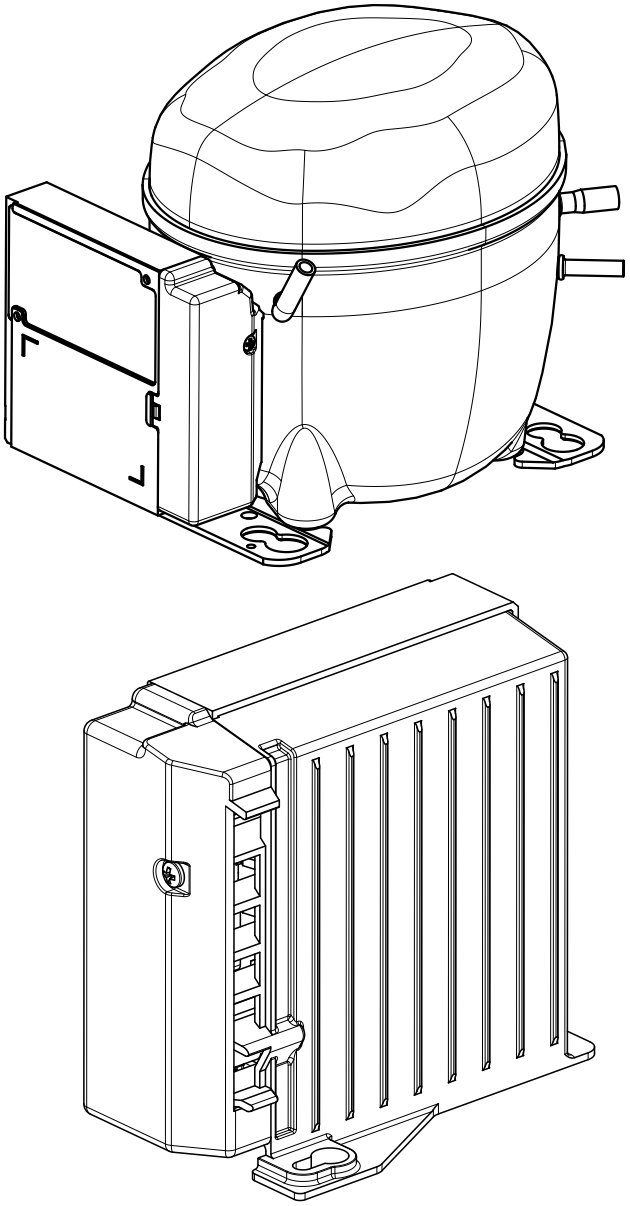
VARIABLE CAPACITY COMPRESSORS
ELECTRONIC INVERTER

PRODUCT MANUAL
CF03B INVERTER



IP55

HIGH PROTECTION AGAINST DUST AND WATER JETS FROM ANY DIRECTION

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Contents

Chapter 1

INTRODUCTION

This document contains information regarding technical specifications, installation instructions and functionality of CF03B Inverter family. It is intended to be used during project phase for proper specifications of system configuration and design, in order to ensure the best application and performance available with use of Embraco's Variable Capacity Compressors and avoid undesired issues.

Before you begin the reading of this material, below is presented the convention about some information contained in this document and how such information must be interpreted.

WARNING

Incorrect operation that could result in bodily injury or death due to electrical hazard.

CAUTION

Incorrect operation that could result in equipment damage.

NOTICE

Contain helpful suggestions or references to material not covered in this document. To obtain access to such materials, please contact your technical support.

Chapter 2

TECHNICAL SPECIFICATIONS

2.1 Nomenclature

Table 1: Naming rules

CF 03 B XX N/M 0.0 XX F/A XX	
CF	Driver Type
03	Family
B	Generation
XX	Subversion
N/M	Power Supply
0.0	Protective Function Configuration
XX	Electronic Configuration
F/A	Enclosure
XX	Cables and Peripherals

2.2 Product specifications

Table 2: Main features

General Specifications		
Model	CF03B01	CF03B02
Input rated voltage range[i]	115-127/220-240 V	220-240 V
Input operating voltage range[ii],[iii],[iv]	70-140/160-264 V	160-264 V
Maximum input voltage[v],[vi]	280 V	280 V
Input frequency range	50-60 Hz	50-60 Hz
Input rated current	6.2 A	3.8 A
Input rated power	400 W	400 W
Control mode[vii]	SDI (default) & Pin Defrost & Frequency or Serial	SDI (default) & Pin Defrost & Frequency or Serial
Operating humidity	$\leq 85\%$	$\leq 85\%$
Environmental humidity[viii]	10 to 85%	10 to 85%
Operating ambient temperature[ix]	-20°C to 60°C / -4°F to 140°F	-20°C to 60°C / -4°F to 140°F
Storage temperature	-20°C to 85°C / -4°F to 185°F	-20°C to 85°C / -4°F to 185°F
Air forced ventilation (min)[x]	Static (260W) or 3 m/s (400W)	Static (260W) or 3 m/s (400W)
Ingress Protection Grade	IP55	IP55

Table 3: Product Specifications

Maximum Ambient Temperature [°C]	Rated Input Power	Box Type	Ventilation
60	≤260	Attached	static
60	≤300	Stand Alone	static
55	≤300	Attached	static
60	≤400	Attached or Stand Alone	3 m/s

WARNING

- Do not connect the CF03B Inverter to a power supply above declared Maximum Input Voltage.

CAUTION

- This inverter is for use only with the Embraco VCC compressors.
- Operating the product at voltages out of declared input operating voltage range may reduce its reliability and significantly impair product performance.
- Make sure to apply the proper match of Inverter SKU and compressor. The use of incorrect Inverter - VCC may degrades product overall performance.
- In order to avoid loss of performance, make sure to operate the inverter inside the temperature range of -20 °C to 60 °C.
- An ambient operation temperature above 60 °C or an inappropriate positioning of the inverter related to forced ventilation air flow may activate inverter thermal protection.

[i] Voltage range approved by Agencies.
[ii] Minimum voltage without impact on compressor starting performance.
[iii] Opearating below the minimum voltage may limit the cooling capacity due to power and compressor speed limitation.
[iv] Maximum voltage without impact on performance and long term reliability.
[v] Maximum voltage without inverter being damaged, but with impact on reliability and performance.
[vi] The inverter may be damaged with voltage above this limit.
[vii] Additionally, it has a micro USB port, which is used to communicate with the computer or hotkey, not to control the speed of the compressor.
[viii] Inverter shall be stored in an adequate environment to avoid condensation and oxidation of its parts.
[ix] Agency approval temperature.
[x] Air flow over the inverter heat sink, as shown in Figure 3.35.

2.2.1 Label information

The Figure 2.1 and 2.2 shows the product label description.

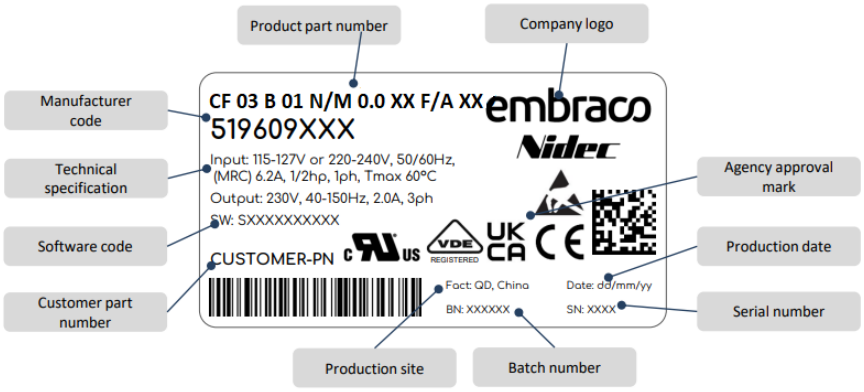


Figure 2.1: Product label example CF03B01

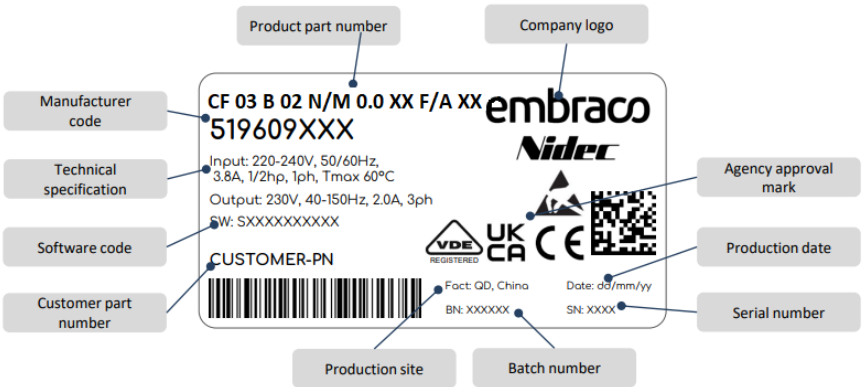


Figure 2.2: Product label example CF03B02

2.2.2 Agency approval

Table 4: Agency approval marks

Inverter Family		c US
CF03B01	✓	✓
CF03B02	✓	

2.2.3 Product dimensions

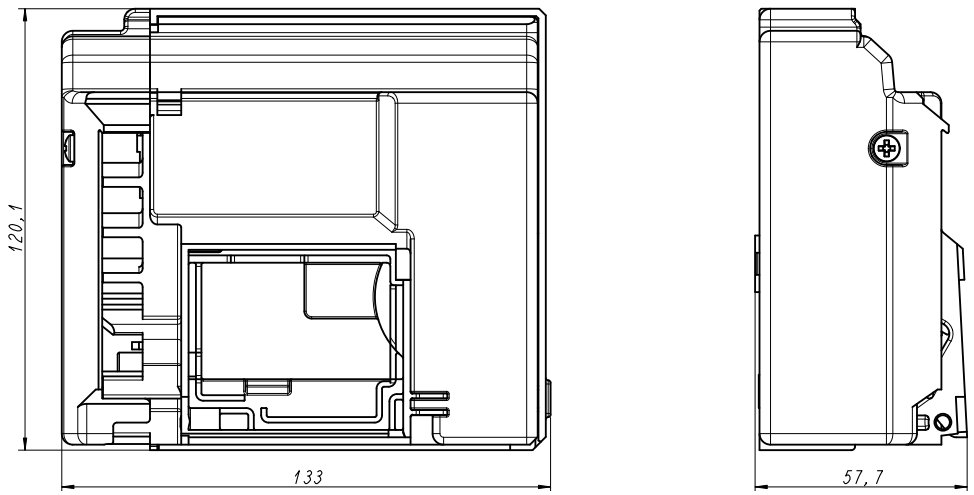


Figure 2.3: Product dimensions (mm) - Attached version

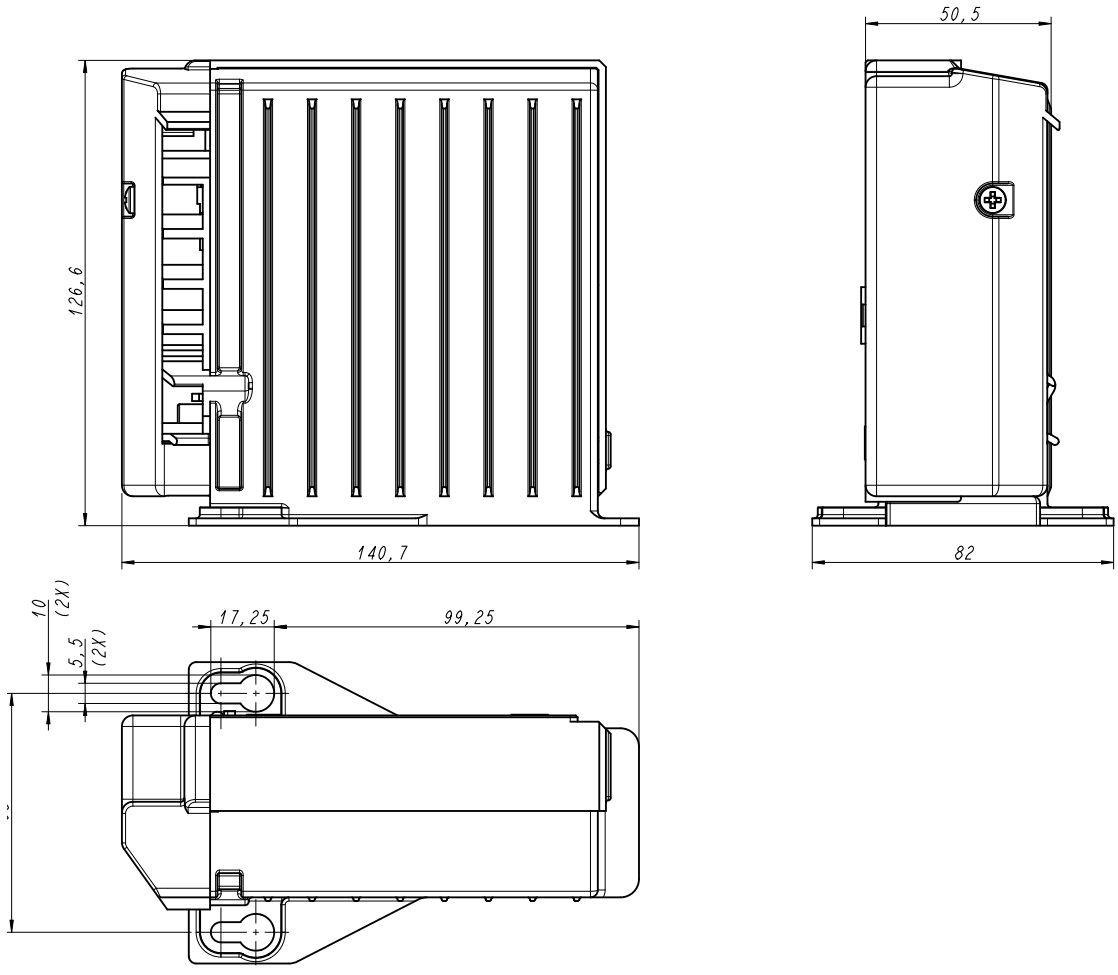


Figure 2.4: Product dimensions (mm) - Stand alone version

2.2.4 Connectors

Table 5: Inverter connections

Connectors part numbers			
Indicator	Description	Part number	Insulation
1	Motor cable connector*	–	-
2	'You Control' input	Micro-USB	-
3.1	Serial communication	S3P-VH (LF) (SN)	Reinforced
3.2	Frequency input	S2P-VH (LF) (SN)	Reinforced
4	Defrost input	2 x Fast-on 4.8mm	Functional
5	Drop in	2 x Fast-on 4.8mm	Functional
6	Neutral or Line 2**	2 x Fast-on 4.8mm	-
7	Line 1	2 x Fast-on 4.8mm	-
8	Harmonic Inductor	2-Ways VH Header	-
9	Safety earth	2 x Fast-on 4.8mm	-
10	External motor cable	-	-
11	Motor Earth motor cable (Attached Version)	-	-

* Compressor motor cable already assembled.

** Line-Line power supply.

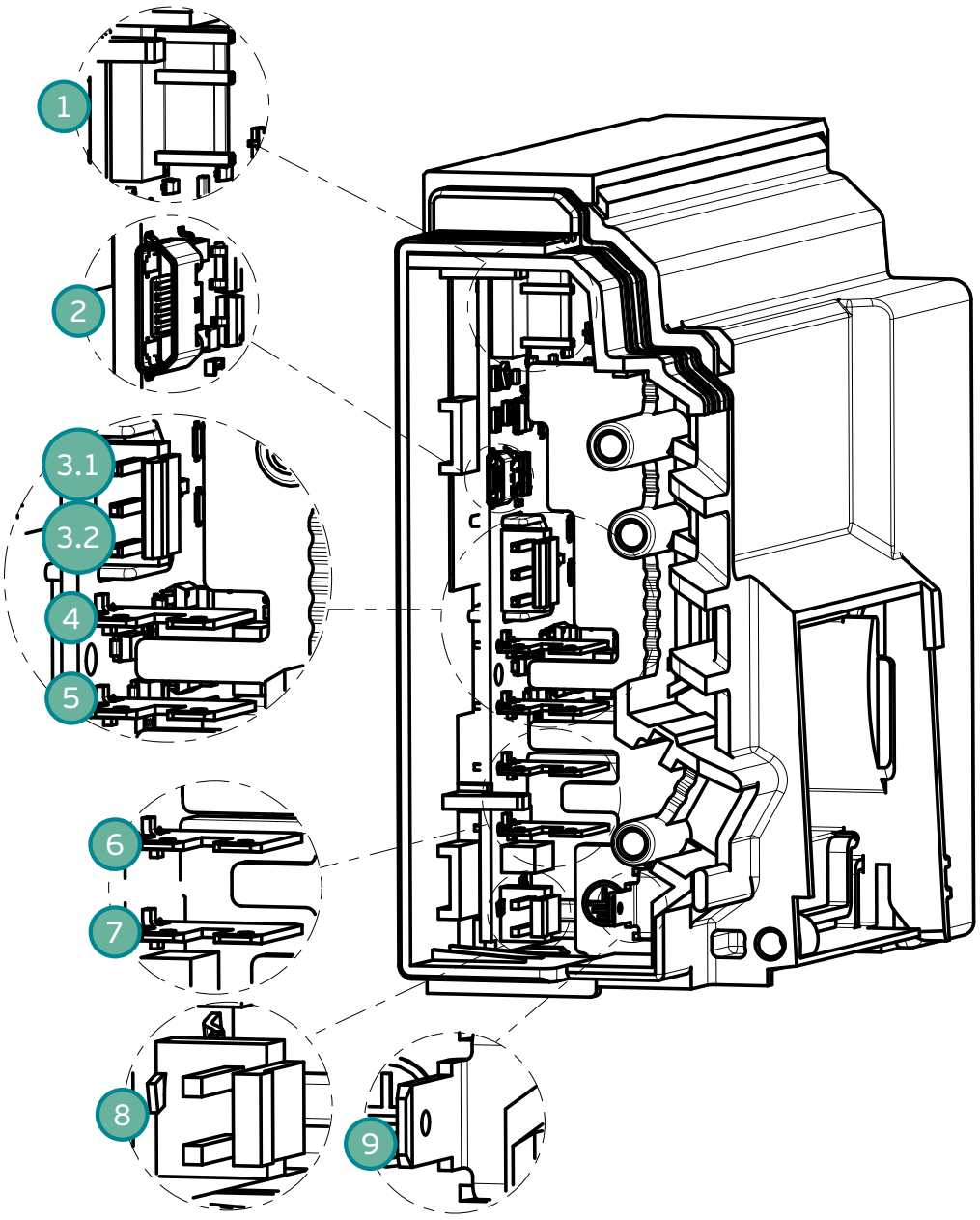


Figure 2.5: Connectors - Attached version

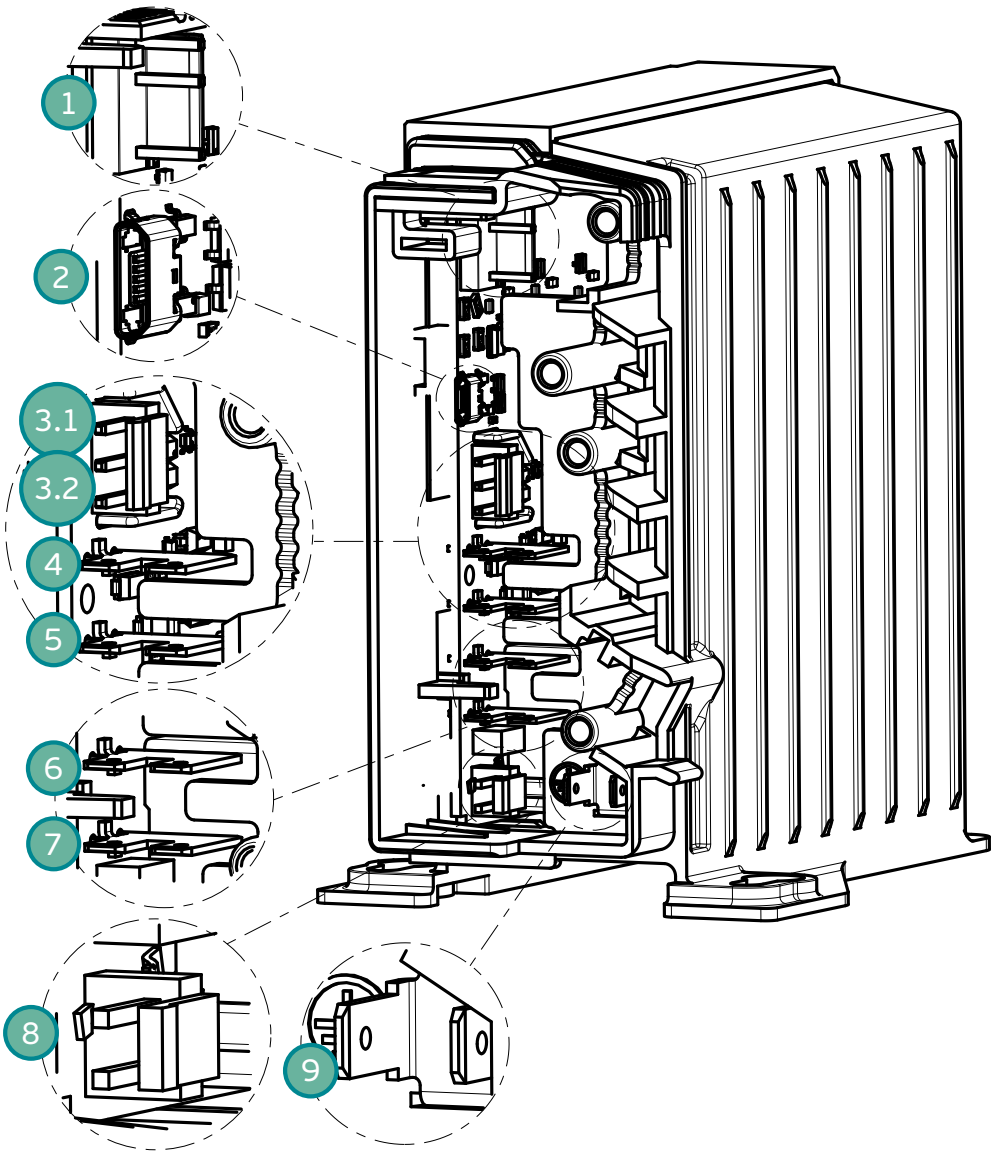


Figure 2.6: Connectors - Stand Alone version

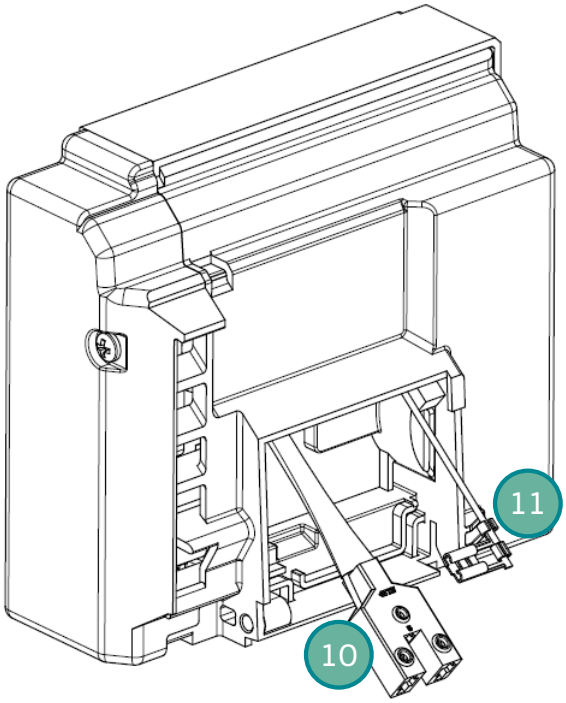


Figure 2.7: External motor cable - Attached version

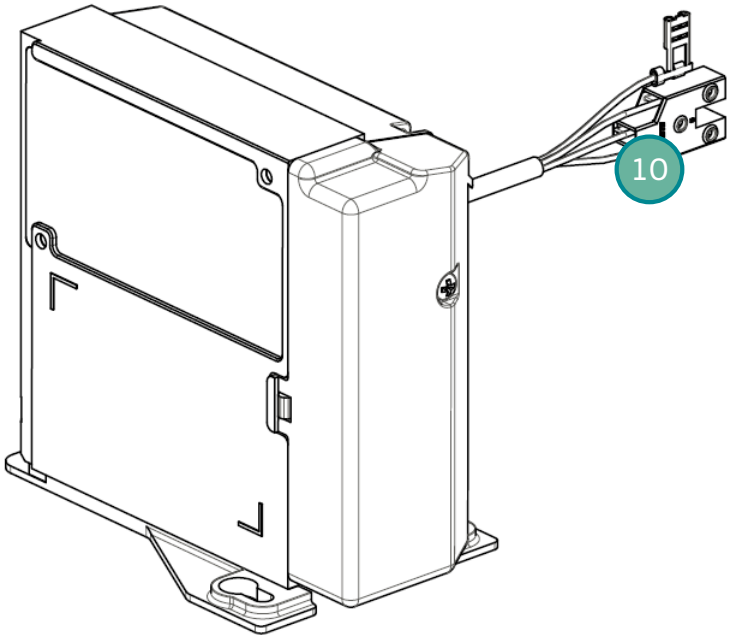


Figure 2.8: External motor cable - Stand Alone version

2.2.5 Cables

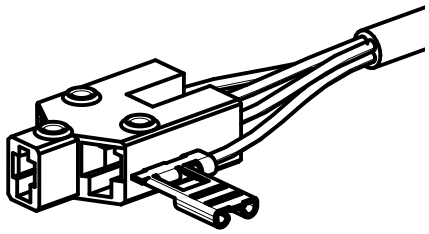


Figure 2.9: Compressor motor cable and earth for FMF compressor series

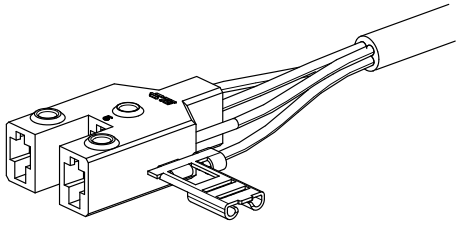


Figure 2.10: Compressor motor cable and earth for VEM compressor series

Table 6: Cable Specification - Attached

Indicator	Description	Part Specification	Color
Figures 2.9 & 2.10	Compressor Motor Cable for UL	UL STYLE 2568 125°C 600 V	Black, Blue and Brown;

Table 7: Cable Specification - Stand Alone

Indicator	Description	Part Specification	Color
Figures 2.9 & 2.10	Compressor Motor Cable for UL	UL STYLE 1015 105°C 600 V	Black, Blue and Brown; Green/Yellow
Figures 2.9 & 2.10	Compressor Motor Cable for IEC	H05V2V2-F 90°C 300/500 V	Black, Blue and Brown; Green/Yellow

WARNING

- The 'You Control' customization input (micro USB port) does not have electrical insulation. Use the provided communication modules defined by Embraco to guarantee electrical insulation. Check Subsection 4.2.1 for information regarding the indicated communication modules and product customization.

2.3 Information about input inrush current

Inrush current refers to a transient phenomenon that occurs rarely and only when the power supply cord is connected to the power grid or in the case of returning after power outages. CF03B inverter series are designed accordingly and can reliably withstand this current along the expected product lifespan. Excessive inrush current events may damage the inverter. Regarding inverter installation, Embraco recommends to have the appliance supply cord directly connected to inverter power input without any disconnection means. Please, contact Embraco Technical Support for any assistance or application assessment needed.

Table 8: Inrush Specifications

Inrush Specifications			
Model	CF03B01		CF03B02
Input Voltage Supply	127 V	240 V	240 V
Allowed inrush events	1 per day	1 per day	1 per day
Peak Inrush current [A] (cold state)	23	43	183
Peak Inrush current [A] (hot state)	77	146	226
Maximum pulse energy [A^2s]	3	10	15

2.4 External Harmonic Indutor

2.4.1 Connection

Pay attention for the correct connection of external harmonic inductor. The connection is shown in the Figures 2.6 and 2.5.

CAUTION

- Make correct connection of harmonic inductor to the number 8 red color connector.

2.4.2 Dimension and Mounting

Dimensions of harmonic inductor used are shown on Figures 2.11 and 2.12. The enclosure is the same for both versions of the product.

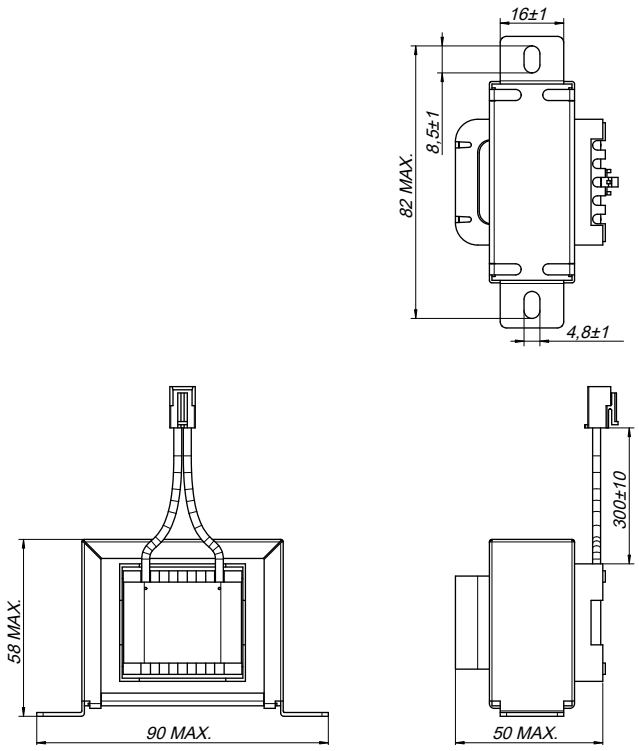


Figure 2.11: Harmonic inductor dimensions - CF03B01 Version

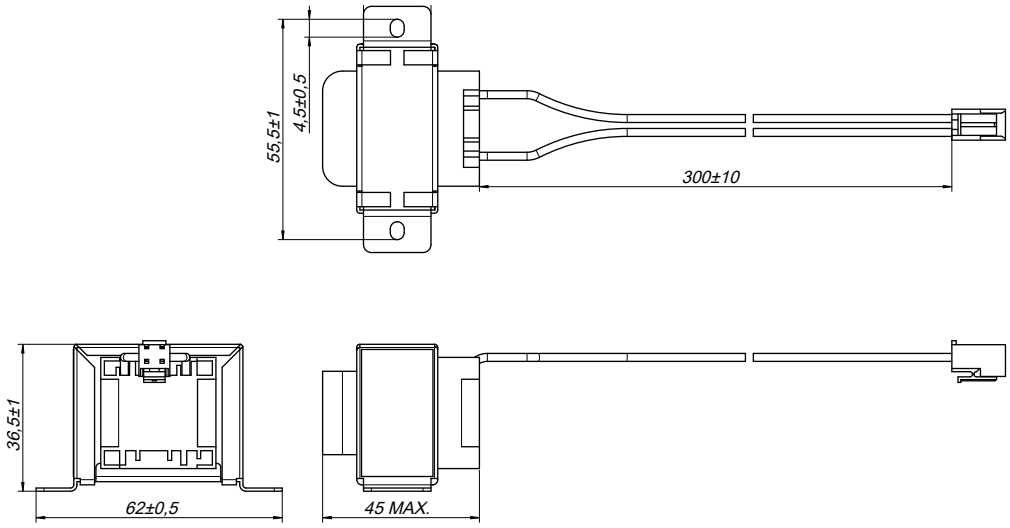


Figure 2.12: Harmonic inductor dimensions - CF03B02 Version

WARNING

- The Harmonic Inductor must be installed in the appliance place which avoid the final user access.

Chapter 3

Installation

3.1 Before you begin

- Make sure that CF03B Inverter will not be in direct contact with flames during assembly.
- The location where the Inverter will be installed must be protected against water jets.
- Do not open the Inverter enclosure. For installation, remove only the Inverter Cover to make the electrical connections.
- Communication modules kit cannot be handled with Inverter turned-on.
- Do not handle the Inverter while it is powered. Perform all connections with the Inverter turned-off.
- Do not handle energized cables.
- The You Control customization input (micro USB port of Inverters) does not have electrical insulation. Use the provided communication modules defined by Embraco to guarantee electrical insulation.

- Before you begin your installation observe technical specifications and proper connections.
- 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.
- Inverter is sensitive to Electrostatic Discharges. The environment must be properly protected against ESD and workers that handle the inverter must be Earthed through adequate ESD wrist strap and wear ESD gloves.

- Take care with product handling until final assembly.
- Do not hold by the wiring.
- Special care must be taken to avoid mechanical impacts on the inverter during assembly process.
- Do not use the inverter if it drops during handling.
- Check if product is properly identified and if it's enclosure is without cracks.

3.1.1 Inverter cables arrangement - Attached version

The CF03B inverter is supplied only with compressor motor cable, which has your own cord relief. The compressor motor cable is already assembled in the inverter. The input power cord, grounding and communication cables are not provided by Embraco. As shown in Figure 3.1, the CF03B - version Attached has 5 cable paths and 2 cord anchorages dedicated to retain the system cables.
Inverter cables must be arranged according to the following instructions.

1. Remove the inverter cover.
2. Make the electrical connections and route the cables trought the cable path (see Figure 3.1).

3. Route all the cables trought the output (see Figure 3.1).
4. Screw the cord reliefes with torque of 1.0 Nm (± 0.2).
5. Reassemble the plastic cover fixing the screw with torque of 1.0 Nm (± 0.2).

Table 10: Cable paths and cord reliefs

Routing Description			
Cable path	Max cable width [mm]	Cord relief	Purpose
P1	6.3	C2	Interconnection cords
P2	7.2	C2	Interconnection cords
P3	8.5	C2	Interconnection cords
P4	6.7	C2	Interconnection cords
P5	10.2	C1	Power supply cords + EMI and/or Safety earth

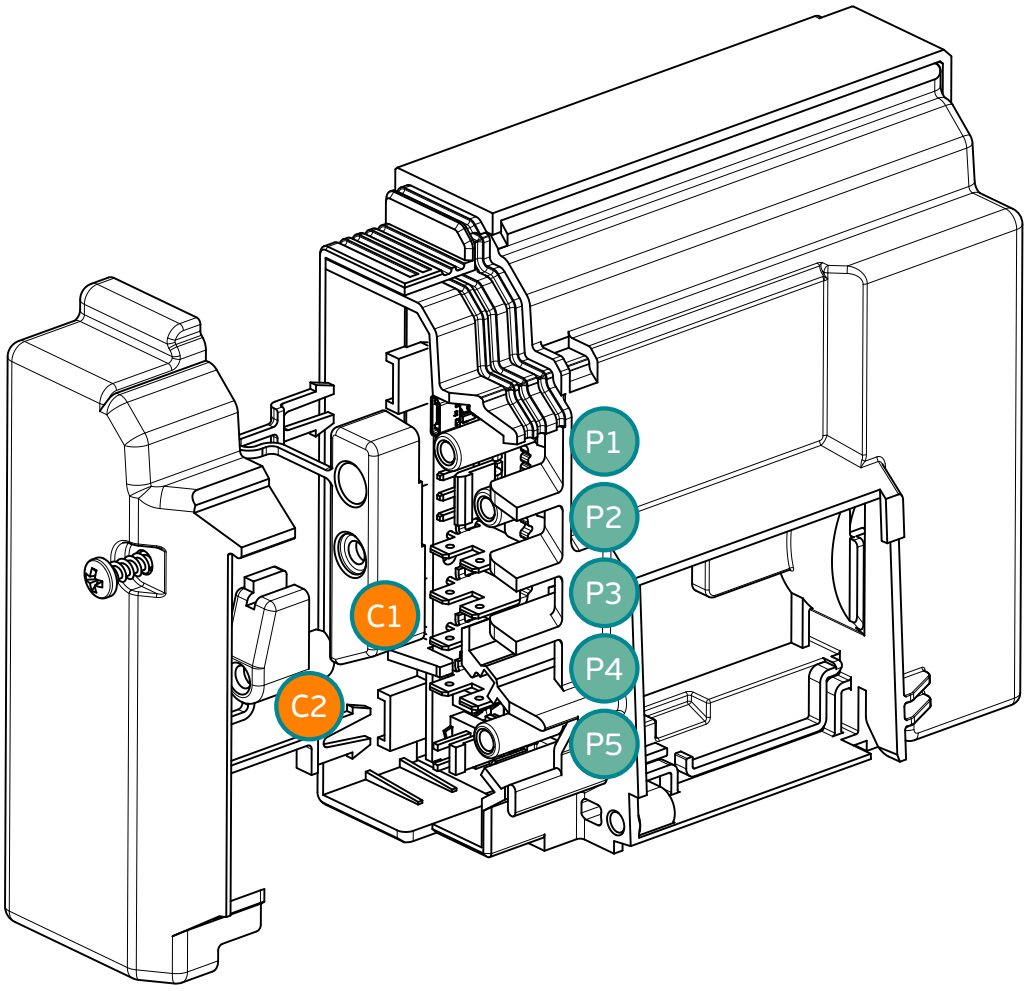


Figure 3.1: Cable paths and cord reliefs - Attached version

CAUTION

- It is recommended the use of insulated female FASTON terminals in order to prevent any risk of short-circuit due to terminals bending.
- Avoid routing cables over the cord anchorage, otherwise the product may damage due to mechanical stress.
- The screws shown in Figure 3.1 must be fixed with torque of 1.0 Nm (±0.2).

NOTICE

- The approval of the input supply cables specifications and certifications as well as the cord anchorage interaction with the input cables is customer responsibility.
- For appliance supply cord, it is recommended to apply cords with Phase and Neutral wires at least 40mm shorter than earth cable.

3.1.2 Inverter cables arrangement - Stand Alone version

The CF03B inverter is supplied only with compressor motor cable, which has your own cord relief. The compressor motor cable is already assembled in the inverter. The input power cord, grounding and communication cables are not provided by Embraco. As shown in Figure 3.2, the CF03B - version Stand Alone has 5 cable paths and 2 cord anchorages dedicated to retain the system cables.
Inverter cables must be arranged according to the following instructions.

1. Remove the inverter cover.
2. Make the electrical connections and route the cables trought the cable path (see Figure 3.2).
3. Route all the cables trought the output (see Figure 3.2).
4. Screw the cord reliefes with torque of 1.0 Nm (±0.2).
5. Reassemble the plastic cover fixing the screw with torque of 1.0 Nm (±0.2).

Table 9: Cable paths and cord reliefs

Routing Description			
Cable path	Max cable width [mm]	Cord relief	Purpose
P1	10.2	C1	Power supply cords + EMI and/or Safety earth
P2	7.2	C2	Interconnection cords
P3	8.5	C2	Interconnection cords
P4	6.7	C2	Interconnection cords
P5	6.3	C2	Interconnection cords
P6	7.2	C3	Compressor motor cable

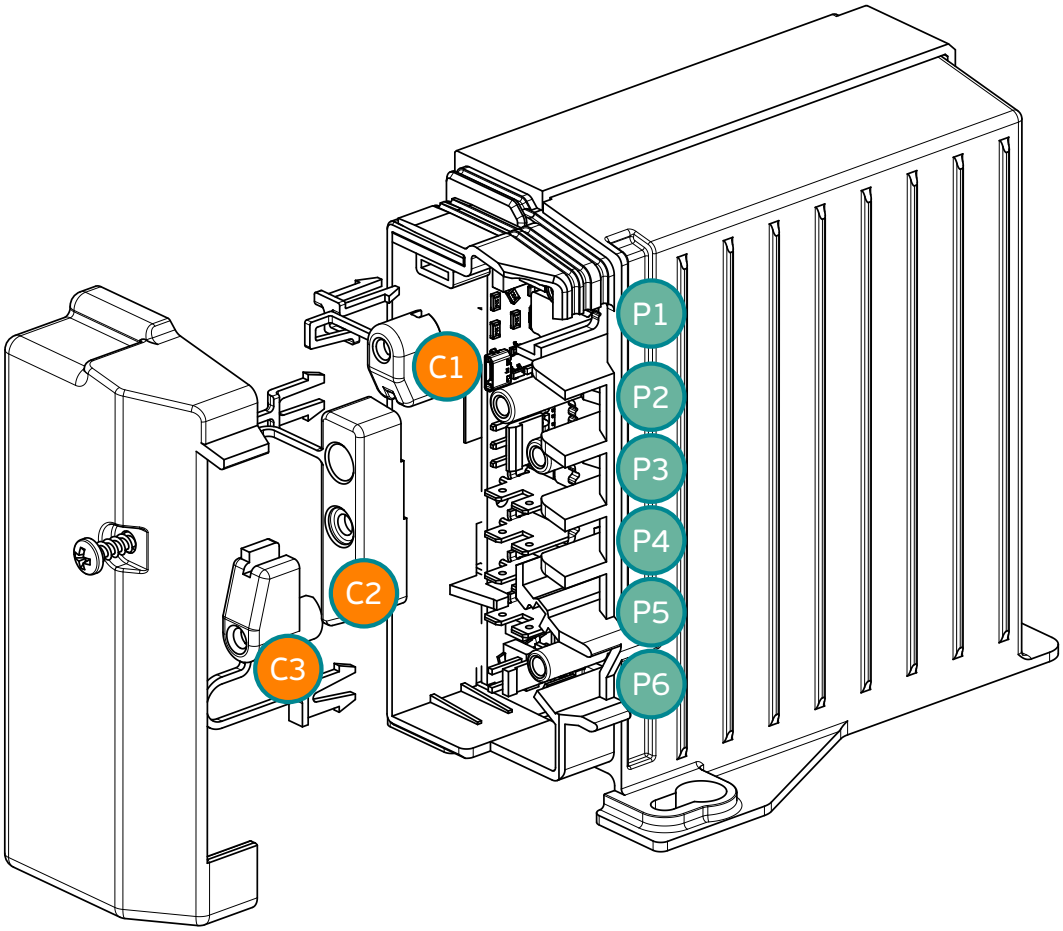


Figure 3.2: Cable paths and cord reliefs - Stand Alone version

CAUTION

- It is recommended the use of insulated female FASTON terminals in order to prevent any risk of short-circuit due to terminals bending.
- Avoid routing cables over the cord anchorage, otherwise the product may damage due to mechanical stress.
- The screws shown in Figure 3.2 must be fixed with torque of 1.0 Nm (±0.2).

NOTICE

- The approval of the input supply cables specifications and certifications as well as the cord anchorage interaction with the input cables is customer responsibility.
- For appliance supply cord, it is recommended to apply cords with Phase and Neutral wires at least 40mm shorter than earth cable.

3.2 FMF compressor series description

1 - Fence cover
2 - Cord anchorage
3 - Cord anchorage Screw
4 - Compressor fence
5 - Fence screw

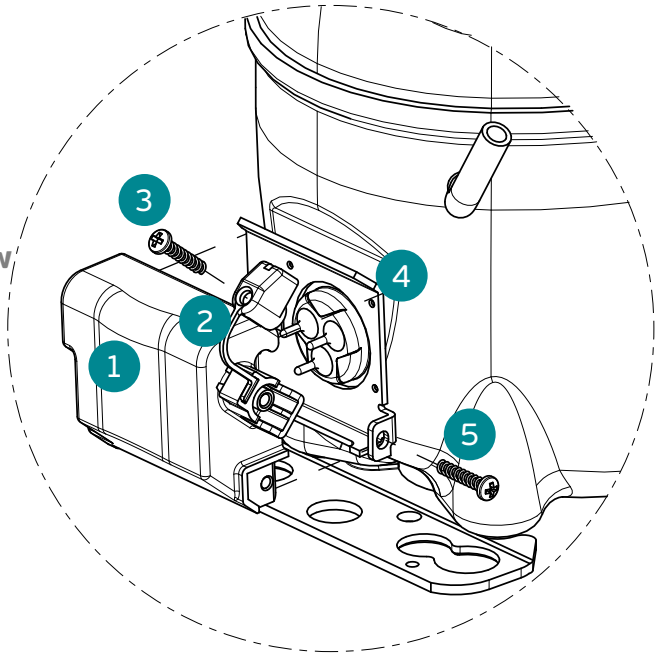


Figure 3.3: FMF compressor series description

3.2.1 FMF Compressor cable connection - Attached Version

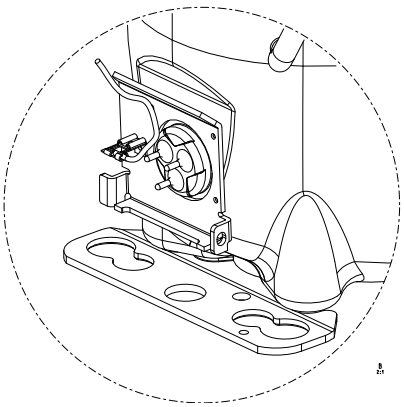


Figure 3.4: Step 1 - Connect the earth cable

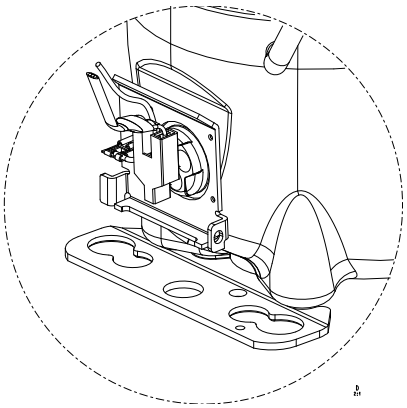


Figure 3.5: Step 2 - Connect the compressor motor cable

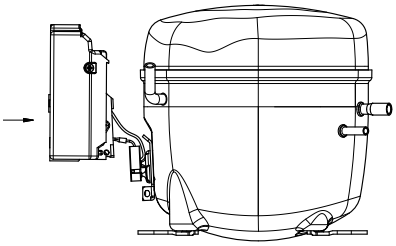


Figure 3.6: Step 3 - Assemble the inverter to the fence

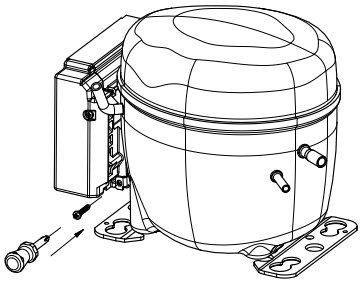


Figure 3.7: Step 4 - Screw the inverter

3.2.2 FMF Compressor cable connection - Stand Alone Version

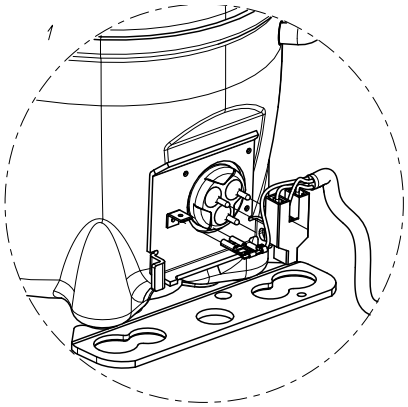


Figure 3.8: Step 1 - Connect the earth cable

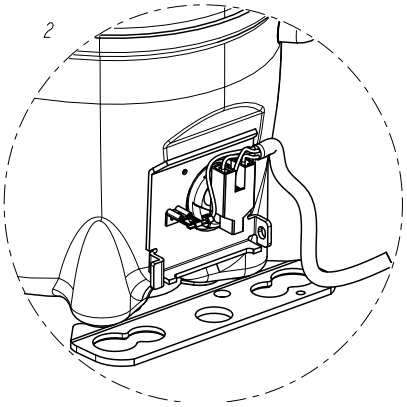


Figure 3.9: Step 2 - Connect the compressor motor cable

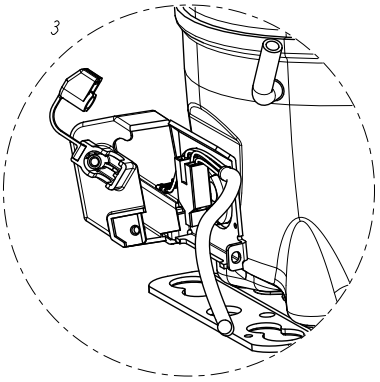


Figure 3.10: Step 3 - Connect the back corner of the cover

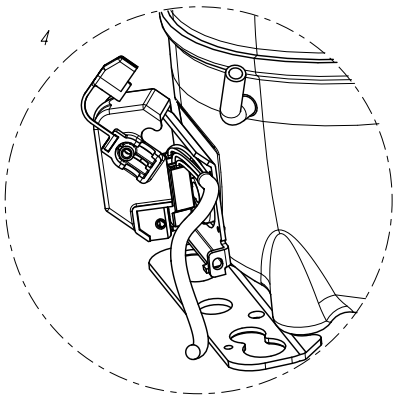


Figure 3.11: Step 4 - Assemble the fence cover

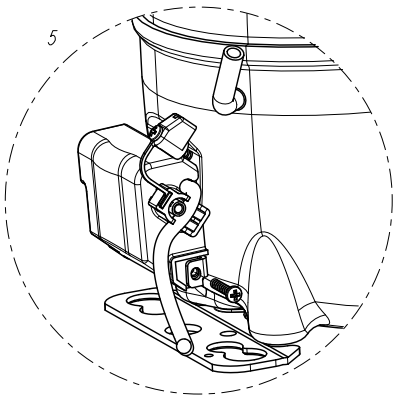


Figure 3.12: Step 5 - Screw the fence cover

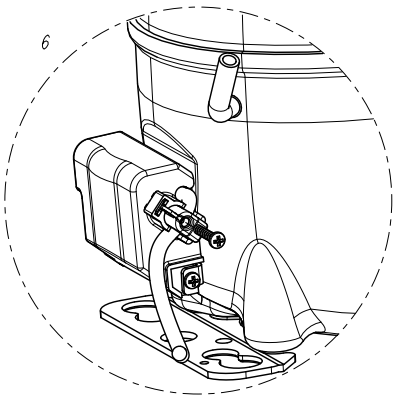


Figure 3.13: Step 6 - Screw the cord anchorage

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.

NOTICE

- Before employing the inverter with compressor, refer to compressor technical documentation not covered in the inverter manual. In case of doubt, please, contact Embraco technical support.

- Motor connector must be properly mounted on the 3 pins of compressor hermetic terminal. Bad connection will cause compressor malfunction.
- The screws shown in Figure 3.7 and Figures 3.12, 3.13 must be fixed with torque of 1.0 Nm (± 0.2).
- The handling of Inverter enclosure 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. Refer to Figures 3.25 till 3.28 or 3.29 till 3.34 for recommended assembling positions.
- When using Serial or Frequency communication mode the inverter has reinforced isolation. When using Drop-in mode the inverter has functional insulation.
- In order to avoid ESD discharge to the inverter circuit, insert the earth terminals at first.
- To disassemble the fence cover, first remove the cord anchorage screw and then remove the fence cover screw.

3.3 VEM compressor series description

1 - Fence cover
2 - Cord anchorage
3 - Cord anchorage Screw
4 - Compressor fence
5 - Fence screw

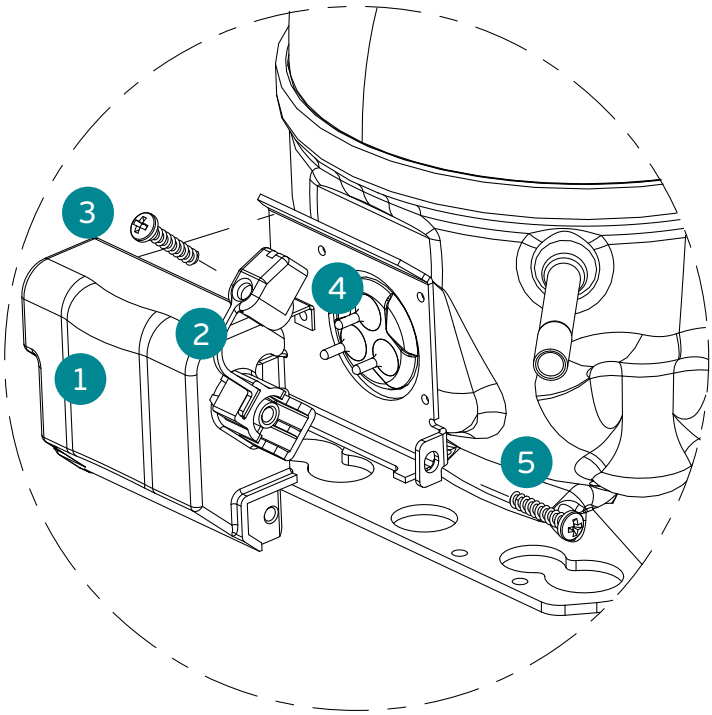


Figure 3.14: VEM compressor series description

3.3.1 VEM Compressor Cable Connection - Attached Version

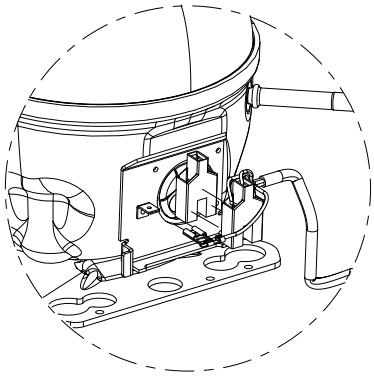


Figure 3.15: Step 1 - Connect the ground cable

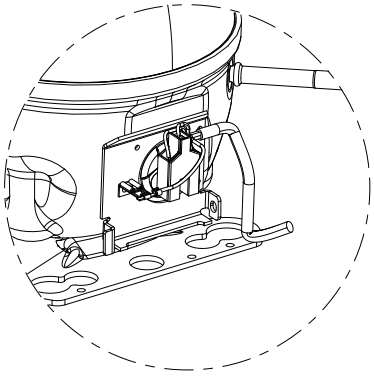


Figure 3.16: Step 2 - Connect the compressor motor cable

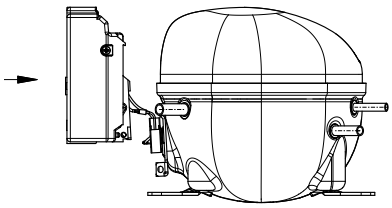


Figure 3.17: Step 3 - Assemble the inverter to the fence

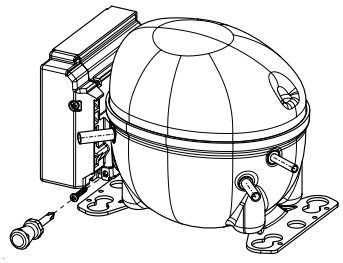


Figure 3.18: Step 4 - Screw the inverter

3.3.2 VEM Compressor Cable Connection - Stand Alone Version

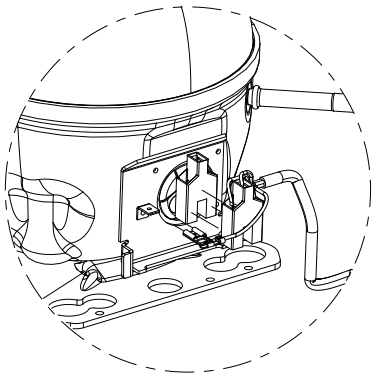


Figure 3.19: Step 1 - Connect the ground cable

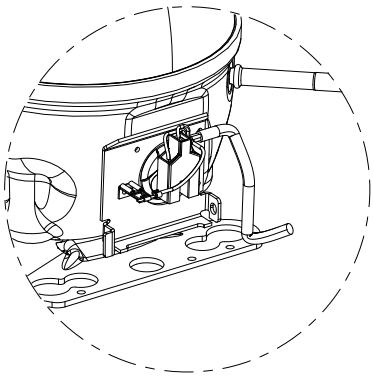


Figure 3.20: Step 2 - Connect the compressor motor cable

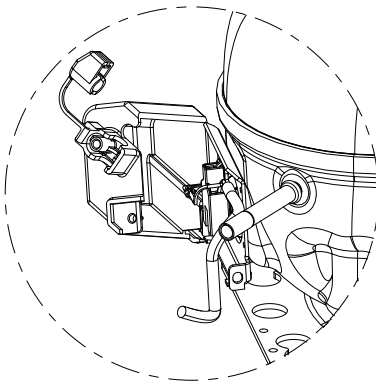


Figure 3.21: Step 3 - Connect the back corner of the cover

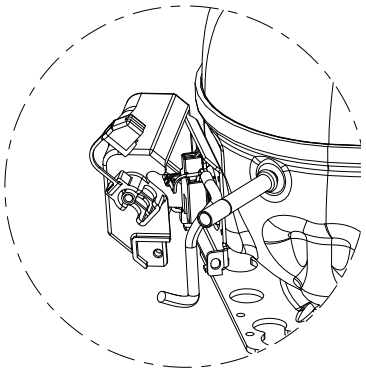


Figure 3.22: Step 4 - Assemble the fence cover

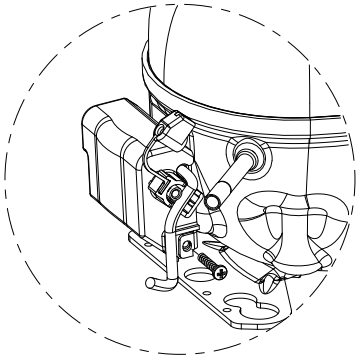


Figure 3.23: Step 5 - Screw the fence cover

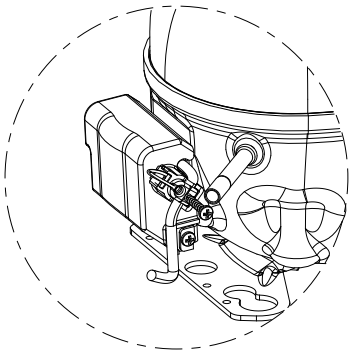


Figure 3.24: Step 6 - Screw the cord anchorage

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.

NOTICE

- Before employing the inverter with compressor, refer to compressor technical documentation not covered in the inverter manual. In case of doubt, please, contact Embraco technical support.

- Motor connector must be properly mounted on the 3 pins of compressor hermetic terminal. Bad connection will cause compressor malfunction.
- The screws shown in Figures 3.18 and Figures 3.23, 3.24 must be fixed with torque of 1.0 Nm (± 0.2).
- The handling of Inverter enclosure 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. Refer to Figures 3.25 till 3.28 or 3.29 till 3.34 for recommended assembling positions.
- When using Serial or Frequency communication mode the inverter has reinforced isolation. When using Drop-in mode the inverter has functional insulation.
- In order to avoid ESD discharge to the inverter circuit, insert the earth terminals at first.
- To disassemble the fence cover, first remove the cord anchorage screw and then remove the fence cover screw.

3.3.3 Forced ventilation - Attached version

Acceptable positions for the fan, compressor, and inverter are illustrated in Figures 3.25 to 3.28.

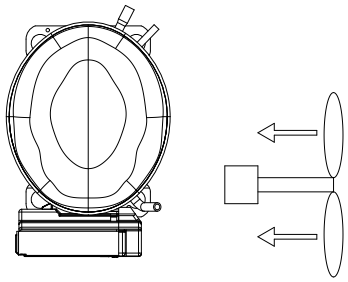


Figure 3.25: Option 1

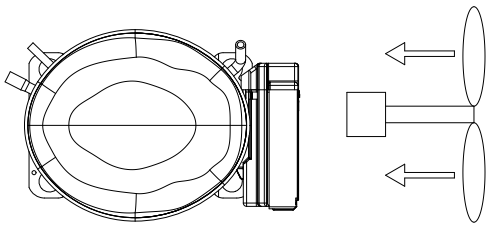


Figure 3.26: Option 2

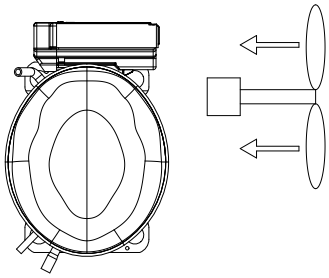


Figure 3.27: Option 3

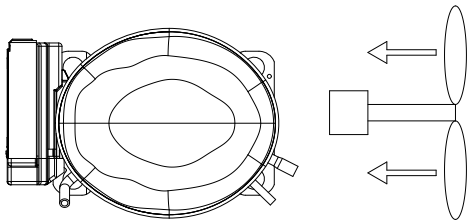


Figure 3.28: Option 4
*This option will be limited at 250W

All mentioned positions are acceptable. Considering specific aspects such as inverter and motor-compressor cooling, the most recommended options are Options 1-3.

3.3.4 Forced ventilation - Stand Alone version

Acceptable positions for the fan, compressor, and inverter are depicted in Figures 3.29 to 3.34.

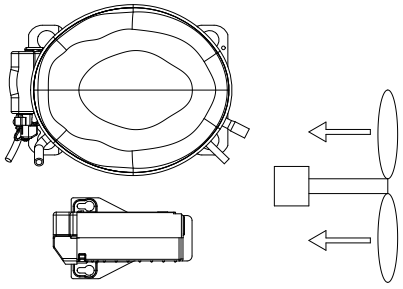


Figure 3.29: Option 1

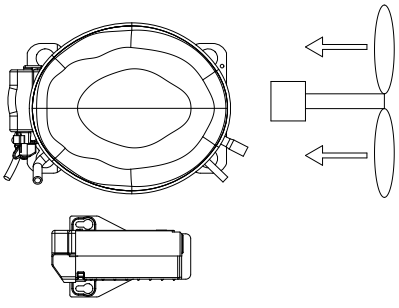


Figure 3.30: Option 2

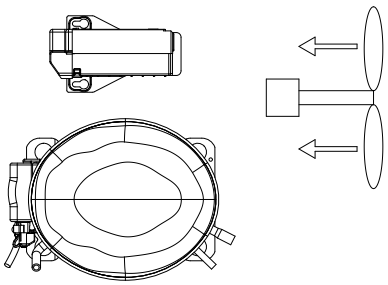


Figure 3.31: Option 3

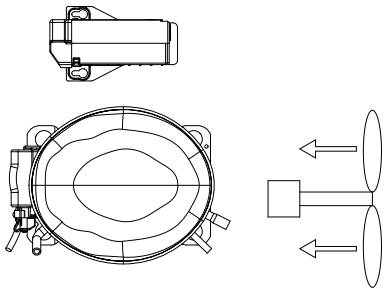


Figure 3.32: Option 4

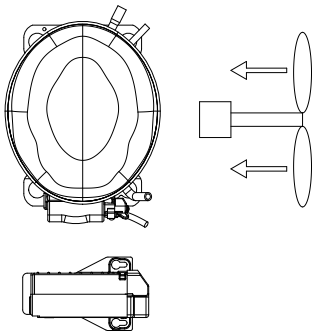


Figure 3.33: Option 5

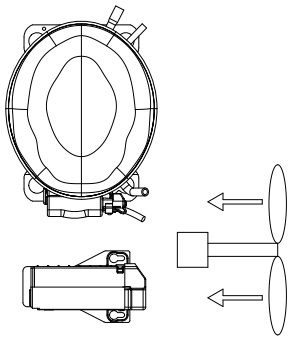
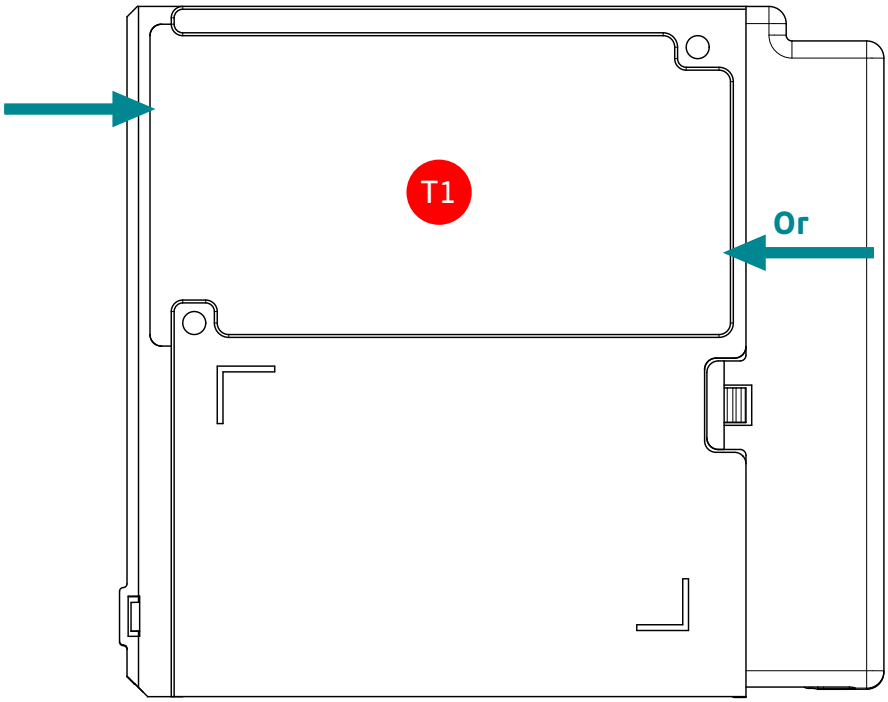


Figure 3.34: Option 6

All mentioned positions are acceptable. Considering specific aspects such as inverter and motor-compressor cooling, the most recommended options are Options 1, 3, and 6.

The acceptable air flow directions in the Inverter heat sink are shown in Figure 3.35.

ATTACHED



STAND ALONE

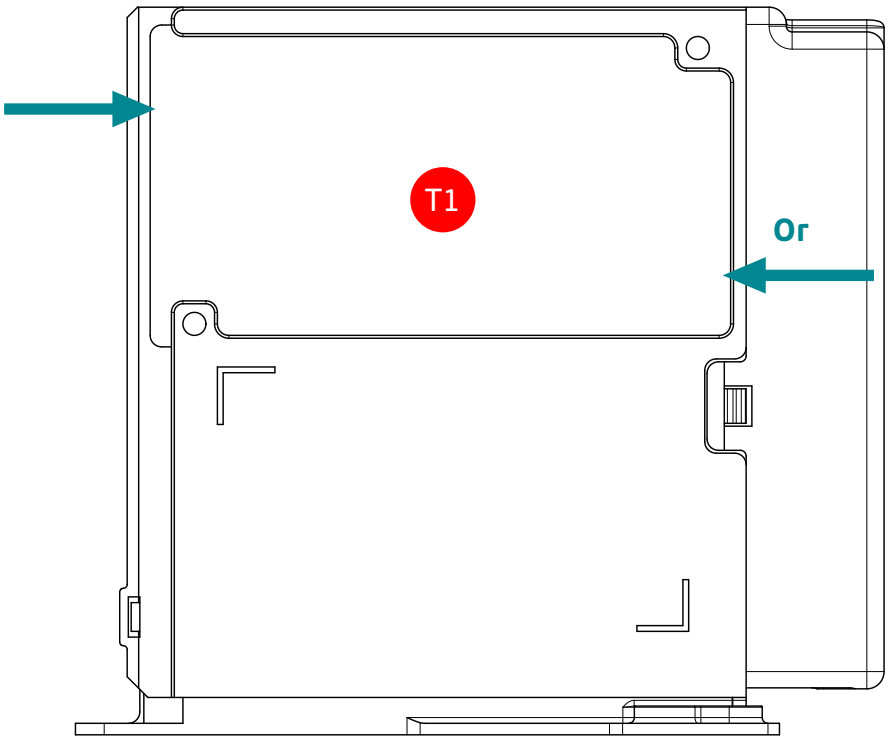


Figure 3.35: Inverter air flow direction

During the refrigeration system's development that will apply the CF03B inverter, it is recommended to measure the temperature T1 (center of the heat sink). The temperature should never be higher than 85 °C, even when the inverter is working with high power and it is subjected to high ambient temperatures.

- In order to avoid loss of performance, make sure that the heat sink is not obstructed from the air ventilation.
- Maximum power is only achieved with minimum forced ventilation of 2 m/s over the inverter heat sink and 520 m^3/h air flow over the compressor.
- Distance from fan to compressor shell must be less than 30 cm.
- During the refrigerator system's development, the ambient temperature of inverter compartment (measured 50 mm distance from heatsink) and inverter Input Power must respect the maximum ratings provided in Table 2. When operating with forced ventilation, the temperature of heatsink pointed in Figure 3.35 must not exceed 85 °C.

3.4 Safety Recommendations of Electrical Installation

The Inverter shall be powered only in electrical installations with a ground fault circuit interrupter (GFCI) circuit breakers or residual current device (RCD), according to the country technical requirement.

In single-phase installations, the line phase wire must be protected by a circuit breaker. Furthermore, the line phase wire must be connected to the phase input connector of the inverter and the line neutral to the neutral input connector of the inverter.

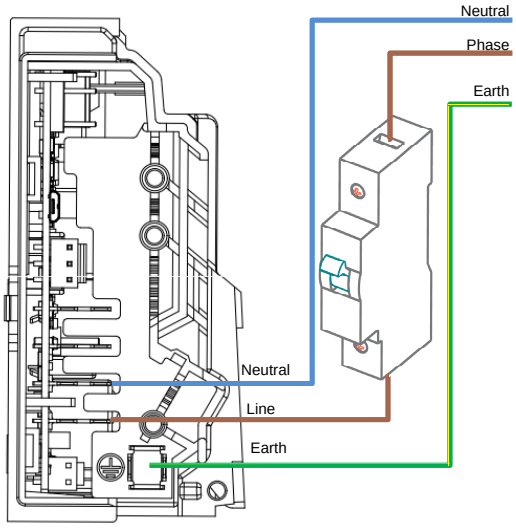


Figure 3.36: Phase-Neutral connection - Attached version

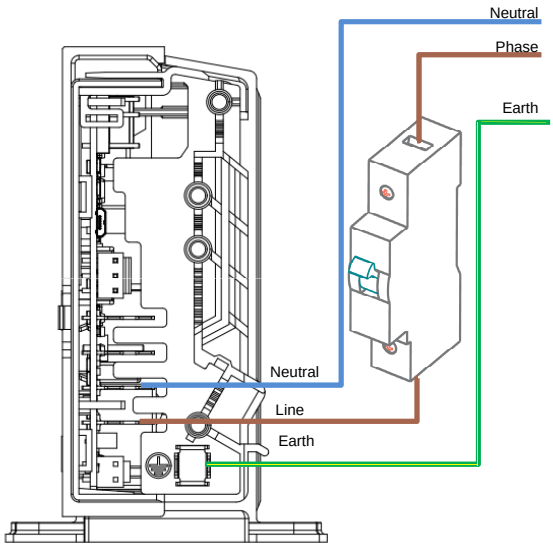


Figure 3.37: Phase-Neutral connection - Stand Alone version

In the case of two-phase installations, it must be used a 2-pole circuit breaker, because in case of a short circuit both phases of power supply are protected.

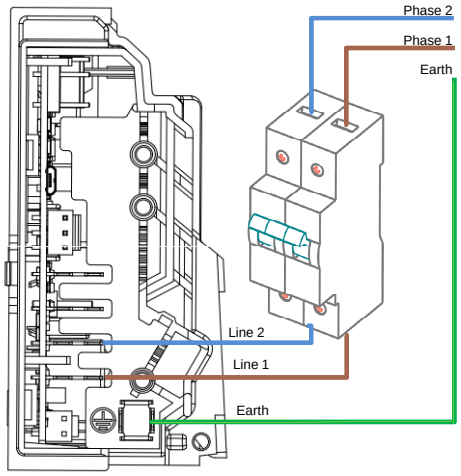


Figure 3.38: Phase-Phase connection - Attached version

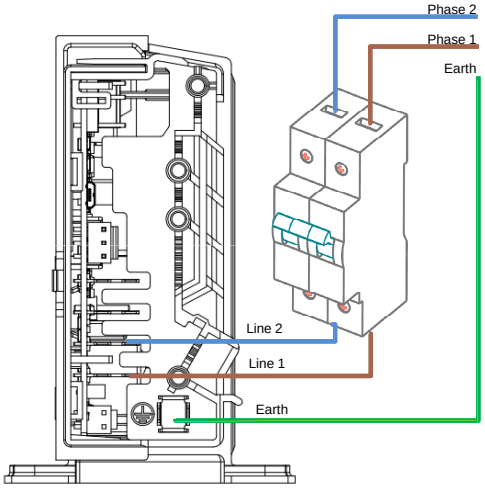


Figure 3.39: Phase-Phase connection - Stand Alone version

3.5 Package information

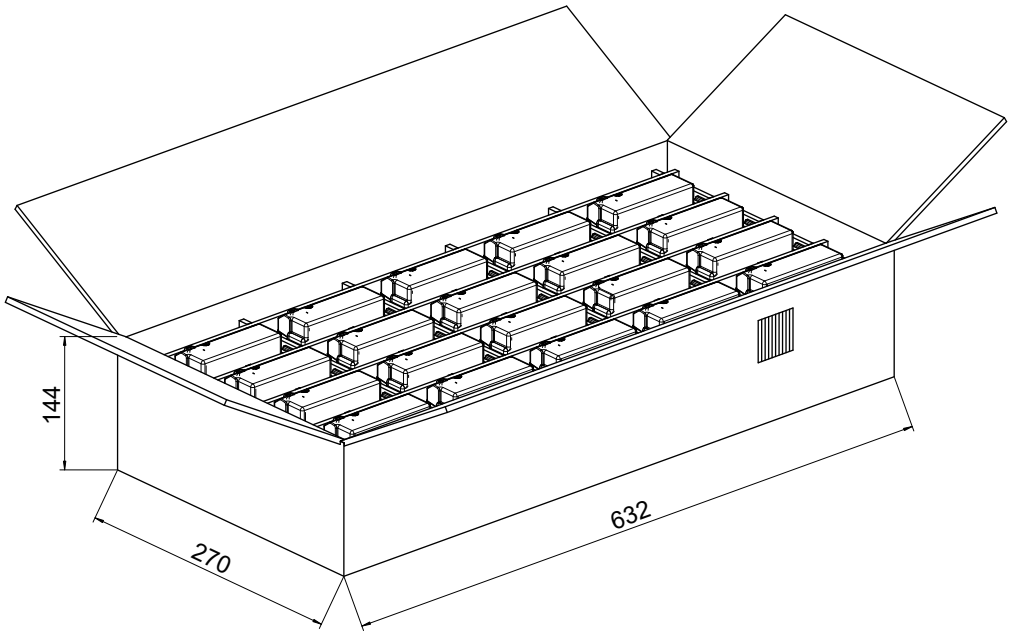
The inverters are delivered packed in a carton box. Box dimensions can be changed without previous information.

Table 11: Storage Conditions

Storage Conditions	
Storage humidity	≤85%
Storage ambient temperature	-20 ºC to 85 ºC

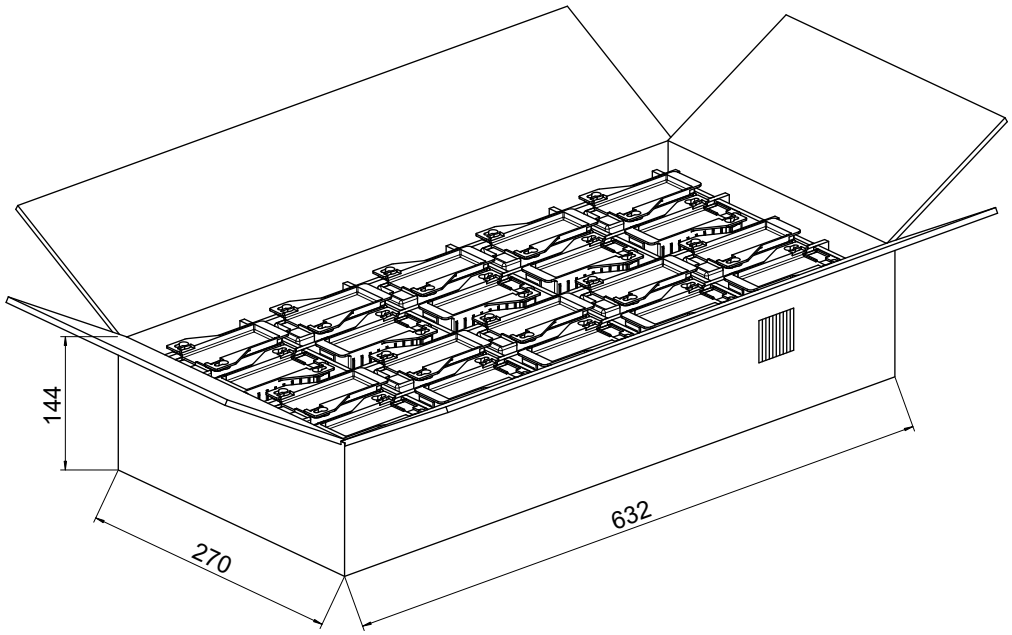
Table 12: Package information

Configuration	Description	Quantity	Dimensions (mm)
Config #1	Inverter (Attached or Stand Alone)	20	632 x 270 x 144
Config #2	Inverter (Stand Alone) + Inductor for CF03B02	16	565 x 390 x 195
Config #3	Inverter (Stand Alone) + Inductor for CF03B01	9	530 x 380 x 220
Config #4	Inductor for CF03B02	20	375 x 345 x 50
Config #5	Inductor for CF03B01	16	300 x 195 x 150



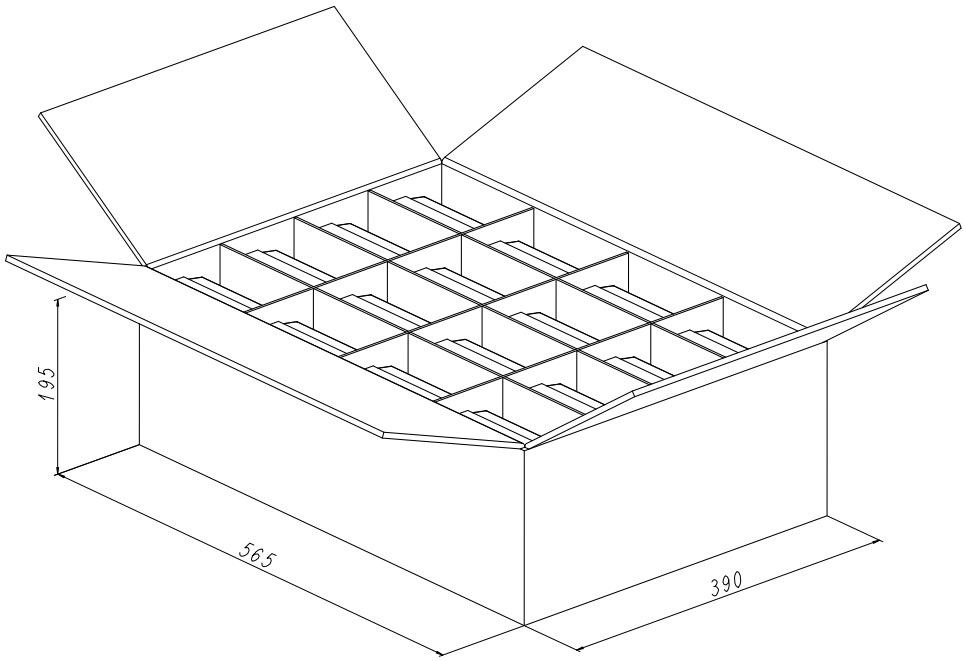
*Dimensions are in mm.

Figure 3.40: Product package - Config 1 - Attached version



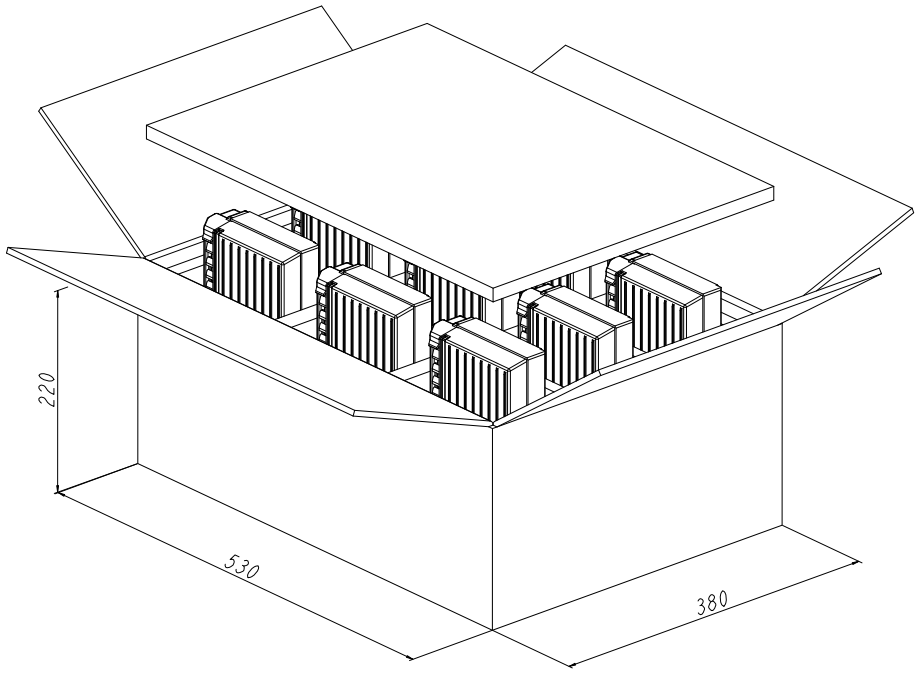
*Dimensions are in mm.

Figure 3.41: Product package - Config 1 - Stand Alone version



*Dimensions are in mm.

Figure 3.42: Product package (Inverter SA + Inductor for CF03B02) - Config 2



*Dimensions are in mm.

Figure 3.43: Product package (Inverter SA + Inductor for CF03B01) - Config 3

3.5.1 Product discards

CAUTION

- Do not remove the inverter board from its case.
- Do not incinerate Embraco's 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.
- The product package and its internal partitions are made of carton and can be disposed as recyclable waste.
- The inverter 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 4

Operation

The CF03B Inverter have support for Serial or Frequency and Drop-In communication modes.

WARNING

- Do not handle the Inverter while it is powered.Perform all connections with the Inverter turned-off.

NOTICE

- The inverter is assembled with all communication modes and the control mode is chosen automatically by the inverter.
- Output frequency and motor speed may have reduced range based on maximum working conditions of the respective compressor, not following some specific set point conditions. For detailed operating range of the selected compressor, please contact Embraco Technical Support.

4.1 Frequency control mode

In this operation mode the compressor speed is controlled 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.

Table 13: Signal specifications

Signal specifications	
Voltage range	-5 V to +15 V
OFF state	-5 V to +0.7 V
ON state	+4.5 V to +15 V
Maximum duty-cycle	70%
Minimum duty-cycle	30%
Maximum current	15 mA @ 15 V

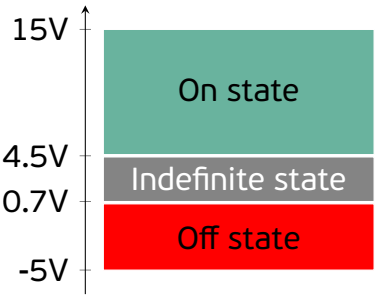
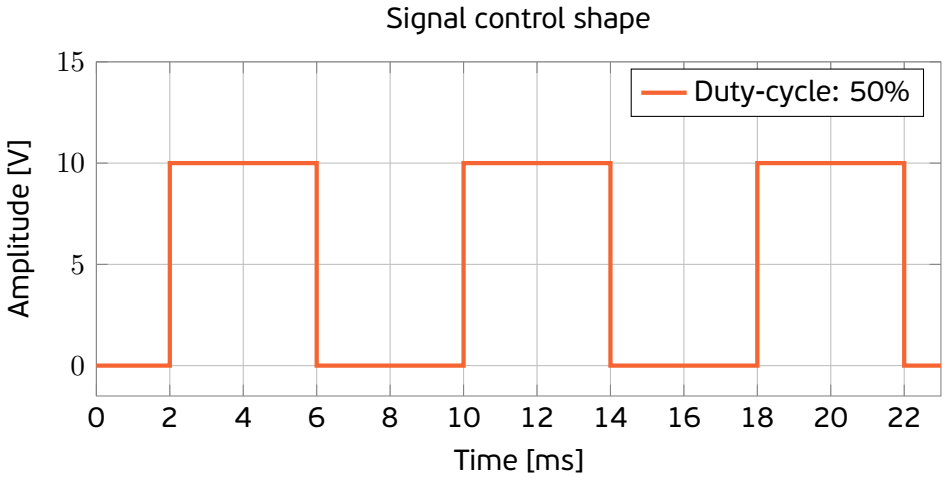


Figure 4.1: Signal levels for frequency control mode

From 0.7 V to 4.5 V the inverter behaviour is indefinite, therefore, it is not recommended to use signals within this range. The following figure presents a graphic example of an input frequency signal of 125 Hz sent to the inverter. The digital signal duty-cycle can vary in the range of 30% to 70%.



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

Figure 4.2: Frequency Signal

Linear Curve 1400 - 4500 rpm		Linear Curve 1800 - 4500 rpm		Linear Curve 1200 - 4500 rpm	
Input [Hz]	Output [rpm]	Input [Hz]	Output [rpm]	Input [Hz]	Output [rpm]
0 to 20	0	0 to 20	0	0 to 20	0
21* to 40*	1200	21* to 46*	1400	21* to 46*	1800
41* to 150	(Hz x 30)**	47* to 150	(Hz x 30)**	61* to 150	(Hz x 30)**
≥150	4500	≥150	4500	≥150	4500

*Frequency changes depending on the minimum speed of the compressor

** Equation can change depending on the maximum speed of the compressor

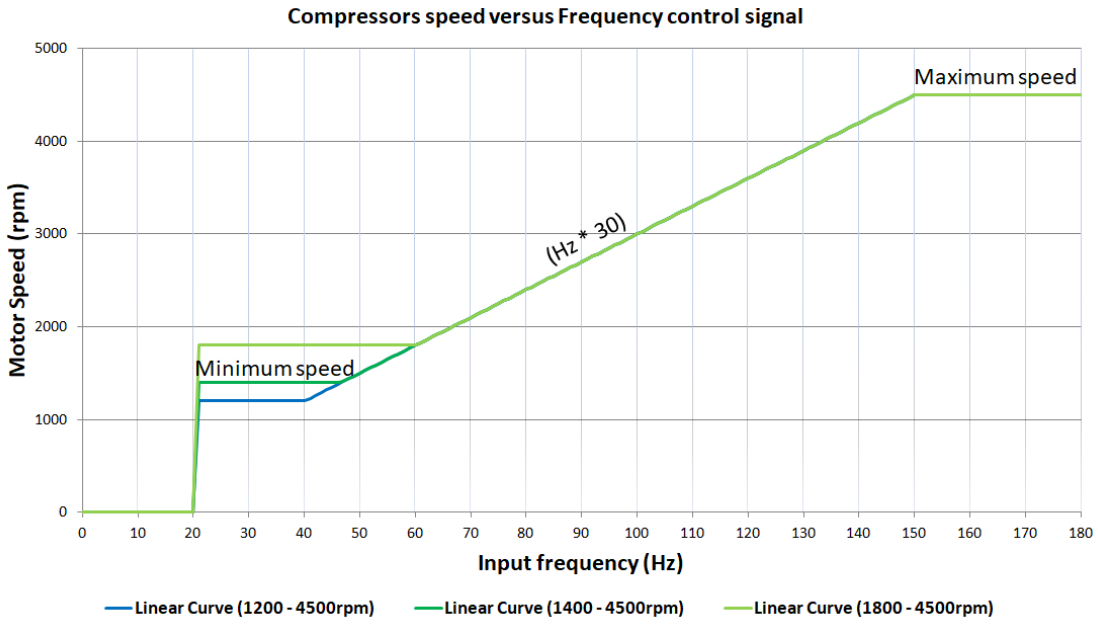


Figure 4.3: Curve Compressors speed

The Figure 4.4 shows the electrical connections to perform frequency communication between an electronic thermostat and CF03B Inverter Control connector. For Frequency Control Mode, the input resistance is 1.2 kΩ.

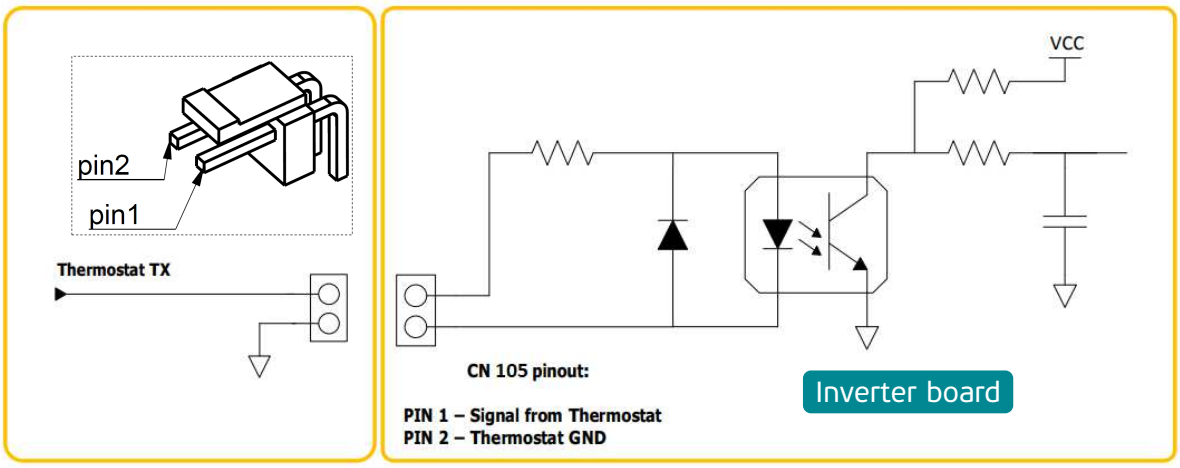


Figure 4.4: Electrical schematic of frequency communication

*For frequency control mode there is a 3-pin option.

4.2 Drop-In control mode

The Drop-In mode is a CF03B 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 the need of a rotation control signal through serial or frequency communication. The compressor speed will be adjusted automatically by the Inverter, in accordance to the thermal load variation.

4.2.1 Smart Drop-In

The Smart Drop-In was designed with focus on cooling capacity, but always considering good system efficiency. This solution provides a customization tool that allows the routine to be parameterized and adjusted for each refrigeration system.
The logic is divided in four mains parts: Pull-down, Stability Routine, Heavy Duty Routine and Defrost Routine. The Stability, Heavy Duty and Defrost Routine begin to run in parallel after Pull-down is completed.

First time Pull-down

Whenever the inverter is powered up, Drop-in is set to the pull-down state, where the compressor runs on the maximum allowed speed, generating more cooling capacity to reduce the pull-down time. This state is kept until thermal load reach stability.

Stability Routine

The stability cycling is the main routine of Smart Drop-in. This routine will select the best speed to run the compressor, in order to achieve the target cycle duration. The target duration is set by the system's manufacturer through the customization tool via computer.

Heavy Duty Routine

The heavy duty is a routine running on the background, that keeps checking the compressor's load to identify disturbances and exceptional cases of the system. Based on inverter electrical parameters variation, which represents the thermal load curve, it takes decisions of change or not the speed.

Defrost Routine

This routine is used for greater accuracy in detecting defrost, reducing the time of defrost (e.g. Hot-Gas) and accelerating the recovery in the post-defrosting (e.g. Hot-Gas and Heater).

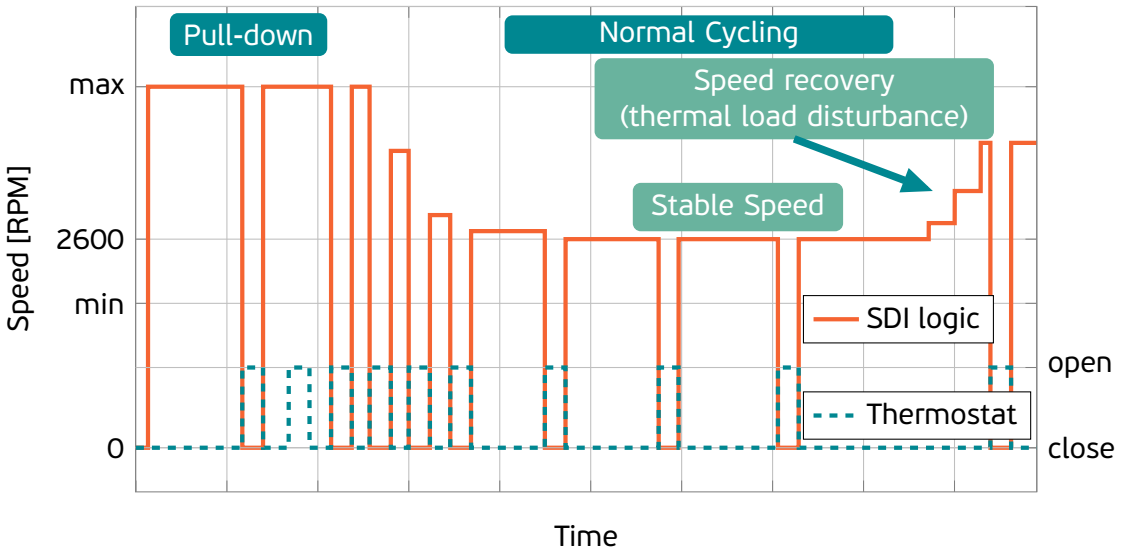


Figure 4.5: Compressor speed versus thermostat behavior Smart Drop-in

For more information, please access our website Embraco Smart Drop-in or contact our Application Engineer.

4.2.2 Defrost input (optional)

The Defrost input is an additional control signal for Drop-in logic, which allows the Inverter to improve the product performance by detecting when a defrost happened.
For the Default Drop-in, the Defrost input sets the compressor at maximum capacity and keeps it for two cycles. The Drop-in input still defines the compressor state, i.e. on/off operation.
For the Smart Drop-in, the Defrost input will be compared to the Drop-in input to detect if appliance is operating with a Heater (resistance) or Hot-gas defrost, acting differently in each case. The logic sets the compressor at maximum capacity during a Hot-gas defrosts. In both cases, the post-defrost cycle is performed with higher speed, in order to recover the appliance temperatures. More information can be requested from our Application Engineer.

NOTICE

- The Drop-in input still defines the compressor state, i.e. on/off operation.

4.2.3 Drop-in connection

The Drop-In mode connection shall be wired according to Figures 4.6 and 4.7. This signal is usually called Thermostat Return Signal.

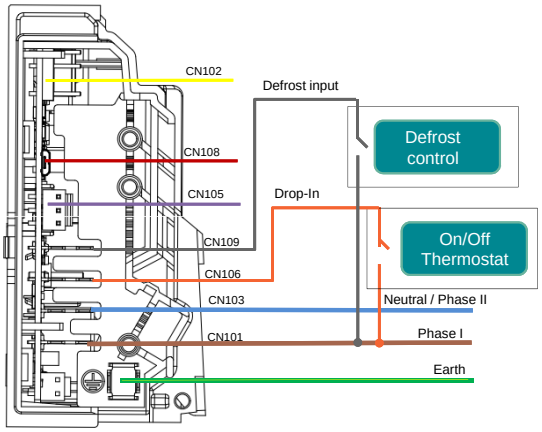


Figure 4.6: Drop-In connection - Attached

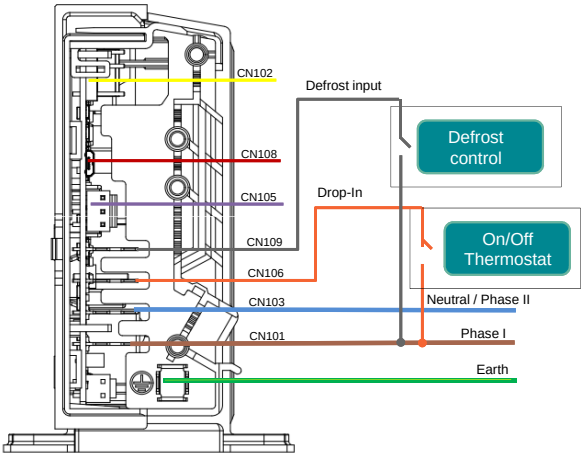


Figure 4.7: Drop-In connection - Stand Alone

CAUTION

- When opened, the thermostat and defrost control impedance must be higher than 380 k Ω . Otherwise the compressor can run continuously, without ever turning off.

NOTICE

- All main parameters, such as minimum and maximum speed are described at compressor datasheet.

4.3 Serial control mode

This option is used when an electronic thermostat controls the CF03B Inverter uses a serial communication protocol. Based on Embraco protocol it is possible to define the compressor speed and check other parameters.

NOTICE

- Do not use the inverter serial communication while using the 'You Control' interface.

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 4.8 shows the electrical connections to perform serial communication between an electronic thermostat and CF03B Inverter serial connector (CN105).
The input resistance for serial communication, shown in Figure 4.8, is 1.2 k Ω.

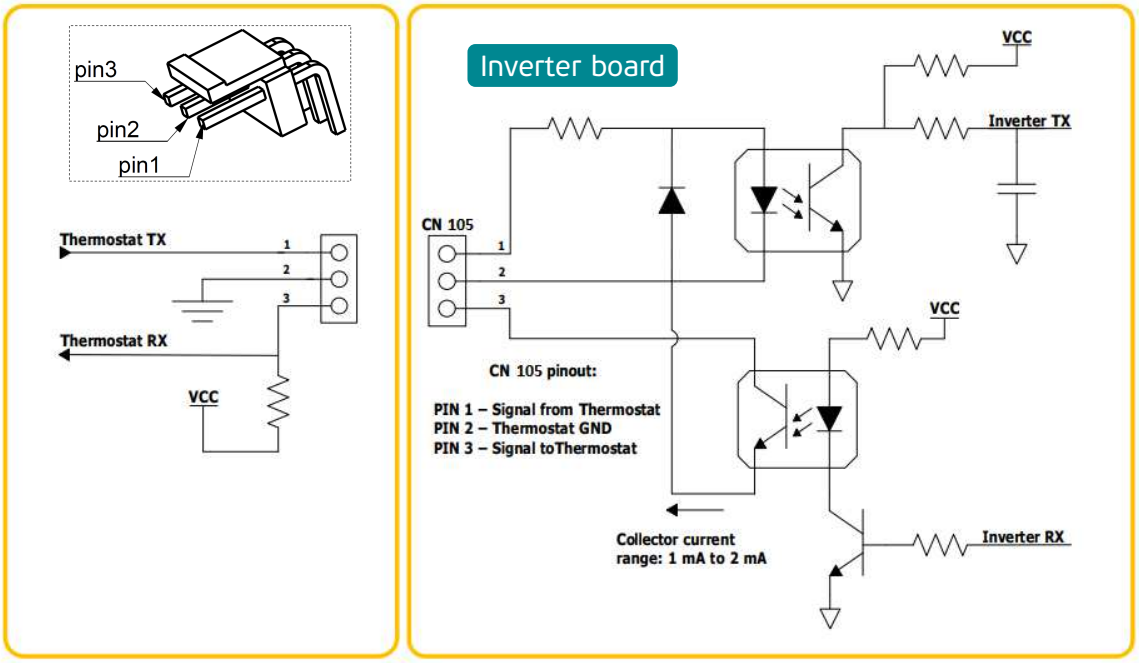


Figure 4.8: Electrical schematic of serial communication

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

Table 14: Signal specifications

Signal specifications	
Voltage range	-5 V to +15 V
TRUE state	-5 V to +0.7 V
FALSE state	+4.5 V to +15 V
Maximum current	2 mA @ 15 V

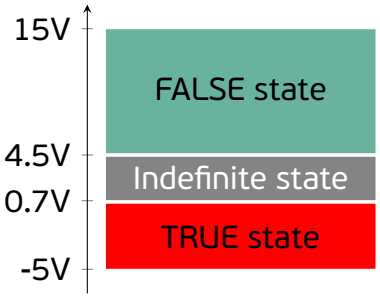
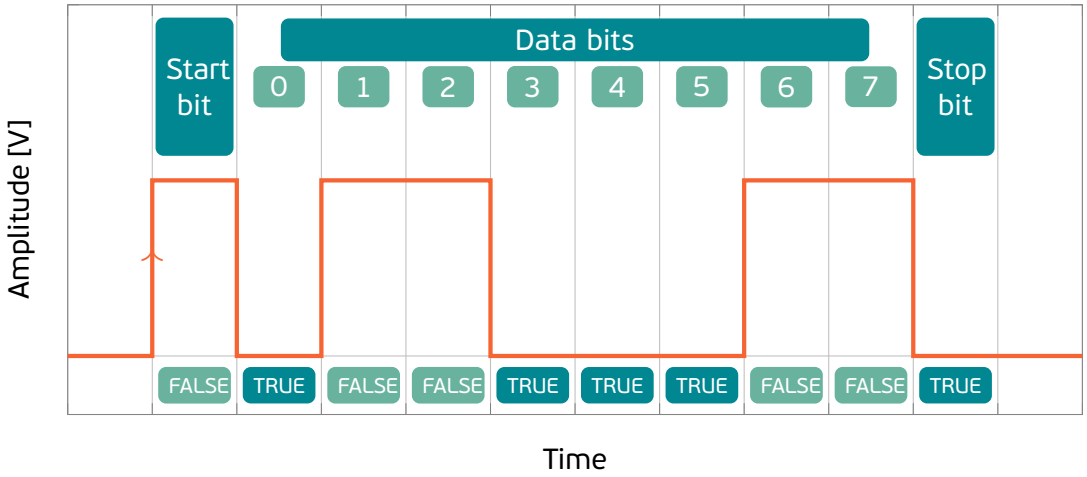


Figure 4.9: Signal levels for serial communication

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 response 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.

Table 15: Basic specification - Serial Control

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 CF03B Inverter serial connection, please contact Embraco Technical Support to receive instructions.

4.3.2 Commands

Table 16: Commands structure

Command structure				
1st Byte	2nd Byte	3rd Byte	4th Byte	5th Byte
Identification (ID)	Command (CMD)	LSB*	MSB**	Check-sum*** (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.

Table 17: 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
Read power	A5h	3Ch	82h	39h	CK
Read starting trials	A5h	3Ch	81h	39h	CK
Read bus voltage	A5h	3Ch	84h	39h	CK
Read temperature	A5h	3Ch	88h	39h	CK
Read power limitation	A5h	3Ch	8Ah	39h	CK

Table 18: 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
Read power	5Ah	82h	Power [W]		CK
Read starting trials	5Ah	81h	Number of trials		CK
Read bus voltage	5Ah	84h	Voltage [V]		CK
Read temperature	5Ah	88h	Temperature [°C x 10]		CK
Read power limitation	5Ah	8Ah	Power limitation [W]		CK
Communication error	5Ah	Code**	FFh	FFh	CK

*See Status Data table.

**See Error Code table

Table 19: Status Data

H Bit	LSB	MSB	Description
-	-	00h	Compressor running
-	-	FFh	Compressor stopped (waiting for a valid start speed)
0	01h	FFh	Start failure
1	02h	-	Overload protection (Note 1)
1	02h	FFh	Overload (Note 3)
2	04h	FFh	Under speed (1550 rpm or lower)
3	08h	FFh	Wrong rotor position
4	10h	FFh	Short circuit
5	20h	FFh	Over temperature failure (Note 6)
7	80h	-	Set speed data out of specification (Note 2)
7	80h	FFh	Set speed data out of specification (Note 4)

Note 1 : This response occurs when compressor is running with a high load. If the Data High byte is 00h, compressor is still running.
Note 2 : Response to the out-of-spec set speed data received while the comp is running.
Note 3 : This response occurs when compressor is stopped due to high load.
Note 4 : Response to the out-of-spec set speed data received while the comp is stopped.

Note 5 : When one or more errors occur, the corresponding bits “H” are set to 1.
Example: Overload and Under speed: 0xFF06
Note 6 : The over temperature failure refers to when the inverter turns off due to over temperature.

Table 20: Error Code

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

If compressor is stopped due to a failure (see Data Status table), it is possible to reset that failure sending a speed command to turn inverter off (0 rpm set speed). However, if nothing is done, the failure 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 $2000\ RPM$.

Example: Set compressor at 2000 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

2000d →07D0h

Step 3: split lower and higher Bytes

LSB →D0h

MSB →07h

Step 4: calculate sum of first 4 Bytes

S14h=A5h+C3h+D0h+07h

S14h→23Fh

Step 5: boolean logic to maintain sum as 8-bit

L14h=0FFh AND S14h

L14h →3Fh

Step 6: calculate checksum

CK=100h-(0FFh AND S14h)=100h-3Fh

CK= →C1h

Command: A5h C3h D0h 07h C1h

NOTICE

- To avoid noise increasing and damages to the compressor due to mechanical resonance, some operating speeds 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 Drop-In modes can have serial communication only for monitoring purpose. This functionality can be used for product diagnostic.

Chapter 5

DIAGNOSTICS

The CF03B Inverter has two diagnostics methods, by visual light emission using a LED indication, or by serial communication protocol.

5.1 LED indication

The LED diagnostics function helps services technicians to diagnose possible fault components by blinking a LED inside the box in different patterns. Basically, it indicates if there is a problem with Compressor, CF03B Inverter or Thermostat. The table below describes the failure modes.

Table 21: Failure modes

LED Status	Period	Color	Description
1 Flash	30 seconds	Green	Normal operation
2 Flashes	5 seconds	Green	Communication problem
3 Flashes	5 seconds	Red	Inverter problem
4 Flashes	5 seconds	Red	Compressor problem
No Flash	–	–	No input power / Damaged inverter

5.2 Troubleshooting

Table 22: 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 damaged 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

Table 23: 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 appropriate control signal is being correctly applied to the Control Input Connection

Chapter 6

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Chapter 7

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