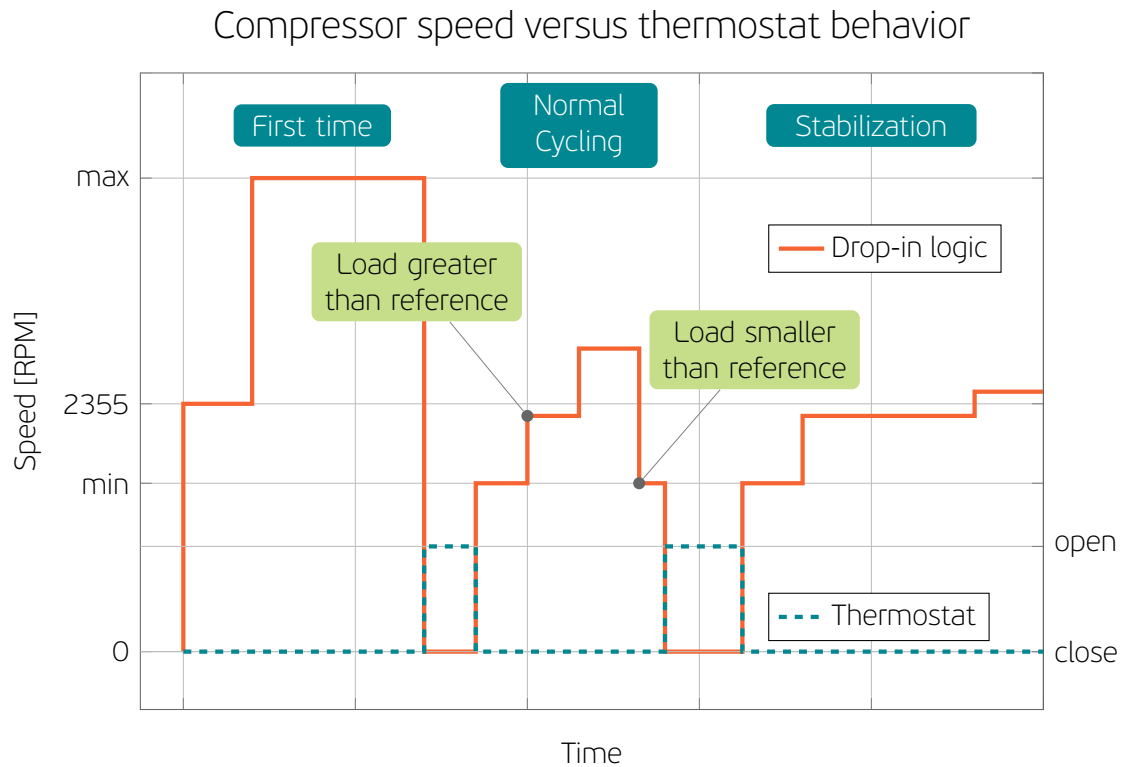
4.2.4   Contact options

There are two working options for Drop-In mode: Energized Contact and Dry Contact/or Isolated Contact. Energized Contact must be used when the thermostat control signal is energized directly from the AC phase. This signal is usually called Thermostat Return Signal.

Dry Contact must be used when the thermostat control signal passes through a "dry contact". It means the thermostat has just a switch, without any kind of energy supply, connected directly to the Control Input Connection.

The following images show the connections for both Drop-In communication options.
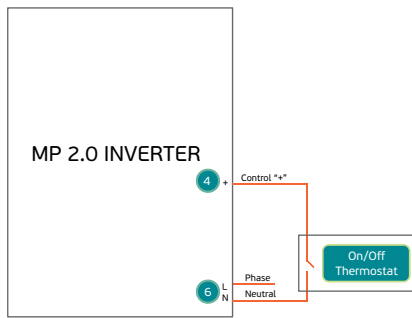
Figure 4.2: Energized Contact Drop-In connections.
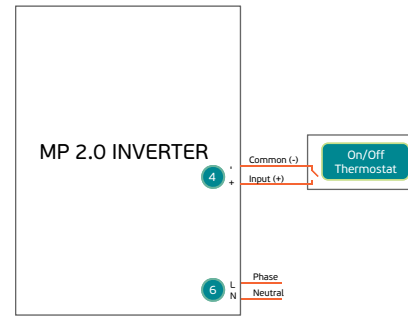
Figure 4.3: Dry Contact Drop-In connections.

> **⚠ CAUTION**
> - When opened, the thermostat impedance must be higher than 380 kΩ. Otherwise the compressor can run continuously, without ever turning off.

> **NOTICE**
> - All main parameters, such as minimum and maximum speed are described at product datasheet.

4.3 Serial control mode

This option is used when an electronic thermostat controls the MP 2.0 Inverter using a serial communication protocol. Based on Embraco protocol it is possible to define the compressor speed and check other parameters.

4.3.1 Serial specifications and Internal Circuit

The Serial Control mode has an isolated input stage provided by the usage of optocouplers. The circuit on Figure 4.4 shows the electrical connections to perform serial communication between an electronic thermostat and Fullmotion MP 2.0 Inverter serial connector (CN203).

The input resistance for serial comunication, shown in Figure 4.4, is 1.2 kΩ.
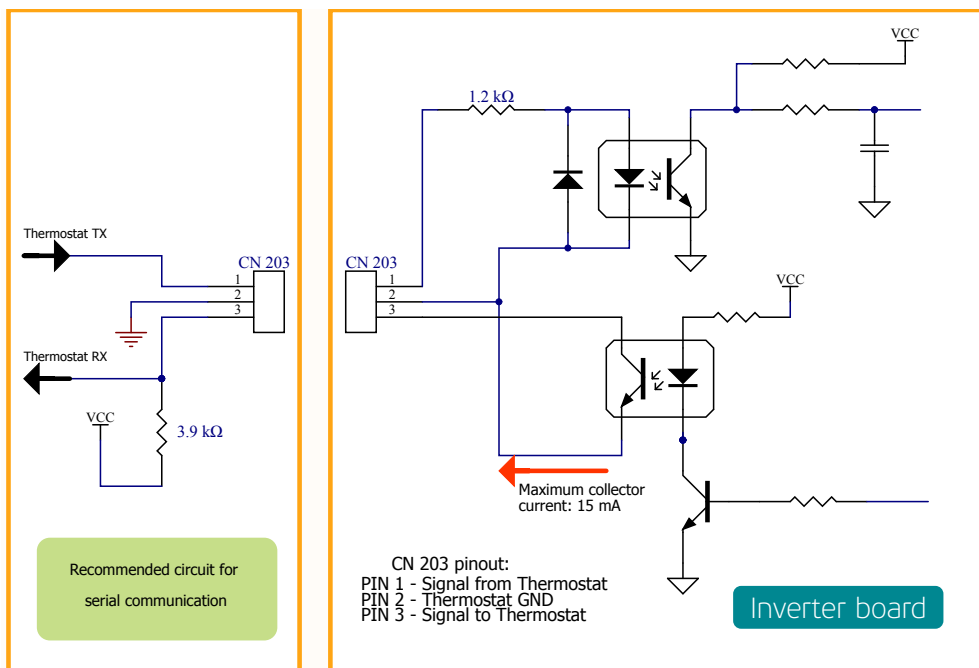
Figure 4.4: Electrical schematic of serial communication.

To guarantee the correct functionality of serial comunication, the signal sent to the inverter must be according to the following values.

Signal specifications	
Voltage range	-5 V to +15 V
TRUE state	-5 V to +0.7 V
FALSE state	+5 V to +15 V
Maximum current	15 mA @ 15 V
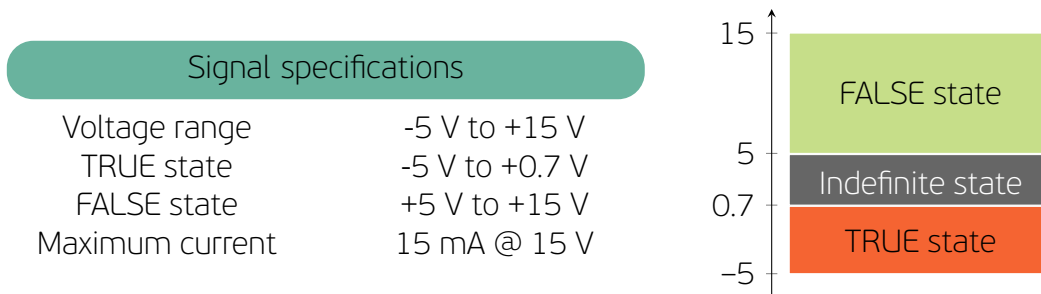
Example: 39h sent to inverter
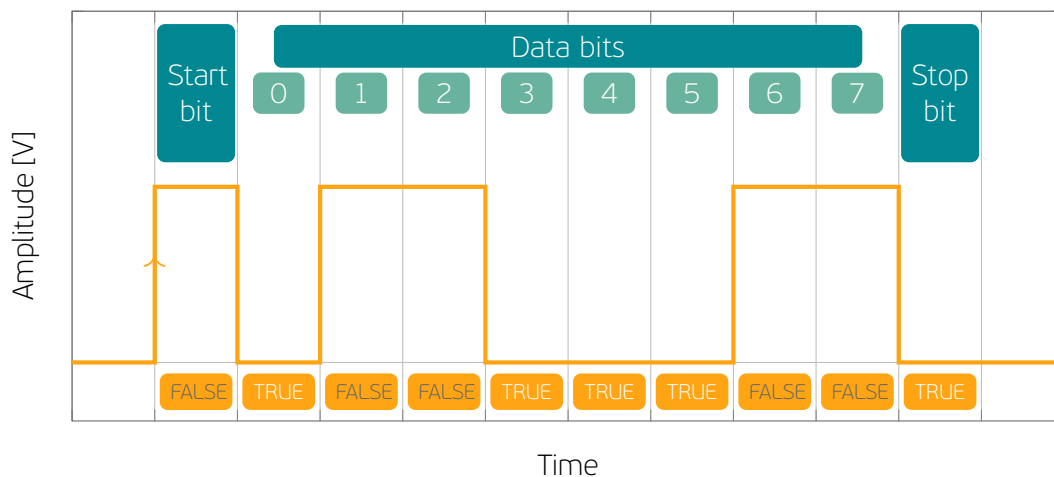
The identification byte (1st byte), is used for command synchronization. After inverter identifies a valid A5h, it starts to read the next 4 bytes. After reading, a re-

sponse will be sent as indicated on "Receive commands structure" table. No response will be sent until the inverter recognizes a byte A5h. There is a time out of 2 seconds to receive the entire command after inverter identifies one A5h. After this time out, a new synchronization will start.

Basic specification	
Communication type	UART (Half-Duplex)
Baud rate	600 baud
Parity	None
Flow control	None
Unit size	5 Bytes
Electronic thermostat	Host
Inverter	Slave

To perform serial communication between a computer (RS-232) and the Fullmotion MP 2.0 Inverter serial connection, please contact EMBRACO ELECTRONICS to receive instructions.

4.3.2   Commands

Command structure				
1st Byte	2nd Byte	3rd Byte	4th Byte	5th Byte
Indentification (ID)	Command (CMD)	LSB*	MSB**	Checksum*** (CK)

*Least significant Byte (LSB) of Data. Example: Data=ABCDh, thus Data low=CDh.

**Most significant Byte (MSB) of Data. Example: Data=ABCDh, thus Data high=ABh.

***Checksum=100h - (S14h AND 0FFh), where S14h is the addition of Bytes 1 to 4.

Transmit commands structure					
Command	ID	CMD	LSB	MSB	CK
Set speed	A5h	C3h	Speed [RPM]		CK
Read set speed	A5h	3Ch	80h	39h	CK
Read operation status	A5h	3Ch	83h	39h	CK

Receive commands structure					
Response to:	ID	CMD	LSB	MSB	CK
Set speed	5Ah	83h	Status*		CK
Read set speed	5Ah	80h	Speed [RPM]		CK
Read operation status	5Ah	83h	Status*		CK
Communication error	5Ah	Code**	FFh	FFh	CK

*See Status Data table.

**See Error Code table

Status Data

H Bit	LSB	MSB	Description
-	-	00h	Compressor running
-	-	FFh	Compressor stopped
0	01h	-	Start fail
1	02h	-	Overload
2	04h	-	Under speed (1550 rpm or lower)
4	10h	-	Short circuit
5	20h	-	Over temperature
7	80h	-	Set speed out of range

Error Code

Code	Error
F0h	Error in 4th Byte
F2h	Checksum error
F4h	Command erro
F8h	Error in the 3rd Byte

If compressor is stopped due to a fail (see Data Status table), it is possible to reset that fail sending a speed command to turn inverter off (0 rpm set speed). However, if nothing is done, the fail reset will occur after 8 minutes and then the compressor will try to restart. The following example shows a situation where the compressor speed is set at 1800 RPM.

Example: Set compressor at 1800 RPM

Step 1: select proper command
    Command for selecting a speed is **Set speed**
    ID →A5h
    CMD →C3h
Step 2: transform speed from decimal into hexadecimal base
    1800d →0708h
Step 3: split lower and higher Bytes
    LSB →08h
    MSB →07h
Step 4: calculate sum of first 4 Bytes
    S14h=A5h+C3h+08h+07h
    S14h→177h
Step 5: boolean logic to maintain sum as 8-bit
    L14h=0FFh AND S14h
    L14h →77h
Step 6: calculate checksum
    CK=100h-(0FFh AND S14h)=100h-77h
    CK= →89h

Command: A5h C3h 08h 07h 89h

NOTICE

- To avoid noise increasing and damages to the compressor due to mechanical resonance, some rotations tracks are forbidden by software for all control modes.

- When one or more errors occur, the corresponding "H" bits are set to 1. Example: Overload and Under speed **LSB** →**06h**.

- The Frequency and Drop-In modes can have serial communication only for monitoring purpose. This functionality can be used for product diagnostic.

Chapter 5

DIAGNOSTICS

The Fullmotion MP 2.0 Inverter has two diagnostics methods, by visual light emission using a LED indication, or by serial communication protocol.

5.1 LED indication
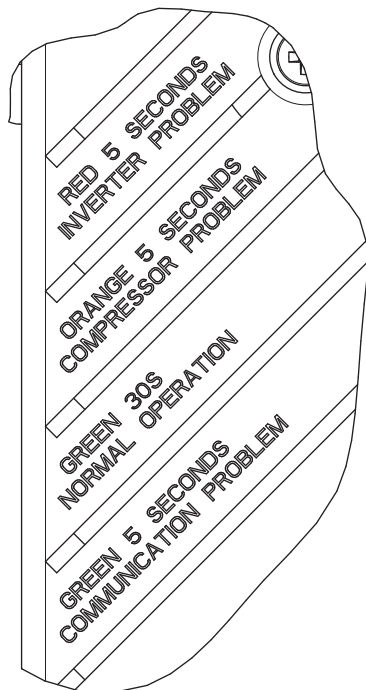
The LED diagnostic unit can be seen through the translucent cover, which also provides the basic information for diagnostic. This function helps services technicians to diagnose possible fault components by blinking a green, orange or red LED inside the box. Basically it indicates if there is a problem with Compressor, MP 2.0 Inverter or Thermostat. The table below describes the failure modes.

LED Status	Period	Description
1 Green Flash	30 seconds	Normal operation
4 Green Flashes	5 seconds	Communication problem
4 Red Flashes	5 seconds	Inverter problem
4 Orange Flashes	5 seconds	Compressor problem

5.2   Serial monitoring

For both Drop-In (energized and dry-contact) and Frequency control modes, there's the possibility of performing a serial communication. For both control modes, this communication is only for monitoring purpose. The electrical connections shall be performed as represented in Figure 5.1 and Figure 5.2.
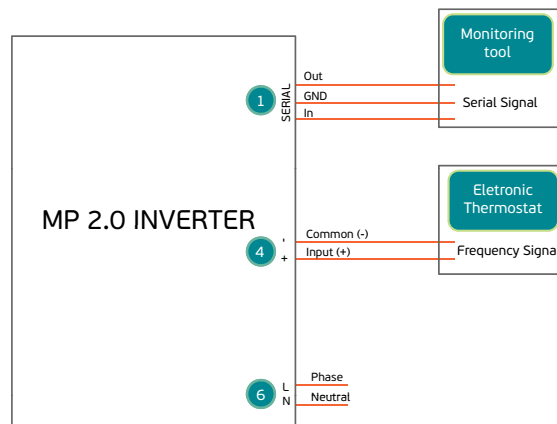

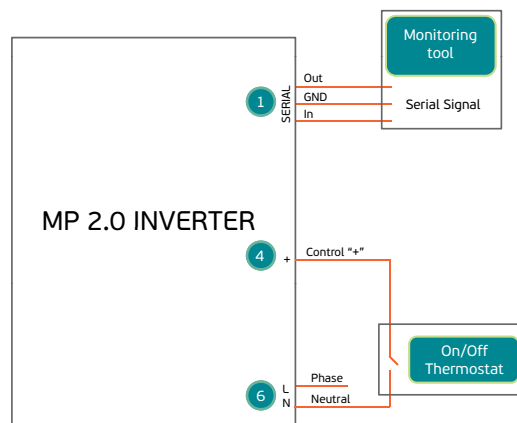Figure 5.1: Serial connection for monitoring Frequency control mode

Figure 5.2: Serial connection for monitoring energized Drop-In control mode

> **NOTICE**
> - For monitoring serial mode, the set speed command is not available.

5.3 Troubleshooting

The following tables shows some possible problems and the best action to deal with them.

Compressor does not start	
Problem	**Action**
Compressor disconnected from the inverter.	·Verify compressor cable connection.
No AC power supply; or wrong voltage/terminals connected.	·Verify AC input cable connection and measure AC input voltage.
No control signal input or bad connection.	·Verify control input cable connection and measure the signal from the thermostat.
Blown fuse (due to previous major failure).	·Return the unit to manufacturer, replacing it by new one.
Open compressor motor winding.	·Measure winding for open circuit between all pair of pins on the hermetic terminal. If any winding is open, return compressor to manufacturer.
Compressor with locked rotor (due to mechanical damage).	·Replace compressor by new one and test for confirmation. Return damaged unit to manufacturer.
Dropped, damaged, burnt inverter.	·Replace by new one and test for confirmation. Return damage unit to manufacturer.
Inverter on waiting time after failed start.	·Wait the necessary time or reset the inverter disconnecting it from the AC power supply. The reset time is about 50s.
Demagnetized rotor (only if compressor was previously connected directly to the AC power supply).	·Replace compressor by a new one and test for confirmation. Return damaged unit to manufacturer.
Unequaled pressures between discharge and suction pressures in the refrigerating system.	·Allow the Inverter to equalize pressure between suction and discharge sides.
Low input voltage supplied to the inverter.	·Measure AC voltage to confirm.

**Compressor does not run at the selected speed**

Problem	Action
High compression load, with compressor being subjected to a stall condition.	·Review system design,refrigerant gas load or compressor capacity is not suitable for the application. If system is apropriated designed, speed will reach set value when load condition is stabilized.
Compressor always on pulldown cycle for Drop-In Mode.	·In Drop-In mode, check if the inverter AC input is connected to thermostat output. Inverter AC input should be directly connected to AC power supply (see Drop-In mode schematic).
No or incorrect control signal.	·Check if the correct control signal is correctly applied at the Control Input Connection.

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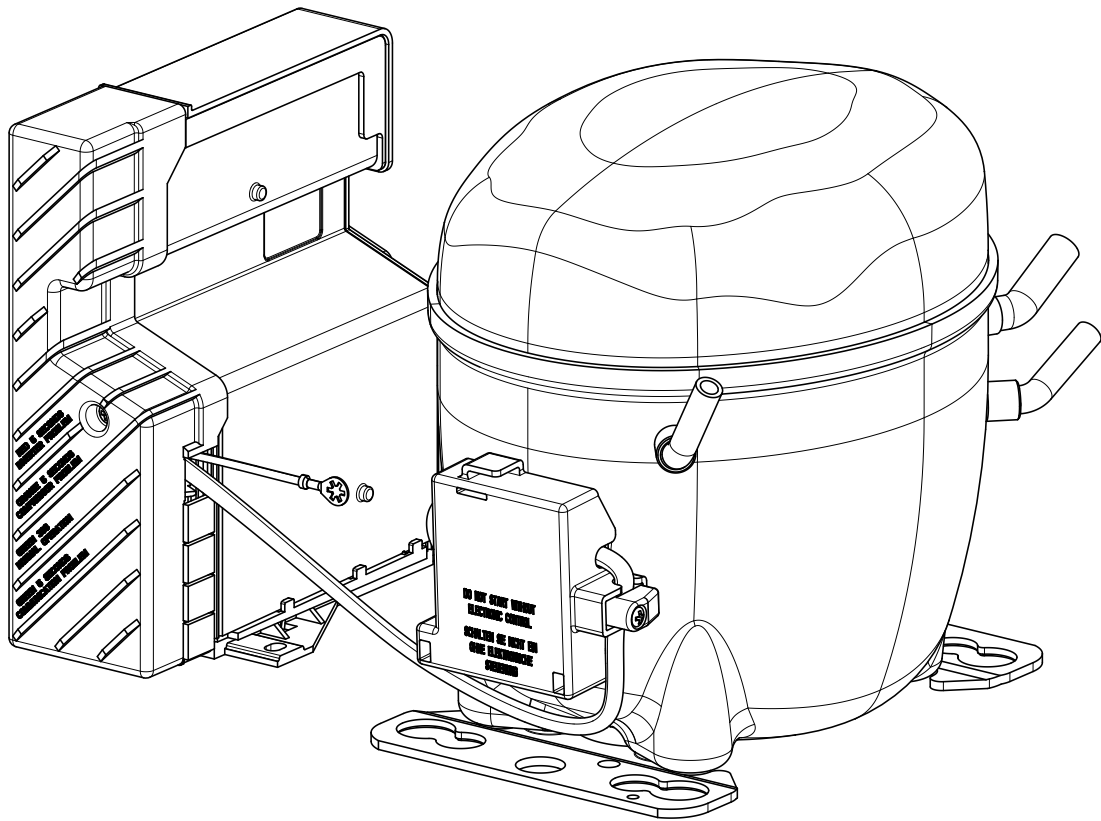
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