CF01F & CF02F INVERTERS

Product Manual

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1. INTRODUCTION

This document contains information regarding technical specifications, installation instructions, and functionality of the CF01F and CF02F Inverters. It should be used during the development stage for proper specifications of the appliance configuration and design to ensure the best application and performance available using Embraco's VCC compressor and avoid undesired issues.

Before you begin reading this material, please consider the convention about some information contained in this document, and how one must interpret such information, which is presented below.

1.1. Conventions

	WARNING • An incorrect operation that could result in bodily injury or death due to electrical hazard.
	CAUTION • An 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 get in contact with your Nidec GA Application Engineer.

2. TECHNICAL SPECIFICATIONS

2.1. Nomenclature

#	Description	Definitions
CF	Driver Type	Controller for VCC (variable capacity compressors)
02	Family	01 - Standard power (150 W) 02 - Extended power (240 W)
F	Generation (within the family)	A sequential letter indicating relevant external modification
01	Subversion (within the generation)	01 – Standard efficiency level, without PFC 02 – High efficiency level, without PFC 03 – Ultra high efficiency level, without PFC 21 – Standard efficiency level, with PFC (internal) 22 – High efficiency level, with PFC (internal) 23 – Ultra high efficiency level, with PFC (internal)
L	Power Supply	L = 115-127 V, 50/60 Hz M = 220-240 V, 50/60 Hz N = 115-127 V or 220-240 V, 50/60 Hz W = 220-240 V, 50/60 Hz (withstand larger voltage fluctuation)
0.0	Protective Function configuration	Class A software, without hardware PEC
YY	Electronic Configuration	Changes according to control mode, diagnosis feature, connections, and non-safety-related features. Any combination of letters and numbers: 00 to ZZ
F	Enclosure	F = Attached. To be applied on the refrigerator with opened or closed compressor niche
ZZ	Cables and Peripherals Configuration	Any combination of letters and numbers: 00 to ZZ

Table 1 – Inverter nomenclature

Examples:

CF01F21 M 0.0 21 F B3 – 150W, standard efficiency, 220-240 V with PFC (internal), attached

CF02F01 L 0.0 A4 F Z1 – 240W, standard efficiency, 115-127 V, attached

2.2. Product specification

Parameter	Specification
Nominal input voltage and frequency (Notes 1, 2)	L / N = 115-127 V, 50/60 Hz M / N / W = 220-240 V, 50/60 Hz
Minimum input voltage (Note 3)	L / N = 85 V M / W = 160 V
Maximum input voltage (Note 4)	L = 140 V M / W = 264 V N = 280 V
Maximum input overvoltage	L = 140 V (Note 6) M = 300 V (Notes 5, 6) N / W = 350 V (Notes 5, 6)
Maximum input current	CF01Fxx L / CF01Fxx N = 2,5 A CF02Fxx L = 4,0 A CF01Fxx M / CF01Fxx W = 1,3 A CF02Fxx M / CF02Fxx W = 2,0 A
Maximum input power (Note 7)	CF01F = 150 W CF02F = 230W/240 W
Standby consumption (Note 8)	Frequency control version - CF0xFx1/CF0xFx2 < 0,18 / 0,35 W - CF0xFx3 < 0,10 / 0,19 W Serial control version - CF0xFx1/CF0xFx2 < 0,30 W / 0,45 W - CF0xFx3 < 0,16 / 0,23 W Drop-in control version < 0,35 W
Maximum inrush current (Note 9)	L = 195 A @ 25°C M / W = 32 A @ 25°C N = 90 A @ 25°C
Output electrical frequency range (Notes 10, 11)	VES Compressors: 31,7 – 150 Hz FMX Compressors: 43,3 – 160 Hz FMS Compressors: 90,0 – 315 Hz
Motor speed range (Notes 10, 11)	VES Compressors: 950 – 4500 rpm FMX Compressors: 1300 – 4800 rpm FMS Compressors: 1800 – 6300 rpm
Maximum output current	FMX Compressors: 1,80 A VES, FMS Compressors: 2,17 A
Environmental humidity (Note 12)	10 % to 85 % (without condensation)
Storage temperature (Note 13)	-20 °C to 85 °C
Operational temperature (Notes 13,14,15,16)	-5 °C to 80 °C

Table 2 – CF01F and CF02F Inverter specification

Note 1 – Voltage range approved by Agencies.

Note 2 – Operating below the nominal input voltage may reduce the compressor cooling capacity due to lower link voltage and/or due to Inverter power limitation.

Note 3 – Minimum voltage without impact on compressor starting performance. The compressor may start with voltages below this limit if starting conditions (suction and discharge pressures) are not extremes.

Note 4 - Maximum voltage without impact on performance and long term reliability.

Note 5 – Maximum transient voltage without the Inverter being damaged, but with impact on performance, and if it is continuously supplied at this voltage level, there may be a possible impact on product lifespan.

Note 6 – Voltages above this limit may damage the product.

Note 7 – The maximum input power may be reduced depending on the input voltage, ambient temperature, and compressor speed.

Note 8 – For frequency and serial communications, the standby consumption is presented as *sleep mode / standby*. The lower standby consumption (sleep mode) is activated in Frequency and Serial control after the command to turn off the compressor. To stay in sleep mode, it is necessary to stop sending commands after the compressor stops. Any transition level in the communication connector will wake up the Inverter.

Note 9 – Inrush current refers to a transient phenomenon that occurs when the power supply cord is connected to the power grid or in the case of returning after power outages. The CF01F and CF02F Inverters are designed accordingly and can reliably withstand this current along with the expected product lifespan. Excessive inrush current events may damage the Inverter. Embraco recommends having the appliance supply cord directly connected to Inverter power input without any disconnection means regarding Inverter installation. The CF01F and CF02F Inverters shall not be de-energized on every compressor turn off. Please, get in contact with your Nidec GA Application Engineer for any assistance or application assessment needed.

Note 10 – The output frequency and the motor speed may have a reduced range based on the respective compressor's maximum working conditions.

Note 11 – The motor speed range of compressors may change depending on the model. The speed range of Compressors is specified on its datasheet.

Note 12 – Inverter shall be stored in a proper environment to avoid condensation and oxidation of its parts.

Note 13 – If extended storage and operating temperatures are required, please get in contact with your Nidec GA Application Engineer.

Note 14 – Agency approval temperature.

Note 15 – The measuring point of Inverter ambient temperature is 50 mm far from the Inverter label side, as shown in Figure 1.

Note 16 – The maximum ambient temperature around the Inverter depends on the input power, as shown in the Table 3. This limit shall be observed during the refrigerator's heating test.

Inverter Ambient Temperature [°C]	Input Power [W]		
	CF01Fx x	CF02F21 CF02F22	CF02F0x CF02F23
50	150	230	240
55	150	215	235
60	150	205	220
65	150	190	210
70	145	175	190
75	135	155	170
80	120	135	150

Table 3 – Derating table

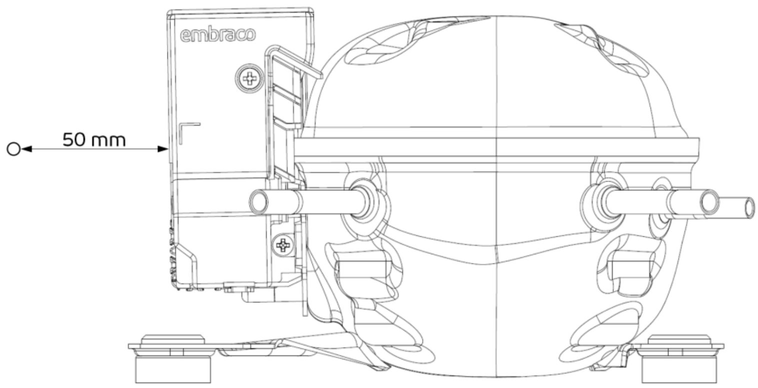

Figure 1 – Measuring point of Inverter ambient temperature (compressor niche temperature)

WARNING

- Do not connect the CF01F or the CF02F Inverter to a power supply above the declared Maximum Input Voltage.

CAUTION

- This Inverter is for use only with the Embraco VCC compressor.
- Operating the product at voltages out of the 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 - Compressor may degrade overall product performance.
- To avoid loss of performance, make sure to operate the Inverter within the temperature and power ranges. Excessive load or high ambient temperature may activate Inverter thermal protection.

2.3. Product dimensions

2.3.1. Inverters without PFC inductor

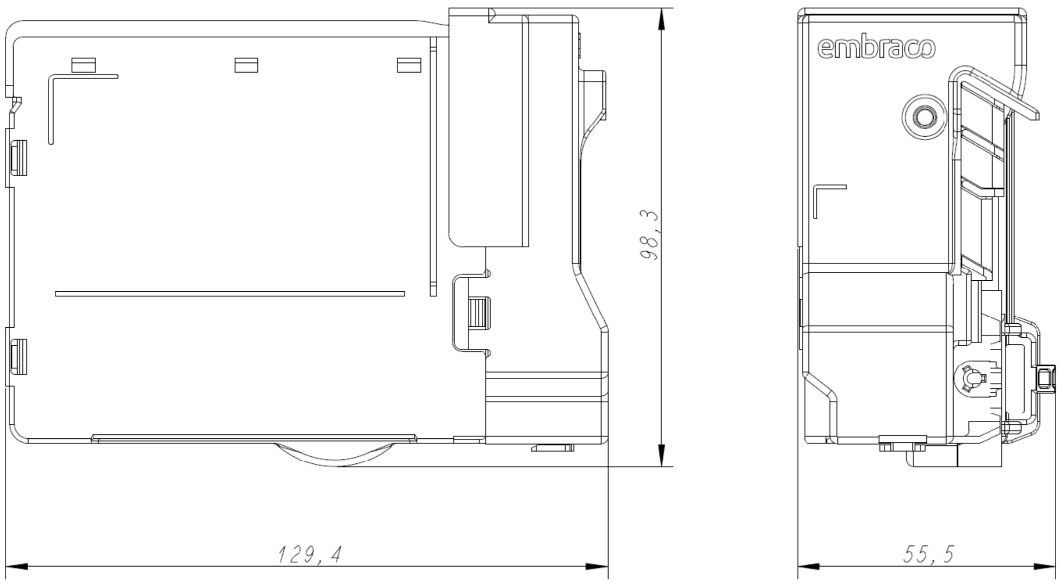

Figure 2 – CF01F0x and CF02F0x Inverters dimensions (mm)

2.3.2. Inverters with internal PFC inductor on the label side

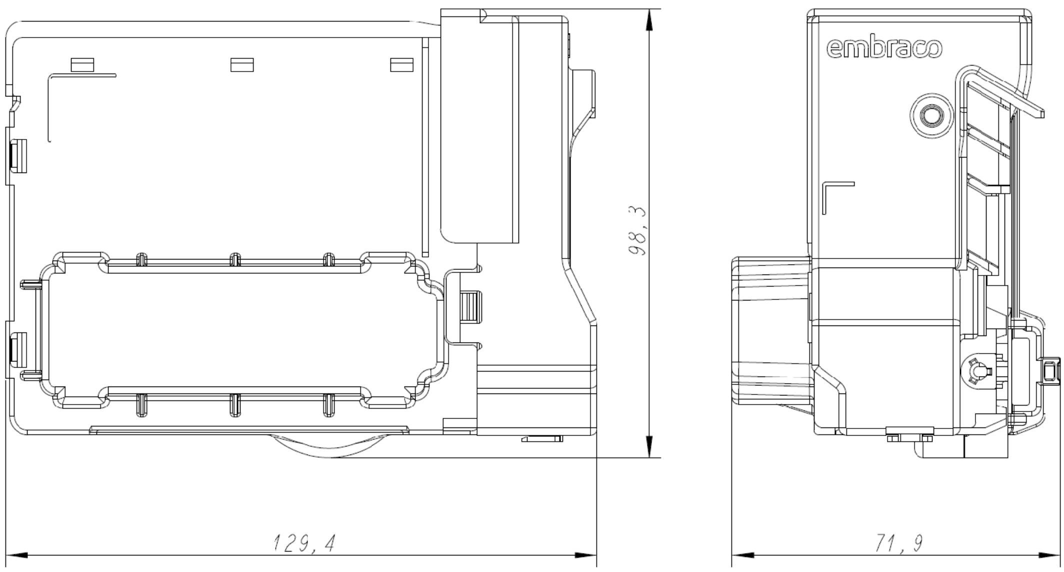

Figure 3 – CF01F2x and CF02F2x Inverters dimensions (mm)

2.3.3. Inverters with internal PFC inductor on the bottom side

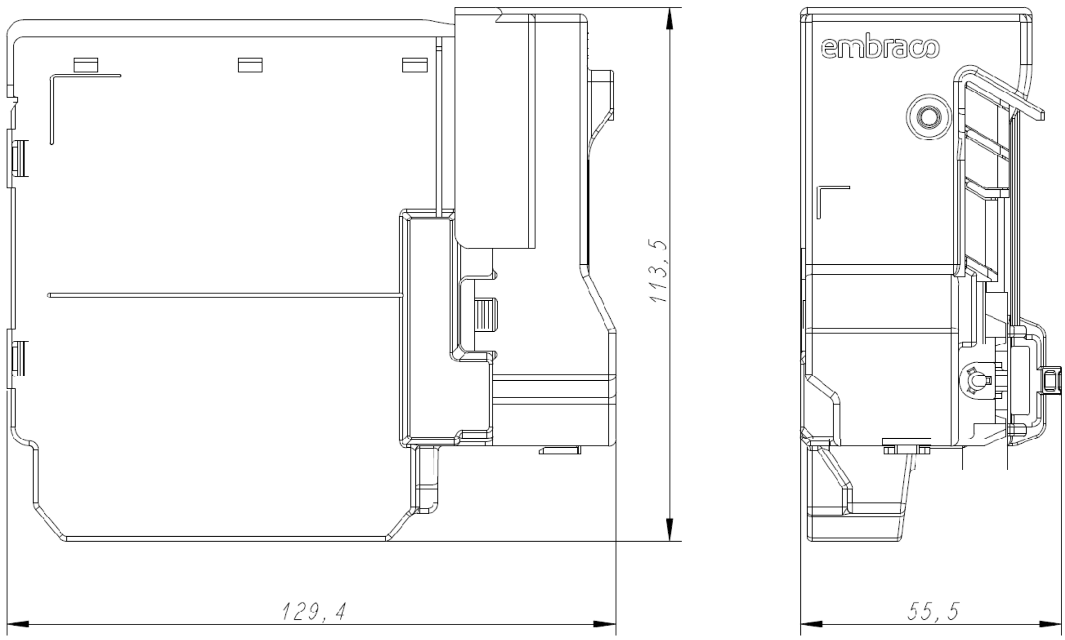

Figure 4 – CF01F2x and CF02F2x Inverters dimensions (mm)

2.4. Connectors

Figure 5 shows the connections available in this Inverter configuration. Figure 6 shows the convention of terminal number on VH connectors. Connections specifications are presented in Table 4.

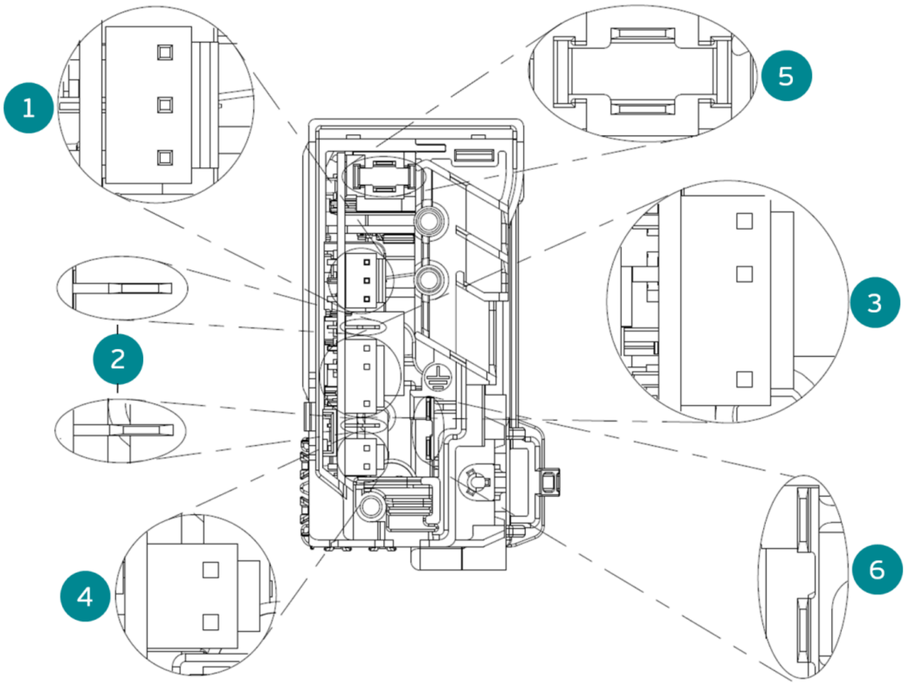

Figure 5 – CF01F and CF02F Inverters connections

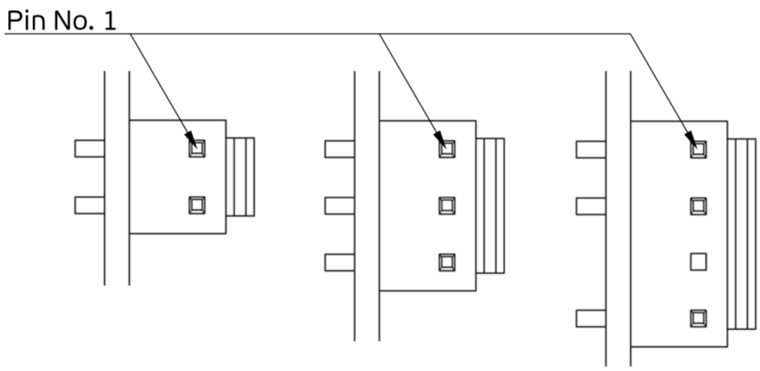

Figure 6 – VH connector circuits

#	Connection	PCB designator	Signal	Pin	Type
1	Communication - Frequency control	CN209	Ref	1	VH connector type, 2 ways (white), or edge connector
			Signal	2	
	Communication - Drop-in control (Not available for CF0xFx3 series)	CN209	Signal	1	VH connector type, 2 ways (white), or edge connector
			NC	2	
		CN211	Signal	-	Faston 4.8
	Communication - Serial control	CN209	OUT	1	VH connector type, 3 ways (white), or edge connector
			GND	2	
			IN	3	
2	AC input	CN204	N	-	Faston 4.8
		CN202	L	-	Faston 4.8
3	AC output (optional)	CN206	N	1	VH connector type, 3 ways, white
			L	3	
		CN206	N	1	VH connector type, 4 ways (white), or edge connector
			N	2	
			L	4	
		CN205	N	-	Faston 4.8
		CN203	L	-	Faston 4.8
4	Inductor (only for PFC versions)	CN200	Ind. 1	1	VH connector type, 2 ways (red)
			Ind. 2	2	
5	Bridge (optional)	-	-	-	2 x Faston 4.8
6	Earth	-	-	-	2 x Faston 4.8

Table 4 – CF01F and CF02F Inverters connections

Figure 7 and Figure 8 show the connections available in the CF01F0xN Inverter (dual voltage version). Connections specifications are presented in Table 5.

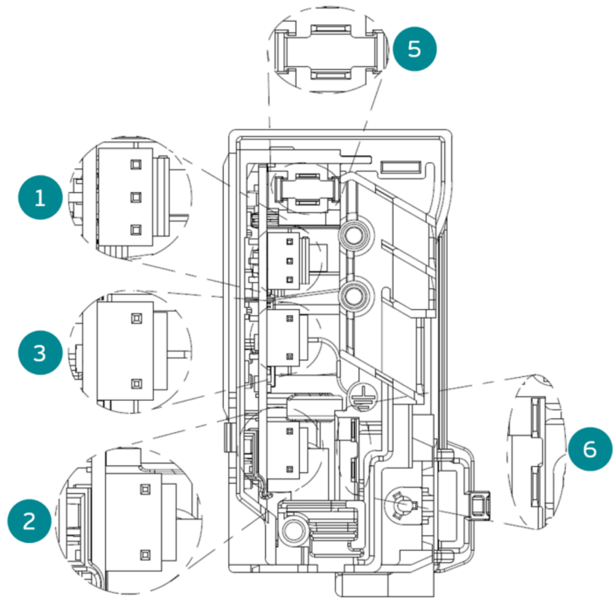

Figure 7 – CF01F0xN Inverter connections with standard connectors

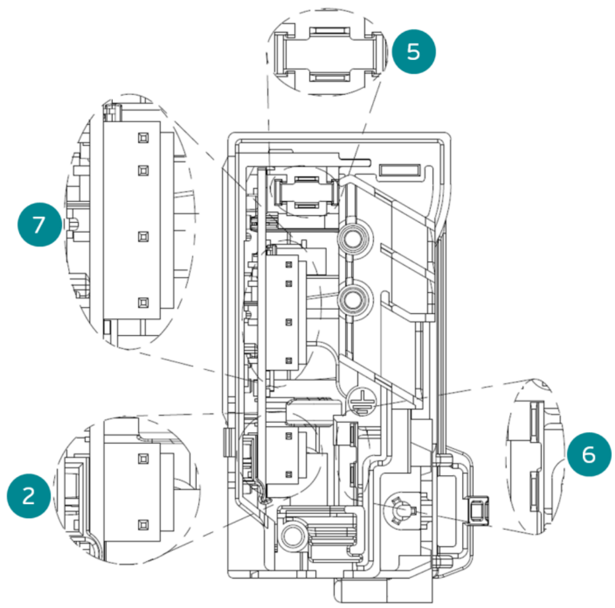

Figure 8 – CF01F0xN Inverter connections with integrated connector

#	Connection	PCB designator	Signal	Pin	Type
1	Communication - Frequency control	CN209	Ref	1	VH connector type, 2 ways (white), or edge connector
			Signal	2	
	Communication - Drop-in control	CN209	Signal	1	VH connector type, 2 ways (white), or edge connector
			NC	2	
		CN211	Signal	-	Faston 4.8
	Communication - Serial control	CN209	OUT	1	VH connector type, 3 ways (white), or edge connector
			GND	2	
			IN	3	
2	AC input	CN204	N	-	Faston 4.8
		CN202	L	-	Faston 4.8
		CN201	N	1	VH connector type, 3 ways, white
			L	3	
3	AC output (optional)	CN206	N	1	VH connector type, 3 ways, white
			L	3	
		CN203	L	-	Faston 4.8
5	Bridge (optional)	-	-	-	2 x Faston 4.8
6	Earth	-	-	-	2 x Faston 4.8
7	Integrated connector (communication & AC output)	CN207	Ref	1	VH connector type, 6 ways, white
			Signal	2	
			N	4	
			L	6	

Table 5 – CF01F0xN Inverter connections

CAUTION

- Serial or Frequency communication has reinforced isolation.
- Drop-in communication has functional isolation.

2.5. Cable path

The CF01F and CF02F Inverters have four cable paths, as shown in Figure 9. The maximum recommended diameter for rigid insulation cables (H05V2V2-F type) is presented in Table 6. In the case of flexible insulation type, larger diameters may be applied. Compliance with clause 25.15 of IEC 60335-1 shall be observed with the final arrangement of cables.

Cable path	Maximum cable diameter [mm]
P1	3,9
P2	6,1
P3	7,2
P4	7,8

Table 6 – CF01F and CF02F cable paths specifications

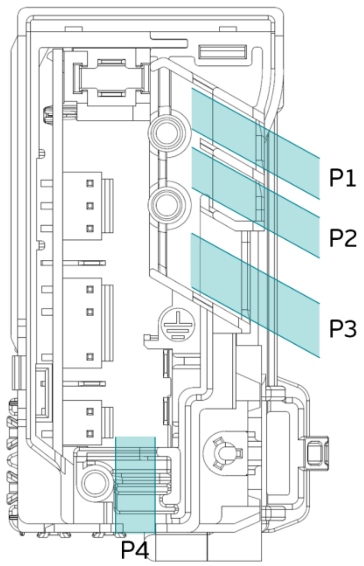

Figure 9 – CF01F and CF02F cable paths

If the system supply cord is connected directly to the CF01F or CF02F Inverters and this cable has the 3 wires (line, neutral, and earth) with the same length, it is recommended to use cable path P4 for this supply cord.

2.6. Harmonic current emissions (PFC version)

In markets where compliance with IEC 61000-3-2 is mandatory, refrigerators and freezers with variable speed compressors must comply with class D requirements. However, according to clause 7 of IEC 61000-3-2, equipment with a rated power of 75 W or less (Note1) are exempted from this requirement.

Note 1 – The clause 10.1 of IEC 60335-1 in addition to the same clause of IEC 60335-2-24 defines Rated Power.

If the refrigeration system is applied in a market where compliance with IEC 61000-3-2 is not mandatory or if the system has a rated power of 75 W or less, the recommended Inverter type is the CF01F0x or CF02F0x (M/W/L). If the refrigeration system must comply with class D requirements of IEC 61000-3-2, the recommended Inverters type are the CF01F2xM and CF02F2xM.

The Inverters CF01F2xM and CF02F2xM are provided with a harmonics inductor that reduces the Inverter harmonic currents. Their limits differ from each refrigeration system since it is a function of power consumption during the pull-down test and currents during regular operation. The CF01F2xM and CF02F2xM Inverters have different inductor options that will better fit a group of systems. To select the best choice for your application, please get in contact with your Nidec GA Application Engineer.

2.7. Capacitors discharge circuit

According to clause 22.5 of IEC 60335-1, appliances intended to be connected to the supply mains by means of a plug or pins for insertion into socket outlets shall be constructed so that in normal use, when pins are touched, there is no risk of electric shock from charged capacitors (max. 34V, 1 sec after disconnection).

The CF01F and CF02F inverters are designed with discharge circuits, that may be assembled upon demand. The Inverters can be configured with passive or active discharge circuit solutions. To select the best choice for your application, please contact your Nidec GA Application Engineer.

2.8. Label

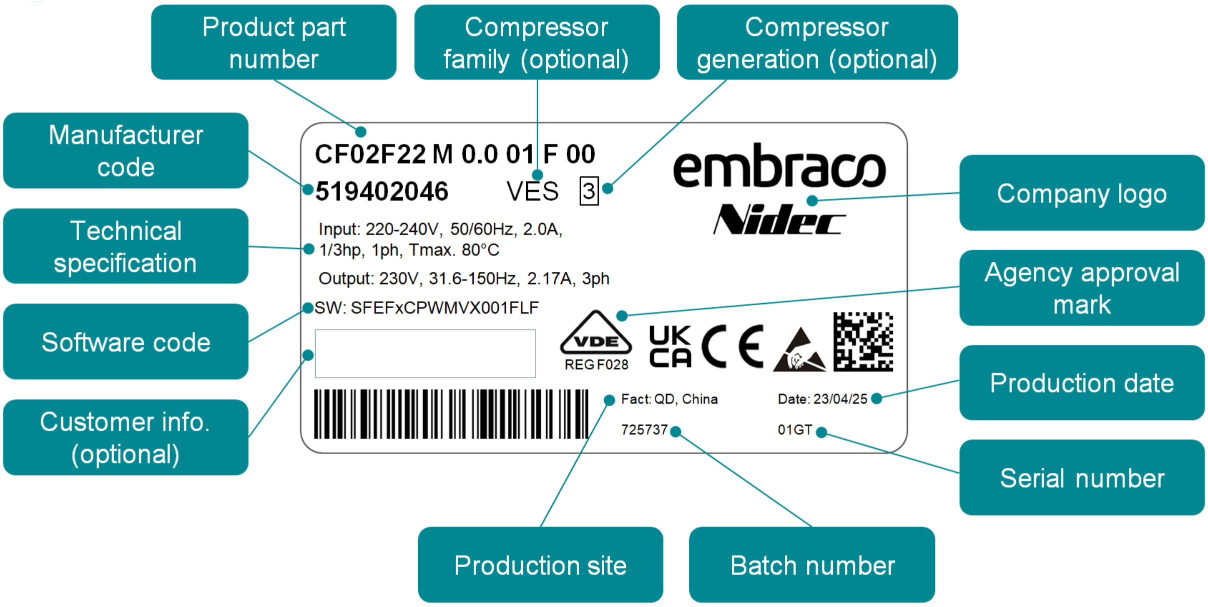

Figure 10 – Product label

2.9. Institute approval

Institute	Inverter Version	Certificate No. / File	Applied standard	Approval mark
VDE	CF0xFx1 CF0xFx2 CF0xFx3	40052297	EN 60335-1:2012 +AC+A11+A13 +A1+A2 +A14:2019 EN 60335-2-34:2013 with Annex AA	REG F028
UL	CF0xFx1 CF0xFx2	E222315, Vol. 3, Sec. 7	UL 60730-1, Fifth edition CAN/CSA-E60730-1:15	

Table 7 – Agency approvals of CF01F and CF02F inverters

3. INSTALLATION

3.1. General Precautions

WARNING

- Do not open the Inverter box. For installation, remove only the Inverter cover to make the electrical connections.
- Make sure that the CF01F or CF02F Inverter will not be in touch with flames during assembly.
- To prevent damage to your CF01F or CF02F Inverter during and after assembly, it must not have contact 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.
- The CF01F and CF02F Inverters are designed for indoor use and must be installed according to the procedures shown in this material. The location where the Inverter will be installed must be protected against splashed water.
- The products were approved considering their use on altitudes until 4000 m.

CAUTION

- Read this material carefully before you begin the CF01F and CF02F installation and start-up procedures.
- The CF01F and CF02F Inverters are to be applied only with Embraco variable capacity compressors.
- Before you begin your installation, observe the CF01F and CF02F Inverter specifications, check if the product is correctly identified, and if the Inverter is without cracks or damages.
- The CF01F and CF02F Inverters are sensitive to Electrostatic Discharges. Take care of product handling until final assembly.
- Workers that handle the Inverter must be earthed through an adequate ESD wrist strap and must wear ESD gloves.
- Take special care to avoid mechanical impacts on the CF01F and CF02F Inverter during the assembly process. If the product falls from a height of 0,5 meters or more, it must be discarded.

3.2. Electrical Installation

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 Inverter's phase input connector and the line neutral to the neutral input connector of the Inverter. Figure 11 shows the recommended connections.

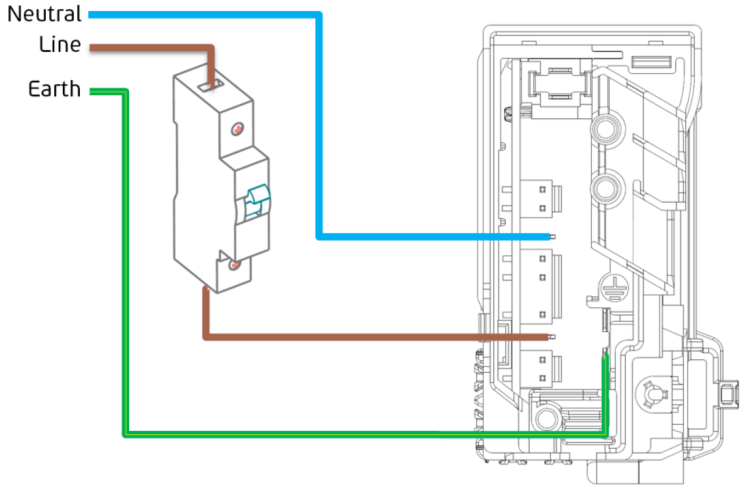

Figure 11 – Line-Neutral connection

In the case of two-phase installations, it is mandatory to use a 2-pole circuit breaker, because in the case of a short circuit, both phases of the power supply are protected. Figure 12 shows the recommended connections.

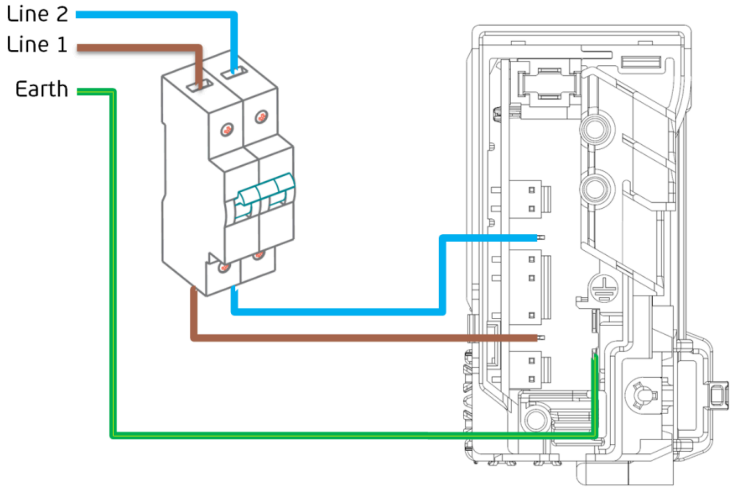

Figure 12 – Line-Line connection

3.3. Mechanical structure

The CF01F and CF02F inverters are available only for direct assembly on the compressor pins (attached version). Figure 13 and Figure 14 show the enclosure components for the inverter versions. Table 8 presents the inverter versions and their corresponding enclosure types.

Mechanical Structure	Inverter Version	Assembling Type
Figure 13	CF01Fx1 CF01Fx2 CF0xFx3	Attached
Figure 14	CF02Fx1 CF02Fx2	Attached

Table 8 – Mechanical structure and inverter versions

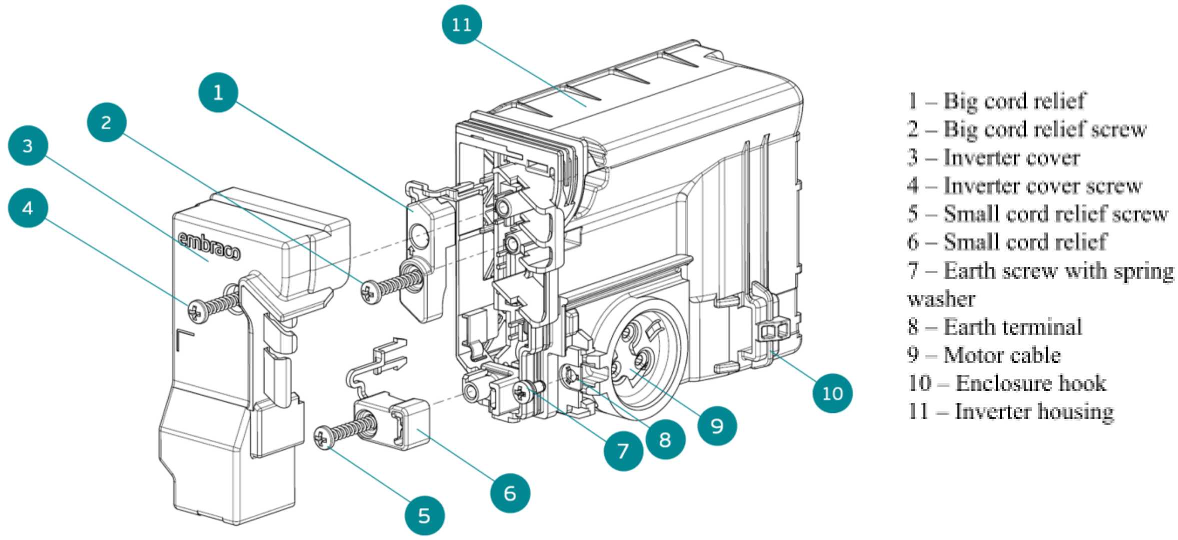

Figure 13 – Mechanical Structure for attached versions of CF01Fx1, CF01Fx2 and CF0xFx3

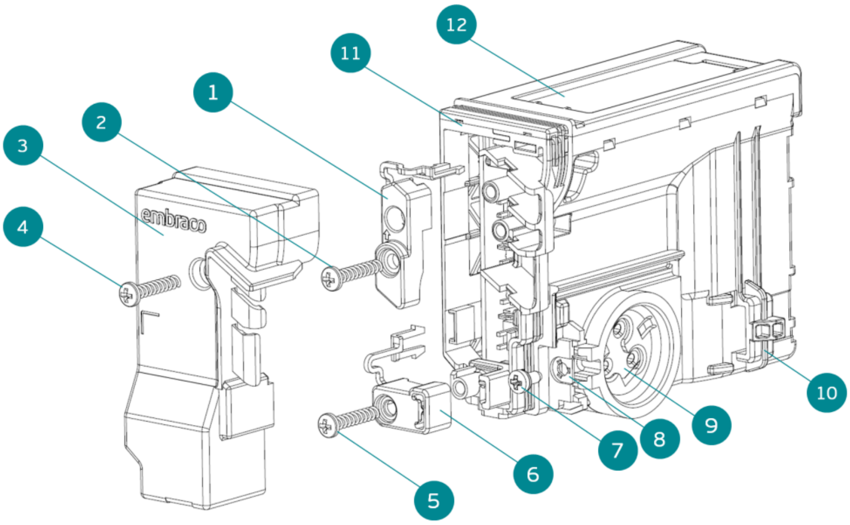

Figure 14 – Structure for attached version of CF02Fx1 and CF02Fx2

3.4. Assembly Instructions

The motor cable (9) of CF01F and CF02F Inverters is pre-assembled in the Inverter enclosure (11). Once the Inverter is correctly attached to the compressor, the motor cable is then connected to the hermetical terminals pins.

The earth terminal (8) is pre-assembled on the Inverter enclosure (11). Once the Inverter is adequately attached to the compressor and the earth screw (7) is assembled, the compressor shell is electrically connected to the earth terminal. The earth screw and the enclosure hook (10) are the fixing elements that keep the Inverter in the correct position during transportation and operation.

Screws for cable fastening and cover (2, 4, 5) are self-tapping 4x20 mm screws. The earth screw (7) is M3,5X0,6, class 5.8, with a spring washer (Embraco SKU 19307899). All the screws (2, 4, 5, 7) shall be fastened applying 1,0 Nm (±0,2) torque. The screwdriver bit is the PH2.

!	**WARNING** • The screws must be free of the following substances: Hydrocarbons; Ester based oils (e.g., compressor oil); Phenols; Amines; Ketenes; Automotive fluids such as grease, except glycol and heavy alcohol. • The specified screwing torque must be met. Embraco recommends to verify it at least once per batch.

	Maximum and minimum specified torque must be met. The screwing torque must be verified at least once per batch.

The CF01F and CF02F Inverters must be assembled in the compressor fence with rotational movement. Assembly instructions to attach the Inverter in the compressor fence are shown in Figure 15.

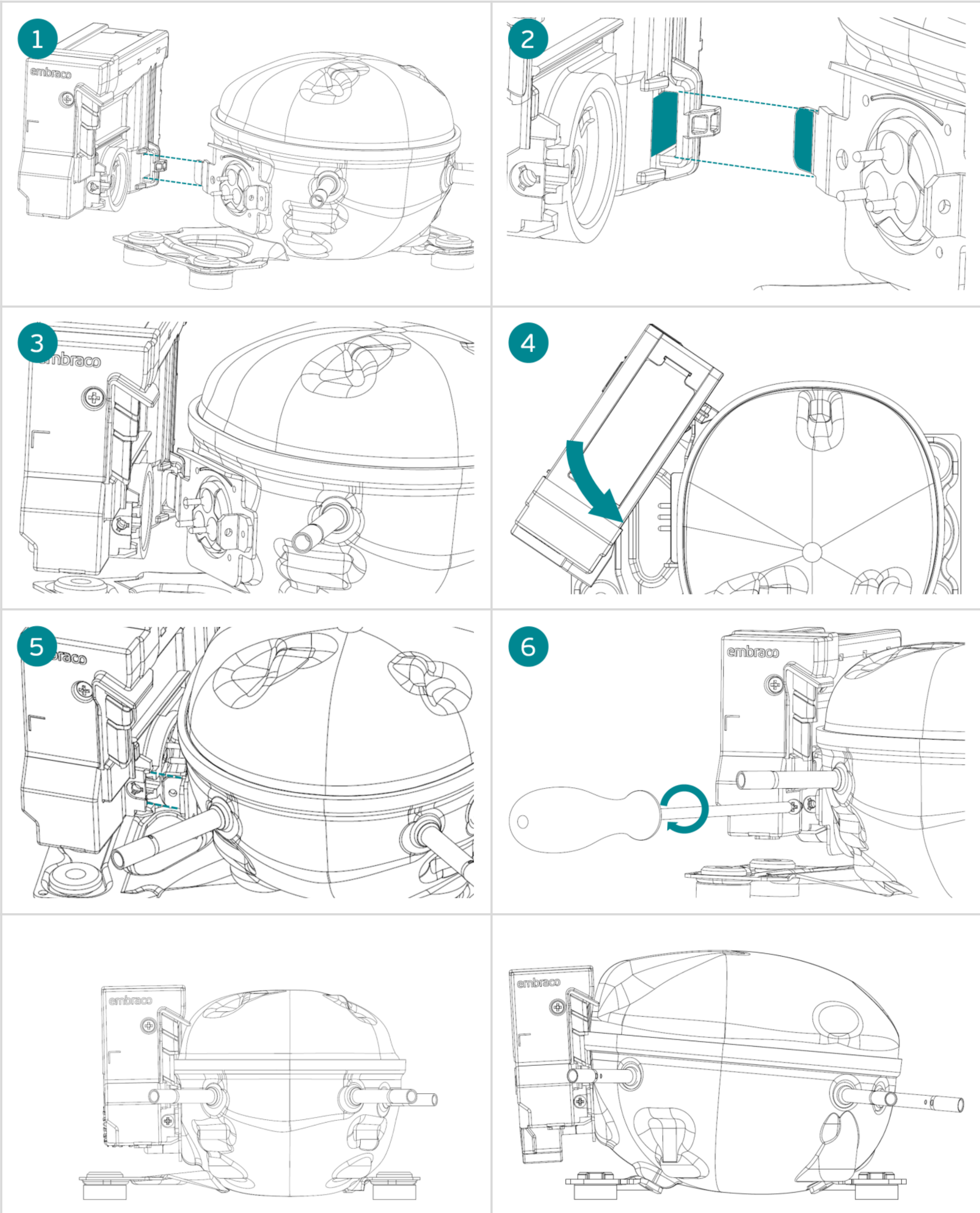

Figure 15 – Sequence of assembly

	CAUTION • Once assembled on the compressor, do not hold the Inverter to lift or transport the compressor. Maximum and minimum specified torque must be met. The screwing torque must be verified at least once per batch.
	NOTICE • The provision for compressor earth connection can be made through the earth connector provided by CF01F and CF02F Inverters. To ensure the connection's low resistance, consider performing the test described on EN 60335-1 Ed5 clause 27.5 in the final appliance.

3.5. Package information

The number of Inverters inside the packing box may change due to internal or external requirements. Figure 16 shows an example of the packing box, and it must be used only as a reference.

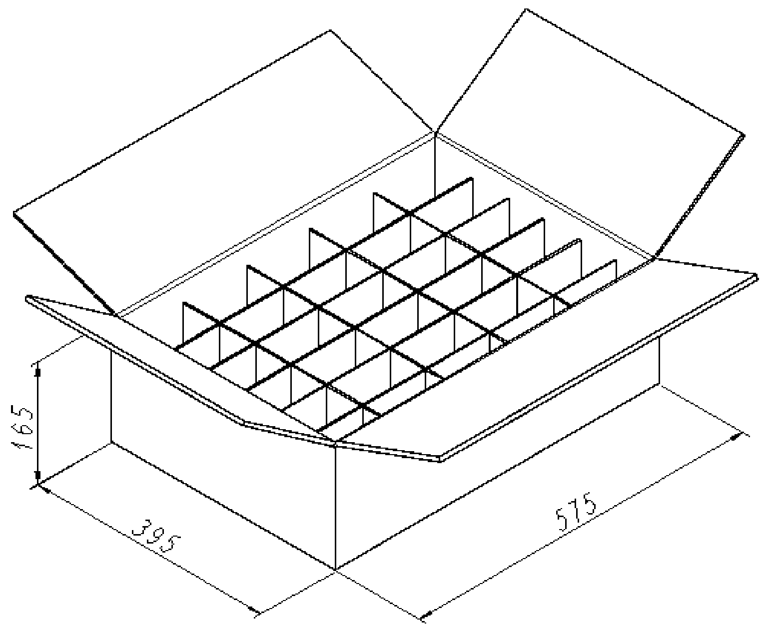

Figure 16 – Example of carton box for inverter transportation

3.6. Product discard

WARNING

- Do not open the Inverter box.
- Do not incinerate the CF01F or CF02F Inverter. Contact your local authorities if you need to incinerate this product for disposal.

CAUTION

- The used CF01F and CF02F Inverters should not be mixed with general household waste after their lifetime or for any other discarding purpose. If you wish to discard this product, please get in touch with your local authorities or dealer and ask for the correct disposal method for proper treatment, recovery, and recycling. In some countries, you may be able to take this product to designated collection points, or qualified environmental agencies or return it to your local retailer.

NOTICE

- Besides this is a RoHS-compliant device, disposing of this product correctly 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. Please contact your local authority for further details.

4. OPERATION

	CAUTION • The compressor OFF must be done through a proper control signal and never by de-energizing the Inverter. Excessive inrush current events that happen under this circumstance may permanently damage the Inverter and/or the thermostat.
	NOTICE • The CF01F and CF02F Inverters have three different possible control modes; frequency, drop-in, and serial-mode. Once a control mode is defined, the product is configured for mass-production.

4.1. Frequency control mode

This option is used when the electronic thermostat controls the VCC's speed (variable capacity compressor) through a frequency signal sent to the Inverter.

4.1.1. Frequency control operation

The compressor speed will follow the frequency signal sent from the thermostat to the Inverter, according to the relationship described in Table 9, Table 10, Table 11, Table 12, Table 13, or Table 14, depending on the compressor model. Compressor speed response to the input frequency and speed range may vary according to customer definitions.

Input frequency signal [Hz]	VES compressor speed [rpm]
0 to 20	0
20 to 43,3	1300
43,3 to 150	30 x Hz
≥150	4500

Table 9 – VES Compressors (1300-4500 rpm) speed versus Frequency control signal

Input frequency signal [Hz]	VES compressor speed [rpm]
0 to 20	0
20 to 31,7	950
31,7 to 150	30 x Hz
≥150	4500

Table 10 – VES Compressors (950-4500 rpm) speed versus Frequency control signal

Input frequency signal [Hz]	FMX compressor speed [rpm]
0 to 20	0
20 to 43,3	1300
43,3 to 133,3	30 x Hz
≥133,3	4000

Table 11 – FMX Compressors (1300-4000 rpm) speed versus Frequency control signal

Input frequency signal [Hz]	FMX compressor speed [rpm]
0 to 20	0
20 to 43,3	1300
43,3 to 133,3	30 x Hz
133,4 to 150	(48 x Hz) - 2400
≥150	4800

Table 12 – FMX Compressors (1300-4800 rpm) speed versus Frequency control signal

Input frequency signal [Hz]	FMS compressor speed [rpm]
0 to 20	0
20 to 42,8	1800
42,8 to 150	42 x Hz
≥150	6300

Table 13 – FMS Compressors speed versus Frequency control signal(1)

Input frequency signal [Hz]	FMS compressor speed [rpm]
0 to 40	0
40 to 42,8	1800
42,8 to 150	42 x Hz
≥150	6300

Table 14 – Legacy FMS Compressors speed versus Frequency control signal(2)

Note 1 – Frequency control curve for new SKUs of inverters for FMS compressors (software PN: FST).

Note 2 – Frequency control curve for Legacy SKUs of inverters for FMS compressors (software PN: FQ0).

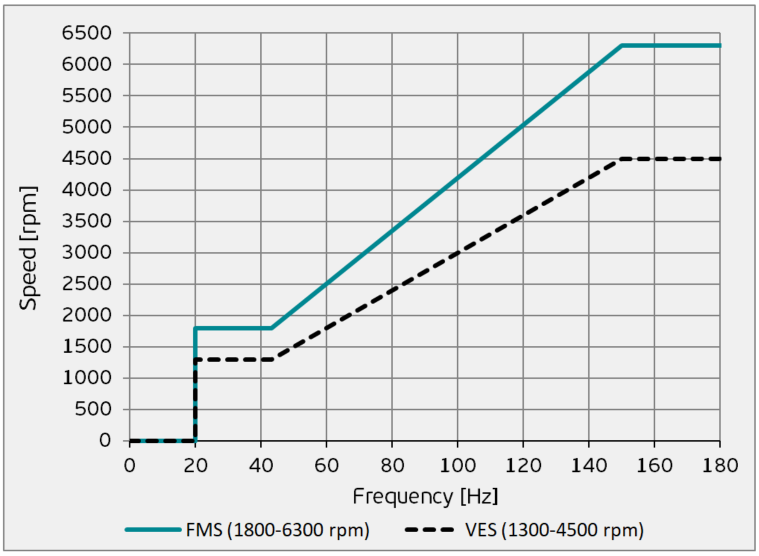

Figure 17 – Examples of Compressor speed versus Frequency control signal

The frequency control option may have up to 1% error in the frequency reading by the Inverter. When determining the thermostat software, it is recommended to consider this Inverter variation, as well as the possible error in the frequency signal generated by the thermostat.

Figure 18 shows an example of an input frequency signal of 125 Hz sent to the Inverter.

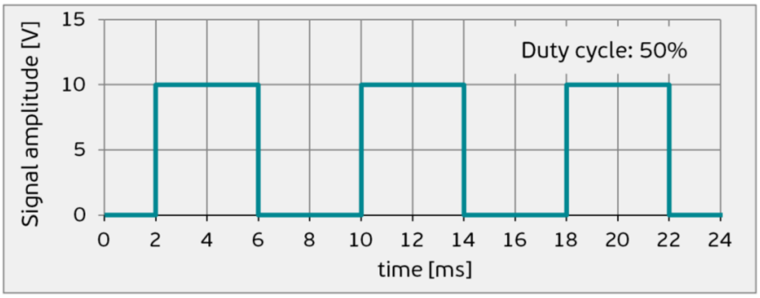

Figure 18 – Frequency signal example

4.1.2. Frequency control connection and electrical schematic

The thermostat is connected to the Inverter through the CN209 connection, using a communication cable (Figure 19).

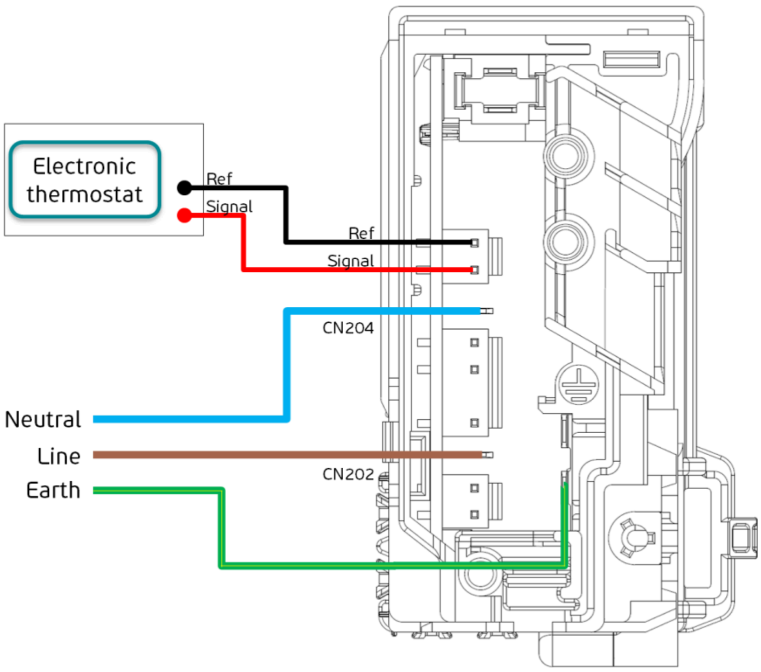

Figure 19 – Frequency control connection

The frequency signal is a digital square wave and its parameters are described in Table 15.

Parameter	Level
OFF state	-5 V to +0,7 V
Indefinite state	+0,7 V to +4 V
ON state	+4 V to +15 V
Signals out of specification	below -5 V, above +15 V
Minimum duty cycle	30 %
Maximum duty cycle	70 %

Table 15 – Frequency signal specification

Once the range from +0.7 to +4 V is an indefinite state, one recommends avoiding it.

For frequency communication, the input resistance (R402) is 1,2 kΩ.

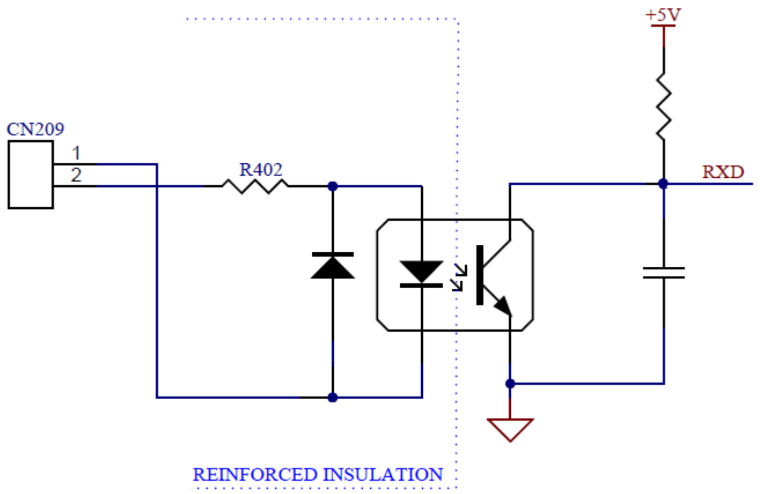

Figure 20 – Electrical schematics of CF01F and CF02F Inverters board configured as frequency communication

4.2. Serial control mode

This option is used when the electronic thermostat controls the CF01F or CF02F using a serial communication protocol. The serial communication protocol is based on RS-232 parameters, but the interface's electrical specifications are different from this standard.

4.2.1. Basic specification

Communication type	Asynchronous (start-stop)
Baud Rate	600 baud
Start Bits	1
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None
Unit Size	5 Bytes

Table 16 – Serial Communication - Basic Specifications

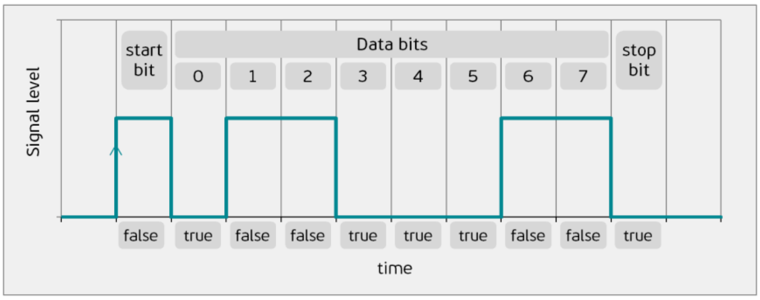

Figure 21 – Example: 39h sent to Inverter

4.2.2. Communication Protocol

Protocol	
Operation	Half-duplex
Unit Board	Master
Inverter Board	Slave

Table 17 – Serial Communication – Protocol

4.2.3. Basic command structure

Transmit command structure	1st byte identification	2nd byte command	3rd byte data low	4th byte data high	5th byte checksum
1: Transmit set speed	A5h	C3h	1)	2)	3)
2: Read set speed	A5h	3Ch	80h	39h	3)
3: Read operation status	A5h	3Ch	83h	39h	3)

Table 18 – Serial Communication – Transmit Command Structure

Receive command structure	1st byte identification	2nd byte command	3rd byte data low	4th byte data high	5th byte checksum
Response to 1	5Ah	83h	4)	5)	3)
Response to 2	5Ah	80h	1)	2)	3)
Response to 3	5Ah	83h	4)	5)	3)
Communication error	5Ah	6)	FFh	FFh	3)

Table 19 – Serial Communication – Receive Command Structure

Definition of command bytes:

1. Set speed data low byte
2. Set speed data high byte
3. Checksum:

   Checksum = 100h – ((1st_byte + 2nd_byte + 3rd_byte + 4th_byte) & FFh)
4. Status data low byte
5. Status data high byte
6. Error code:

   F0h - Error in byte 4
   F2h - Error checksum (byte 5)
   F4h - Error command Code (byte 2)
   F8h - Error in byte 3

Status data	Low byte bit of status data	Description	Remarks
0000h	-	Normal operation	Typically this data is returned 4)= 00h, 5)= 00h
0002h	1	Power/Thermal protection	4)= 02h, 5)= 00h
0080h	7	Set speed data out of spec	4)= 80h, 5)= 00h
FF00h	-	Compressor stopped (waiting for a valid start speed)	4)= 00h, 5)= FFh
FF01h	0	Start fail / Motor cable failure	4)= 01h, 5)= FFh → Compressor fail
FF02h	1	Overload failure	4)= 02, 5)= FFh → Compressor fail
FF04h	2	Under speed failure	4)= 04h, 5)= FFh → Compressor fail
FF08h	3	Wrong rotor position failure	4)= 08h, 5)= FFh → Compressor fail
FF10h	4	Overvoltage failure	4)= 10h, 5)= FFh → Inverter fail
FF20h	5	Over-temperature failure	4)= 20h, 5)= FFh → Compressor fail

Table 20 – Serial Communication – Status Data

Note 1: When one or more errors occur, the corresponding bits are set to 1.
Example: Overload (0b00000010) and Under speed (0b00000100): 0xFF06

Note 2: The status data high byte defines the compressor state:

00xxh → compressor is running

FFxxh → compressor is stopped

4.2.4. Serial control connection and electrical schematic

The thermostat is connected to the Inverter through the CN209 connection, using the Control Input Cable. Use the IN terminal for the Thermostat TX signal, the GND for the Ground signal and the OUT terminal for the Thermostat RX signal (Figure 22).

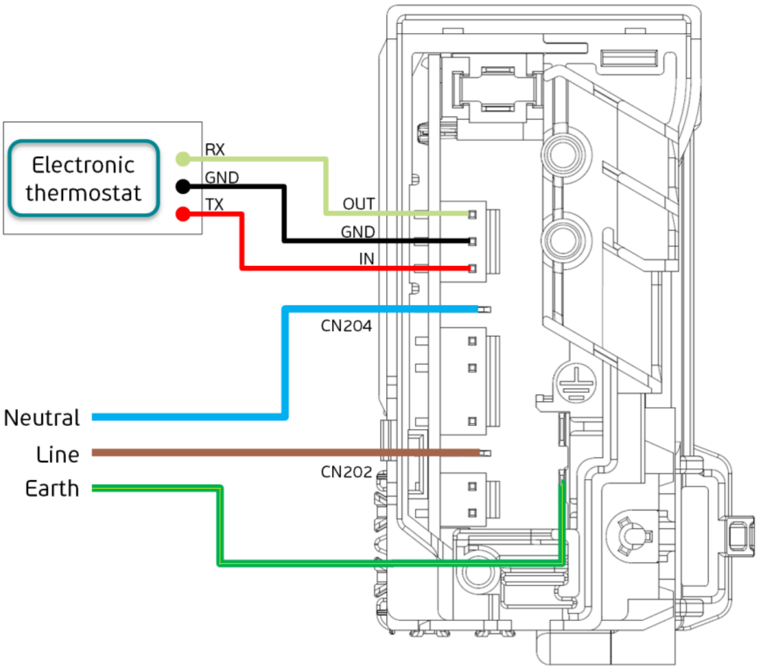

Figure 22 – Serial control connection

To guarantee serial communication's correct functionality, the signal sent to the Inverter must be according to the following values (Table 21).

Parameter	Level
TRUE state	-5 V to + 0,7 V
Indefinite state	+ 0,7 V to + 4 V
FALSE state	+ 4 V to + 15 V
Minimum current	2 mA @ + 4 V
Maximum current	15 mA @ + 15 V
Logic Level	Inverted logic

Table 21 – Serial input signal specification

The input resistance (R402) is 1,2 kΩ. The thermostat resistor connected to the Inverter TX (Pin 1) must be designed considering a maximum current of 1,2 mA through the Inverter optocoupler.

The circuit in Figure 23 shows the electrical connections to perform serial communication between an electronic thermostat and CF01F-CF02F Inverter serial connector (CN209).

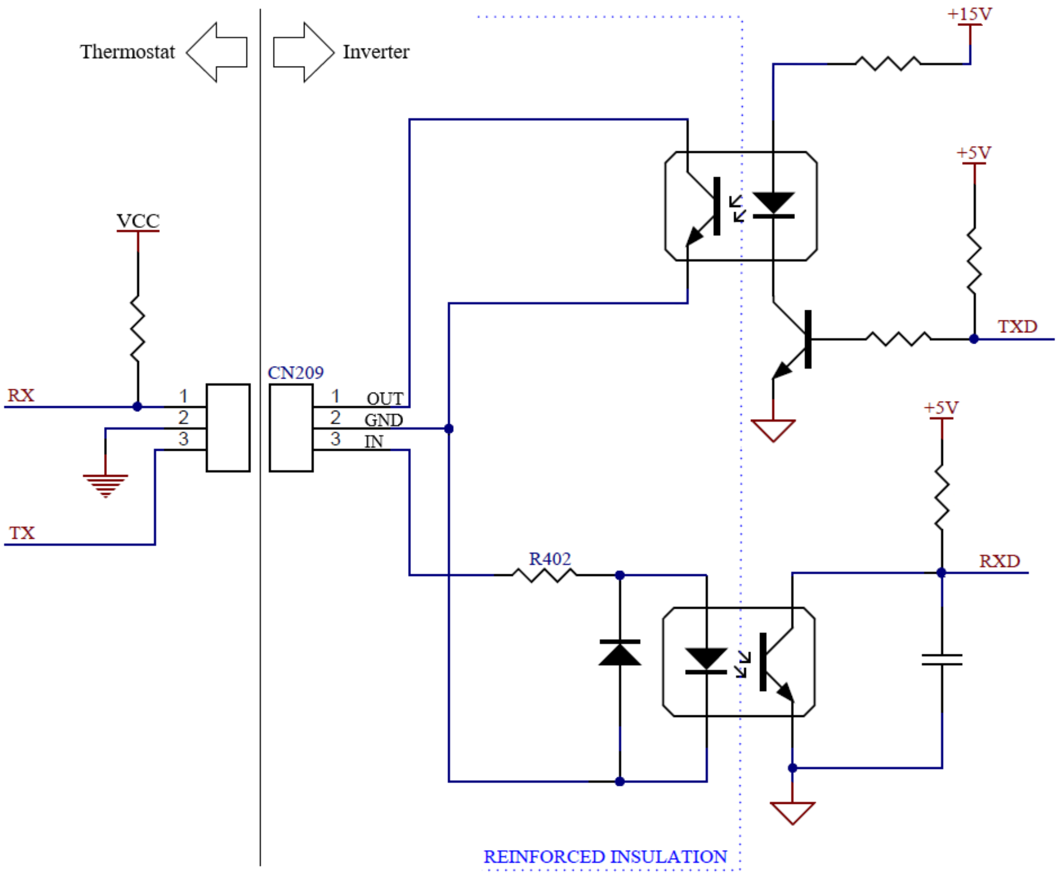

Figure 23 – Electrical schematics of CF01F and CF02F Inverter board configured as serial communication

4.3. Drop-in control mode

The Drop-In mode (not applicable for CF0xFx3) is a control mode of Embraco compressors, where single thermostat contact is used to set the compressor running conditions. Drop-In mode allows the VCC application to any refrigeration system with a simple ON/OFF thermostat, without needing a rotation control signal through serial or frequency communication. In the Drop-in mode, the compressor speed is adjusted automatically by the Inverter, according to the cooling capacity required by the system.

This solution was designed to focus on efficiency. The control logic is divided into two main parts: when the compressor is energized for the first time (pull-down) and when the compressor is cycling (after the thermostat has switched off the compressor the first time).

4.3.1. Standard Drop-in

4.3.1.1. First-time Pull-down

Once the Inverter is energized for the first time and the thermostat contact closes, the Inverter starts the Pull Down routine. The compressor is turned on at an intermediary speed for 7 minutes. The speed is then increased to its maximum and kept until the thermostat opens, switching the compressor off.

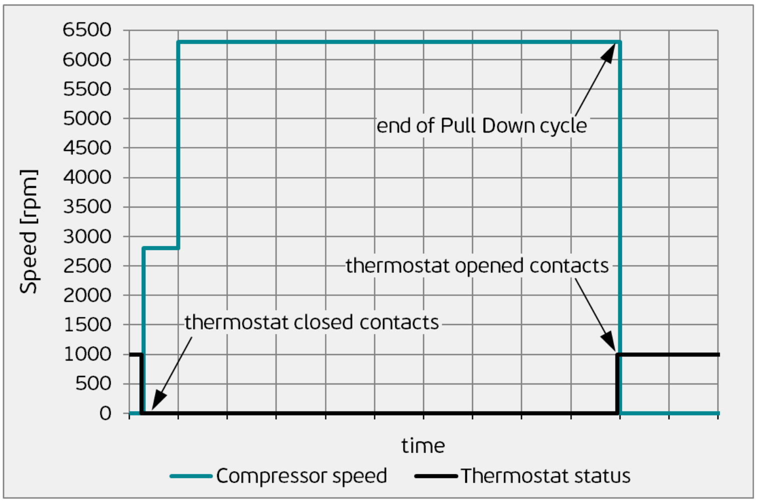

Figure 24 – Example of a pull-down cycle for an FMS compressor

4.3.1.2. Normal cycling

In the beginning of each new cycle (thermostat contact closes), the compressor is turned on at the minimum speed. The Inverter will automatically adjust the compressor speed, increasing or decreasing the rotation according to the thermal load variation. As the thermal load changes inside the appliance, pressures will change, and the Inverter will sense this variation, changing the compressor speed proportionally, without the need for a temperature sensor. Optimum speed will be targeted to minimize energy consumption. If the thermal load remains constant for a period longer than 20 minutes, the compressor speed is increased. Figure 25 presents the basic working of Drop-in in normal cycles.

The standard Drop-in parameters are adjusted to run several systems with different configurations. In the case one appliance requires some adjustment on the Drop-in, its parameters can be tuned on demand to maximize the system's performance. For customization demands, please get in contact with your Nidec GA Application Engineer.

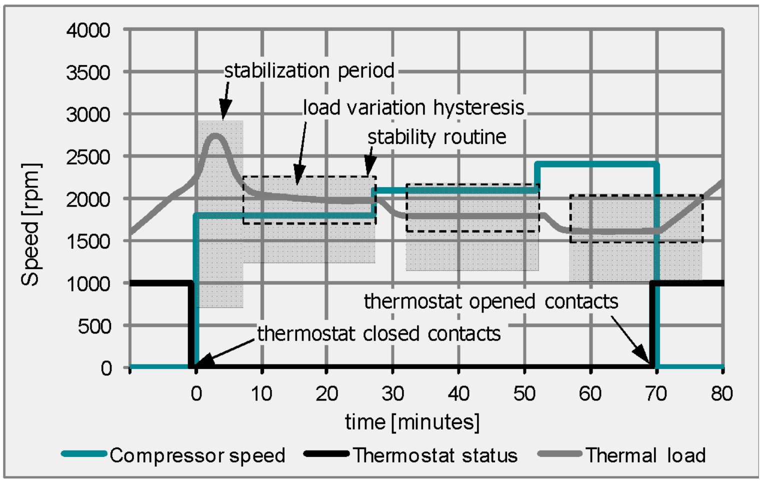

Figure 25 – Drop-in, normal cycling

4.3.2. 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.

4.3.2.1. 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.

4.3.2.2. 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.

4.3.2.3. 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.

4.3.2.4. Defrost Routine

This routine is used for greater accuracy in detecting defrost, accelerating the temperature recovery in the post-defrost cycle.

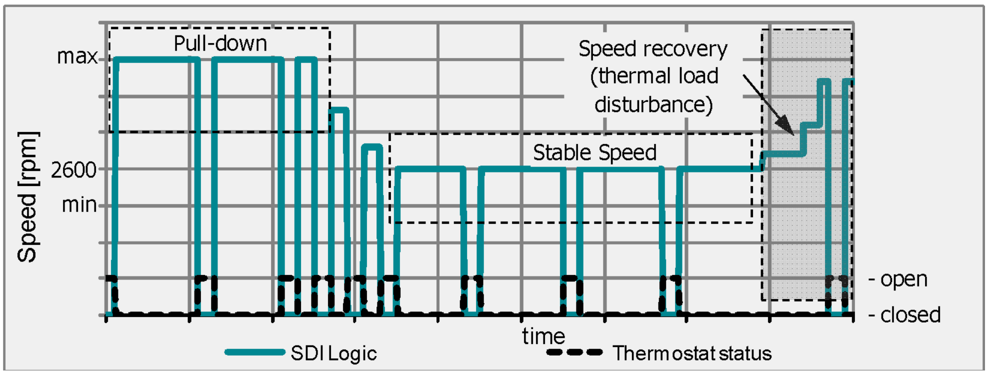

Figure 26 – Compressor speed versus thermostat behavior Smart Drop-in

4.3.3. Drop-in connection and electrical schematic

The thermostat is connected to the Inverter through the CN209 connection (or CN211 in case of faston terminal), using a communication cable (Figure 27).

	**CAUTION** ● Drop-in communication has functional isolation only. ● When opened, the thermostat impedance must be higher than 380 kΩ. Otherwise, the compressor can continuously run without ever turning off. ● When operating with under voltages (160V or lower for 220-240V Inverters) the communication may be lost and the compressor will not works until the input voltage increases again. ● If the application requires working with lower input voltages, please get in contact with your Nidec GA Application Engineer.

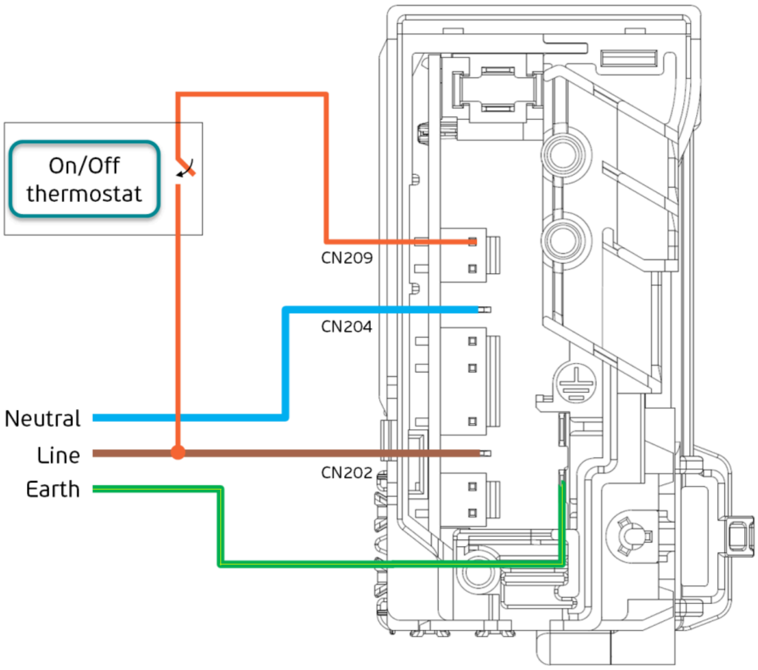

Figure 27 – Drop-in control connection

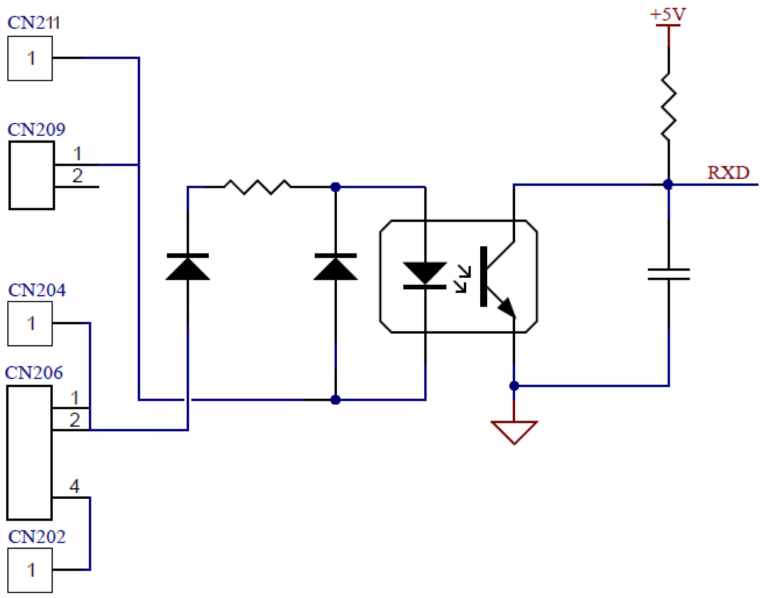

Figure 28 – Electrical schematics of CF01F and CF02F Inverter board configured as drop-in communication

4.4. Basic software routines

4.4.1. Compressor starting and stopping

During the compressor start-up, the motor will run at a medium speed for 10 seconds. The motor speed will then follow the thermostat's set speed.

When the thermostat sets the compressor off, the Inverter software first reduces the speed to a low rpm and then stops the motor. Figure 29 shows two examples of the FMS compressor stopping: one when the motor is at low speed and another when the motor is at high speed. It is not recommended to turn off the compressor by turning the Inverter power supply off.

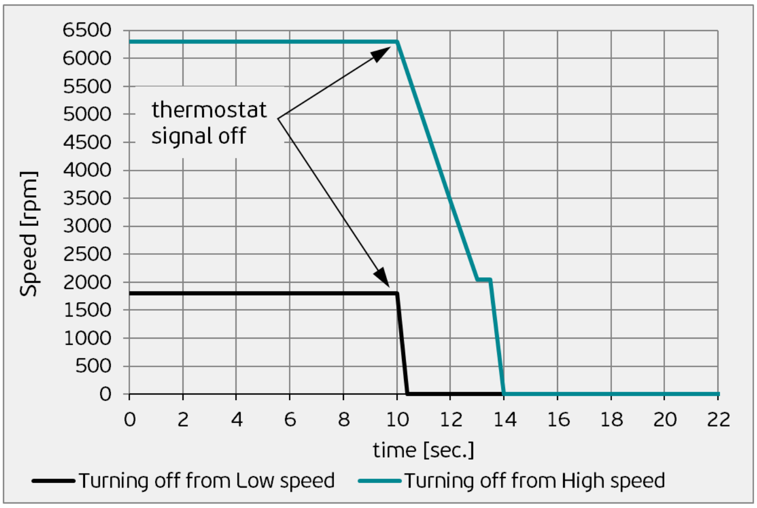

Figure 29 – Motor stopping for FMS compressors

4.4.2. Power limit

The Inverter power limit is designed to ensure that the Inverter does not operate over the components specification limit, minimizing reliability stress. When the input power reaches the power limit, the Inverter software reduces the motor speed to reduce the input power down to the limits of Table 2. Once input power drops under the power limit, the motor speed increases again to the set speed. Figure 30 presents an example of the power limit operation during a pull-down with a high load.

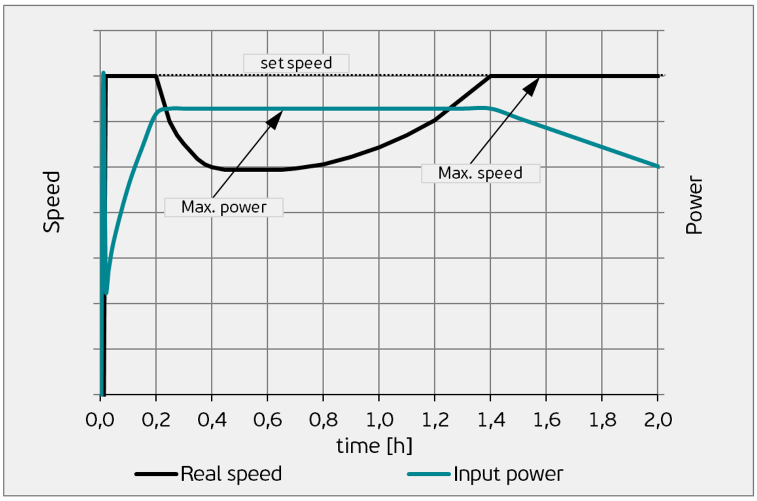

Figure 30 – Example of power limit operation during a Pull Down with high load

4.4.3. Thermal protection

The thermal protection is designed to ensure that the Inverter does not operate at too high temperatures, minimizing reliability stress. When the Inverter reaches the temperature limitation (measured with an NTC in the board), the Inverter software will reduce the motor speed to reduce the input power and restrain the Inverter temperature increase. Once the NTC temperature drops under the temperature limitation, the motor speed is increased again up to the set speed (Figure 31).

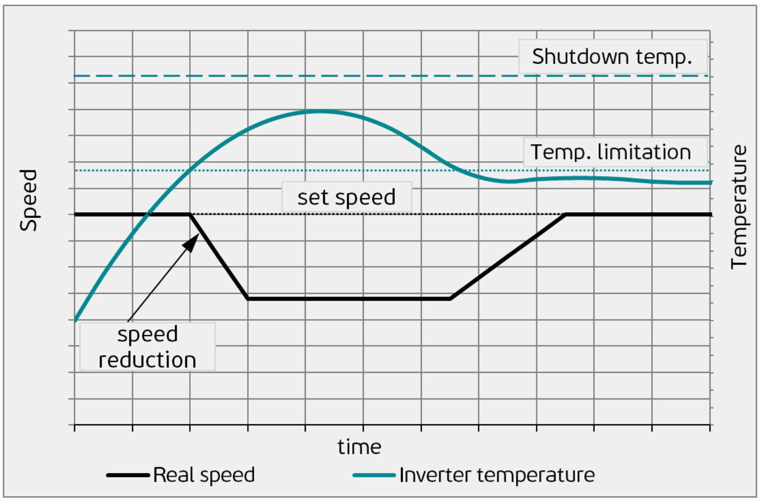

Figure 31 – Example of thermal protection with speed reduction

If the speed reduction is not sufficient to stop the temperature rise, and the NTC reaches the shutdown temperature, the motor is turned off, and the Inverter temperature reduces naturally. After the NTC temperature drops down to the turn-on limit, the compressor restarts automatically, and the motor speed follows the setpoint (Figure 32).

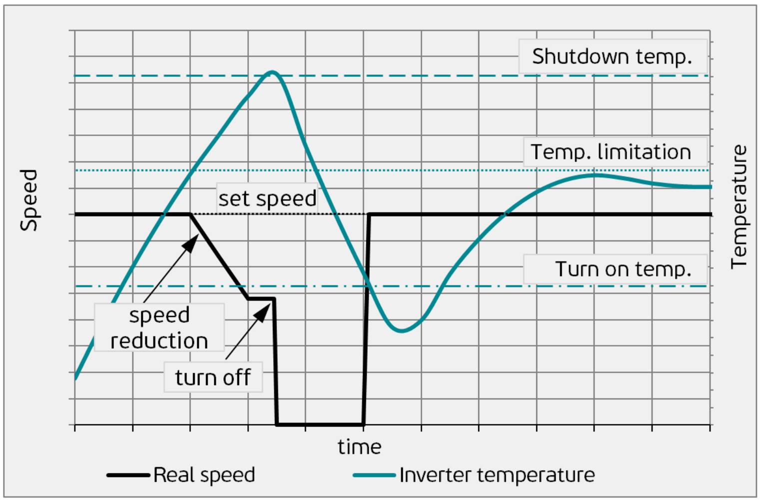

Figure 32 – Example of thermal protection with shutdown

5. DIAGNOSTICS

5.1. LED Diagnosis Function

The CF01F and CF02F Inverters have two diagnostics methods, by visual light emission using a LED indication, or by serial communication protocol. The LED diagnostic unit can be seen through the translucent cover, which also provides the basic information for diagnostic. This function helps service technicians to diagnose possible fault components by blinking a green LED inside the box. Basically, it indicates if there is a problem with the compressor, the Inverter, or the Thermostat. The table below describes the failure modes.

LED Pattern	Period	Status Description
1 flash	15 seconds	Normal operation
2 flashes	5 seconds	Control communication problem
3 flashes	5 seconds	Inverter problem
4 flashes	5 seconds	Compressor problem
1 flash	0.5 seconds	Temperature protection active

Table 22 – LED diagnosis pattern

NOTICE

- This LED feature is available on CF01F and CF02F Inverters and can be implemented under customer request. In case of doubts, please get in contact with your Nidec GA Application Engineer.

5.2. Troubleshooting

The following tables show some possible problems and the best action to deal with them. In case of doubts, please get in contact with your Nidec GA Application Engineer.

5.2.1. Compressor not trying to start

Problem	Action
Compressor disconnected from the Inverter.	Verify the Compressor Cable connection.
No control input signal or bad connection.	Verify the control input cable connection and measure the signal from the thermostat.
Inverter with blown fuse (due to previous major failure).	Return the unit to the manufacturer, replacing it with a new one.
Compressor with the motor winding opened.	Measure the ohmic resistance between all pairs of pins on the hermetic terminal. If the one winding is open (high impedance), return the defective unit to the manufacturer, replacing it with a new one.
Dropped, damaged, burnt Inverter.	Replace with a new one and test for confirmation; Return the defective unit to the manufacturer;

Table 23 – Compressor not trying to start

5.2.2. Compressor fails to start at the initial seconds of operation (with starting attempts)

Problem	Action
The supply voltage is out of specification.	Check the power supply and guarantee the minimum starting voltage.
Balanced pressure above the specified compressor limit due to excessive refrigerant charge.	Revise the refrigerant charge.
Balanced pressure above the specified compressor limit due to the presence of contaminants in the circuit (non-condensable gases).	Repeat the refrigerant charge procedure replacing the filter dryer.
Balanced pressure above the specified compressor limit due to a characteristic of the system design.	Revise the refrigeration circuit design to increase volume to decrease balanced pressure.
Balanced pressure above the specified compressor limit due to the defrost with heater is imposing too high temperature to the evaporator.	Restrain the evaporator temperature below 30°C at end of the defrost to restrain balanced pressure.
Unbalanced pressure above the specified compressor limit due to the compartment temperature excessively high imposing a high suction pressure.	Revise the refrigerator design to reduce the suction pressure (lower compartment temperature).
Unbalanced pressure above the specified compressor limit due to the ambient temperature excessively high imposing a high discharge pressure.	Revise the refrigerator design to reduce the discharge pressure (lower condensing temperature).
Discharge pressure imposed by the system is high above the envelope limit due to obstruction at the discharge line.	Check for defective welding on the discharge tube.
Discharge pressure imposed by the system is high above the envelope limit due to a lack of enough volume at the condenser to hold the refrigerant charge.	Verify the condenser volume and compare it with the refrigerant charge volume (attention for microchannel condenser).
Compressor with a locked rotor (due to mechanical damage).	Replace compressor with a new one and test for confirmation; Return the defective unit to the manufacturer;
Demagnetized rotor (only if the compressor was previously connected directly to the AC power supply).	Replace compressor with a new one and test for confirmation; Return the defective unit to the manufacturer;

Table 24 – Compressor fails to start at the initial seconds of operation (with starting attempts)

5.2.3. Troubleshooting – Compressor stalls after some minutes of operation

Problem	Action
Discharge pressure imposed by the system is high above the compressor limit (application envelope) due to improper design of condenser lacking area to dissipate the heat.	Increase the condenser area; Check operation of the condenser fan;
Discharge pressure imposed by the system is high above the compressor limit (application envelope) due to excessive pressure drop along the condenser.	Increase tube diameter of the condenser to reduce pressure drop.
Discharge pressure imposed by the system is high above the compressor limit (application envelope) due to the presence of contaminants in the circuit (non-condensable gases).	Repeat the refrigerant charge procedure replacing the filter dryer.
Discharge pressure imposed by the system is high above the compressor limit (application envelope) due to excessive refrigerant charge.	Reduce the refrigerant charge.
Discharge pressure imposed by the system is high above the compressor limit (application envelope) due to the capillary tube too restrictive.	Increase the capillary tube mass flow rate to decrease the discharge pressure peak below the envelope limit.
Suction pressure imposed by the system is high above the compressor limit (application envelope) due to excessive refrigerant charge.	Reduce the refrigerant charge.
Suction pressure imposed by the system is high above the compressor limit (application envelope) due to the capillary tube is too wide.	Restrict the capillary tube mass flow rate to decrease the evaporation temperature below the envelope limit.
Suction pressure imposed by the system is high above the compressor limit (application envelope) due to a very wide evaporator area (to increase the evaporation temperature during steady-state but imposing a temperature above the envelope during transients).	Redesign the evaporator (smaller); Increase compressor speed; Restrict the capillary tube;
Inverter shutting down due to excessive niche temperature.	Improper installation of the appliance not respecting the air circulation demands; Condenser fan damaged;

Table 25 – Compressor stalls after some minutes of operation

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