MAKING MODERN LIVING POSSIBLE

Operating Instructions

VLT® Inverter Scroll CDS 801

THE REAL DRIVE

ENGINEERING
TOMORROW

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EU DECLARATION OF CONFORMITY

Danfoss A/S

Danfoss Drives A/S

declares under our sole responsibility that the

Product category: Frequency Converter

Type designation(s): CDS801
176L0765 - 176L0766 - 176L0767

Covered by this declaration is in conformity with the following directive(s), standard(s) or other normative document(s), provided that the product is used in accordance with our instructions.

Low Voltage Directive 2014/35/EU

EN60335-1:2012 + A11:2014

EN60730-1:2012

EMC Directive 2014/30/EU

EN55014-1:2006 + A2:2011

EN55014-2:1997 + A2:2008

EN61000-3-11:2001

EN61000-3-12:2011.

RoHS Directive 2011/65/EU including amendment 2015/863.

EN63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Date: 2020.09.15 Place of issue:	Issued by	Date: 2020.09.15 Place of issue:	Approved by
Graasten, DK	**Signature:** **Name: Gert Kjær** **Title: Senior Director, GDE**	Graasten, DK	**Signature:** **Name: Michael Termansen** **Title: VP, PD Center Denmark**

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1 General

1.1 Coverage

1.1.1 Disclaimer

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1.1.2 Coverage

This instruction covers 3 different drive sizes with single phase 208-240 V power supply matching compressor sizes for

- 13 kW/3 t cooling capacity
- 16 kW/4 t cooling capacity
- 20 kW/5 t cooling capacity

from software version 1.09.

1.2 Safety Instructions

1.2.1 High Voltage Warning

⚠WARNING

The voltage of the variable speed drive is dangerous whenever it is connected to mains. Incorrect installation of the variable speed drive may cause damage to the equipment, serious injury or death. Consequently, it is essential to comply with the instructions in this manual as well as local and national rules and safety regulations.

1.2.2 Safety Instructions

- Make sure the drive is properly connected to earth
- Do not remove the mains connector or motor (compressor) connector while the drive is connected to power
- Protect personnel against supply voltage
- Protect the variable speed drive against over-current according to national and local regulations
- The earth leakage current exceeds 3.5 mA
- A stop command does not disconnect power from the drive

1.3 Approvals

The drive has been designed/approved in accordance with the following standards:

Safety	UL/EN 60335-1, 60335-2-34 (UL 984)
Household	UL/EN 60730
Industrial	EN 61800-3 (frequency converter standard)
Software	UL 1998 cl. B
Polymerics	UL 746 C
EMC	With ferrite: EN 55011 cl. A, EN 55014
Harmonics	EN 61000-3-12, IEEE 519-1992
Surge	EN 61642-12
Immunity	EN 61000-6
Transient	EN 61000-4
Corrosion	UL 50E, ISO 9223, EN 61000-5-1, ASTM B117
Environment	IEC 60721-3-3 cl. 3K4
Enclosure	NEMA 250-2003

Table 1.1 Standards Complied to

The equipment complies with the flicker requirement according to IEC/EN61000-3-11 at 230 V nominal voltage under the condition that the service current capacity is ≥100 A per phase or a maximum permissible system impedance Z_{MAX} = 0.1892 Ω

1.4 General Warning

⚠WARNING

Touching the electrical parts may be fatal - even after the equipment has been disconnected from mains.
Also make sure that other voltage inputs have been disconnected.
Be aware that there may be high voltage on the DC link even when the LED is turned off.
Before touching any potentially live parts of the drive, wait at least 1 minute.

⚠CAUTION

Leakage Current
The earth leakage current from the variable speed drive exceeds 3.5 mA. Grounding and bounding shall comply with UL 1995/NEC.
Residual Current Device
This product can cause a D.C. current in the protective earth, only an RCD of Type B (time delayed) shall be used in the supply side of this product. See also *Application Note on RCD, MN90G*.
Protective earthing of the drive and the use of RCDs must always follow national and local regulations.

⚠WARNING

Installation in high altitudes:
At altitudes above 6000 ft (2000 m), contact Danfoss regarding SELV.

Avoid unintended start
While the variable speed drive is connected to mains, the motor (compressor) can be started/stopped using serial communication commands.

- Disconnect the frequency converter from mains whenever personal safety considerations make it necessary to avoid unintended start.

1.5 Disposal Instruction

Equipment containing electrical components may not be disposed together with domestic waste.
It must be separately collected with electrical and electronic waste according to local and valid legislation.

1.6 Before Commencing Repair Work

1. Disconnect the variable speed drive from mains (flip the circuit breaker or pull fuses).
2. Wait for at least 5 minutes for discharge of the DC-link capacitors.
3. Remove motor (compressor) cable.

1.7 ESD Precautions

A variable speed drive is a sensible electronic device. Electrostatic discharge (ESD) can cause a malfunction or destroy the frequency converter. Do not touch components on the printed circuit board (PCB). When handling the drive make sure that necessary ESD precautions are taken, i.e. wearing wrist straps, using anti-static mats etc.

1.8 Product Identification

A product identification label is placed on the drive chassis. It carries the ordering code i.e. 76L7002. The last 3 digits of the numeric string indicate the production date, i.e. 062 means week 6 in 2012. Do not remove the identification label from the drive (loss of warranty).

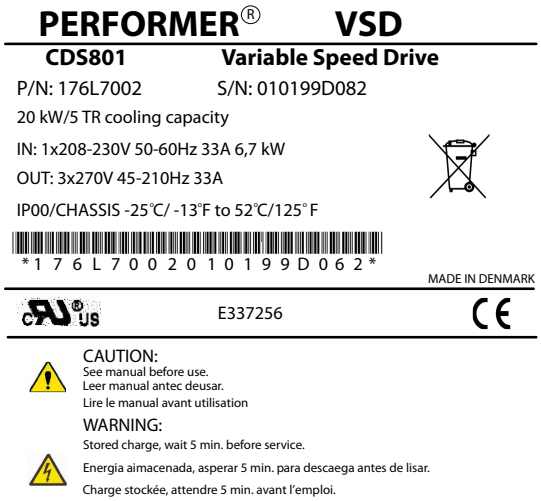

Illustration 1.1 Product Identification Label

1.9 Unpacking the Drive

NOTE

To avoid damage to the drive caused by electrostatic discharge, people handling the drive should wear wrist traps for proper grounding at all time!

1

1.10 Table of Abbreviations

VSD	Variable speed drive
VFD	Variable frequency drive, also used instead of VSD
EMC	Electromagnetic compatibility
RCD	Residual current device
SELV	Safety extra low voltage
ESD	Electrostatic discharge
PCB	Printed circuit board
AWG	American wire gauge
EEV	Electronic expansion valve
RTU	Remote terminal unit
OEM	Original equipment manufacturer
AC	Air-conditioning
HP	Heat pump
RLA	Rated load amperage
AOC	Application oriented controller
MOC	Motor oriented controller

Table 1.2 Abbreviations

2 Mechanical Installation

2.1 Dimensions and Weight

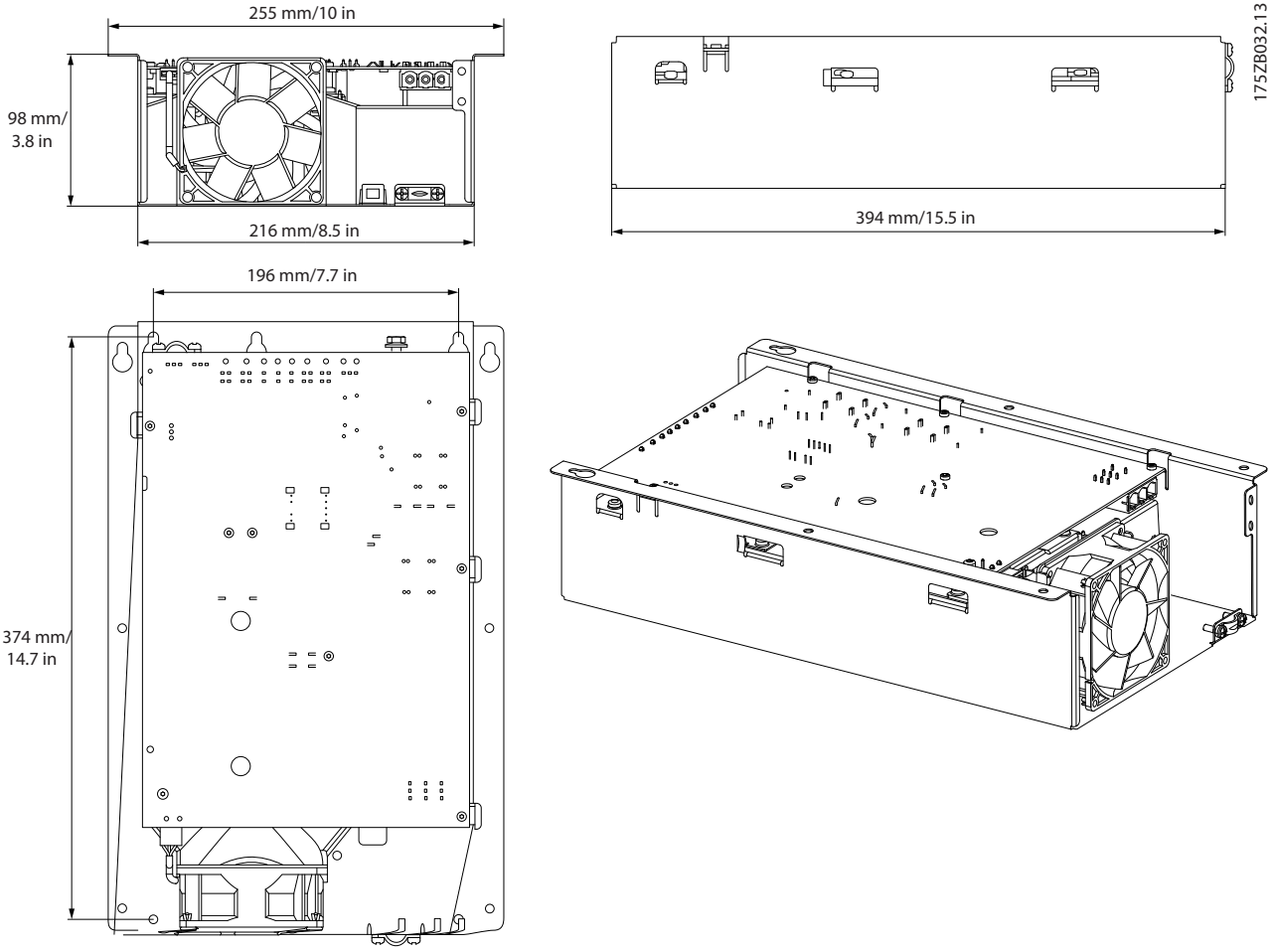

Illustration 2.1 Dimensions

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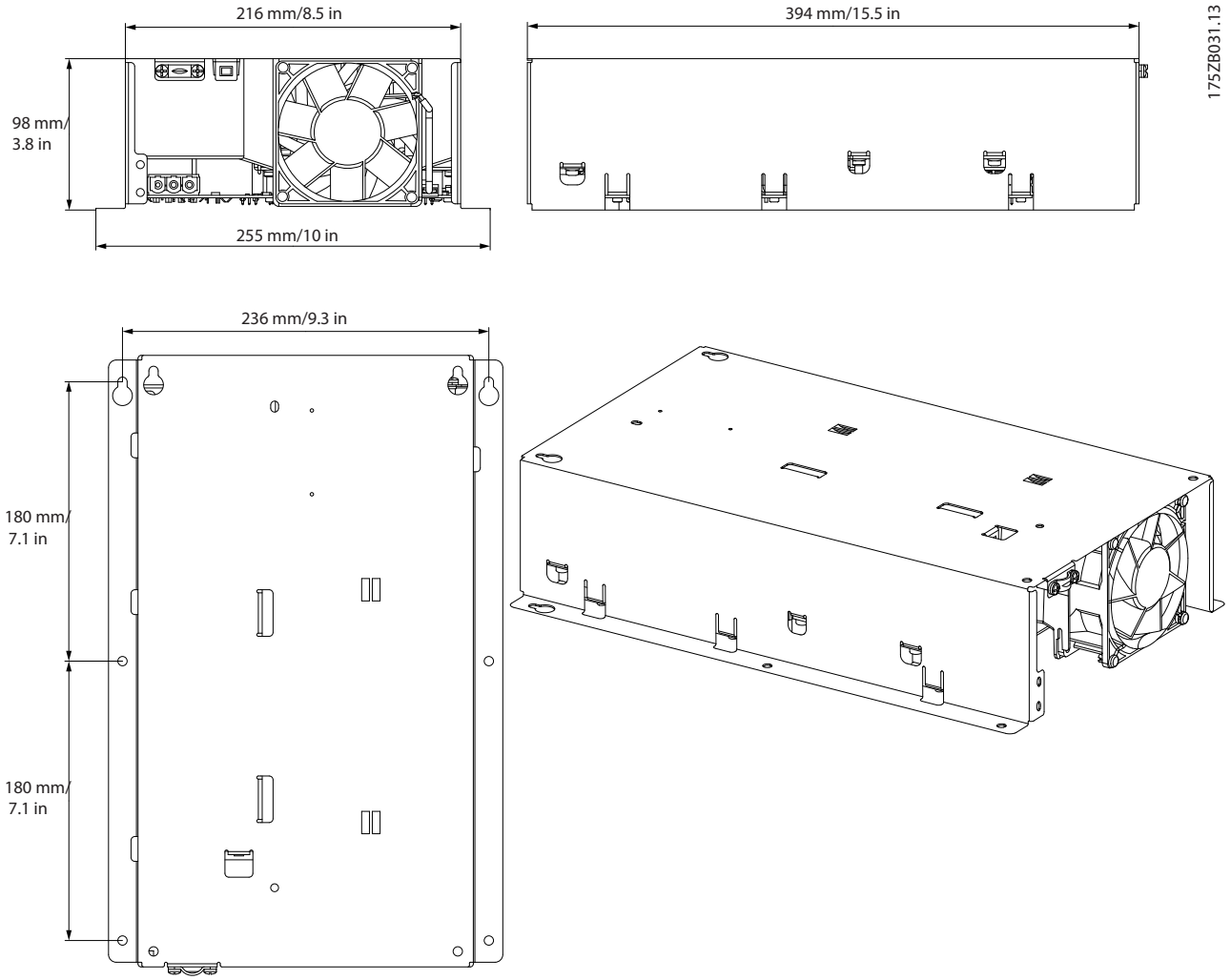

Illustration 2.2 Dimensions

Mounting holes: ¼ inch, Ø 6 mm
Weight: 10.3 lbs/5.5 kg

2.2 Installation Orientation and Clearances

2.2.1 Surface Mounting

The drive can be installed horizontally (see *Illustration 2.4*) or vertically (see *Illustration 2.3*) on any plain surface with the PCB pointing towards the surface. Typically, the 6 mounting holes in the side flaps of the chassis are used for installation.

For vertical installation, the upper two mounting holes can be used as suspension holes.

NOTE

If the drive is installed on a sheet metal surface, the clearance between the drive PCB and the mounting surface must be observed. As a minimum, sheet metal gauge 22, 33/1000 inch or 1 mm should be used. If electrical contact with the mounting surface can not be avoided an additional isolation foil should be used.

NOTE

For outdoor units, do not install the drive horizontally with the PCB in the top or bottom. Water condensing on the PCB cannot be properly drained.

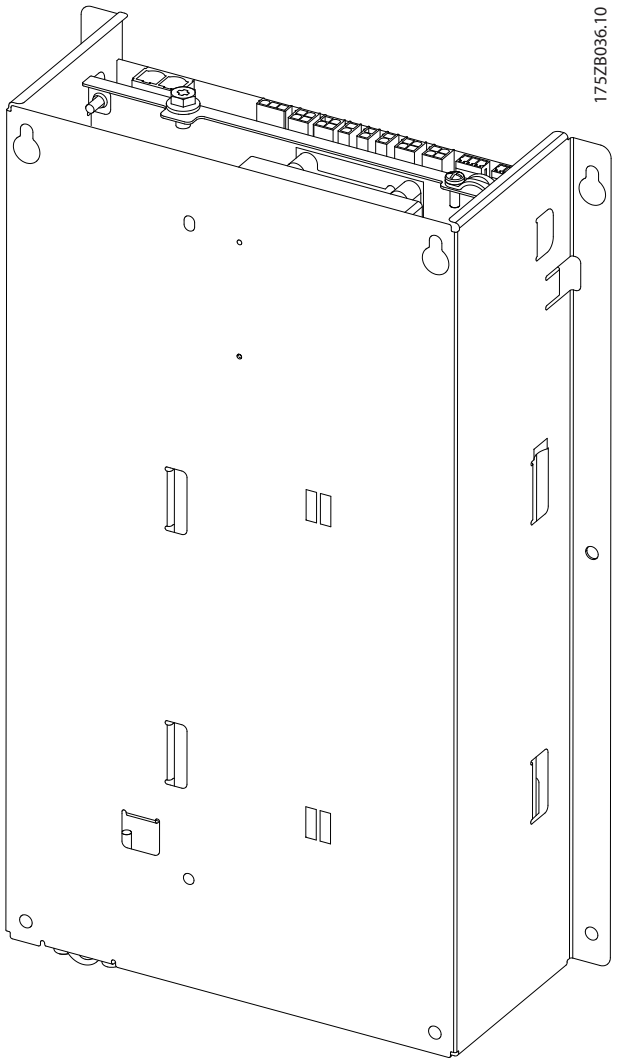

Illustration 2.3 Horizontal Orientation

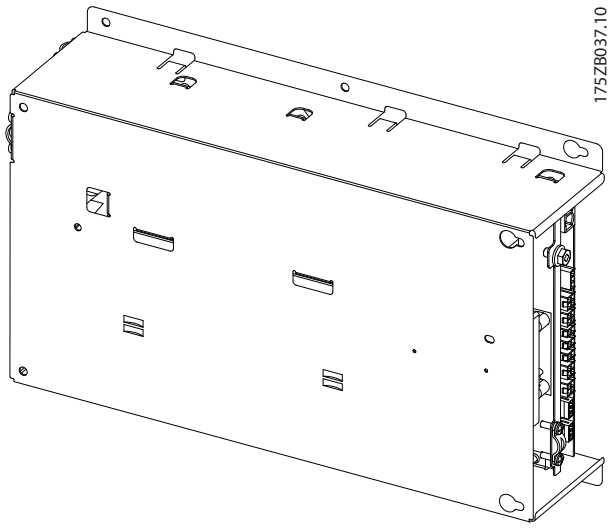

Illustration 2.4 Vertical Orientation

2

To avoid insufficient cooling, do **not** install the drive with the cooling fan in the top, see *Illustration 2.5*.

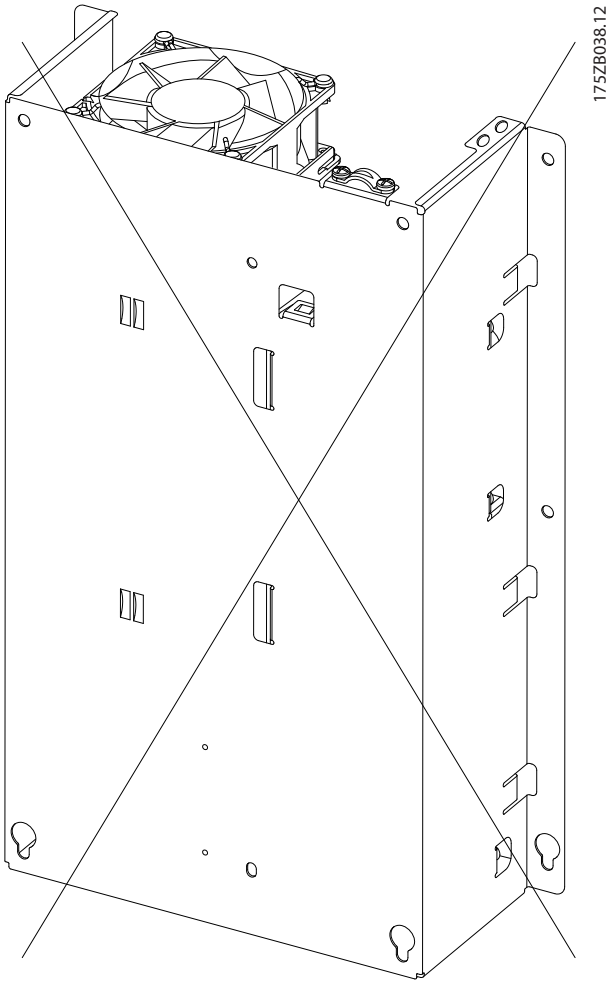

Illustration 2.5 Wrong Drive Orientation

2.2.2 Structural Mounting

The drive can be integrated in any kind of mechanical structure of air conditioning equipment *Illustration 2.6* and *Illustration 2.7*.

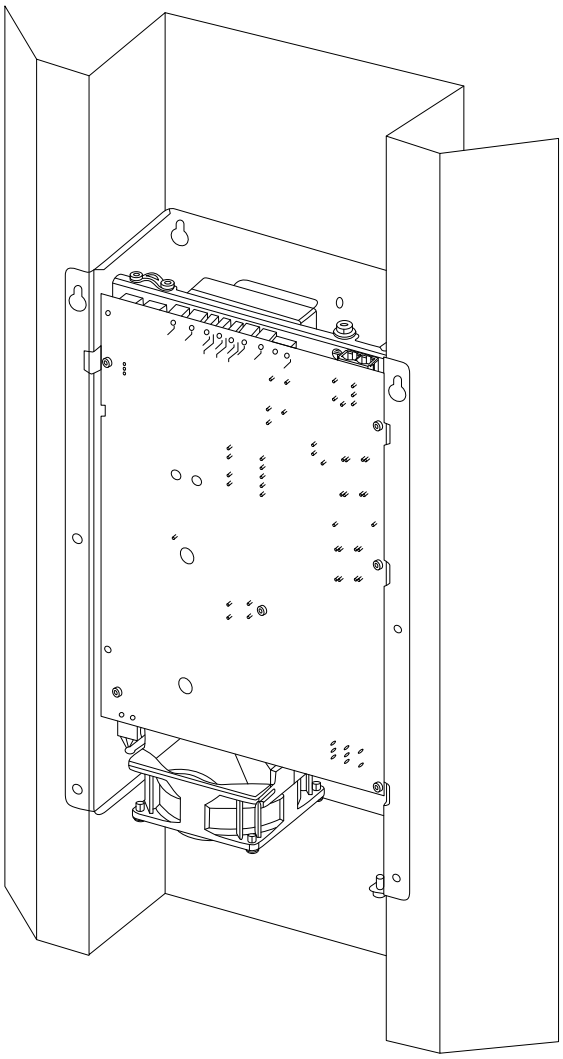

Illustration 2.6 Vertical Installation in Mechanical Structure

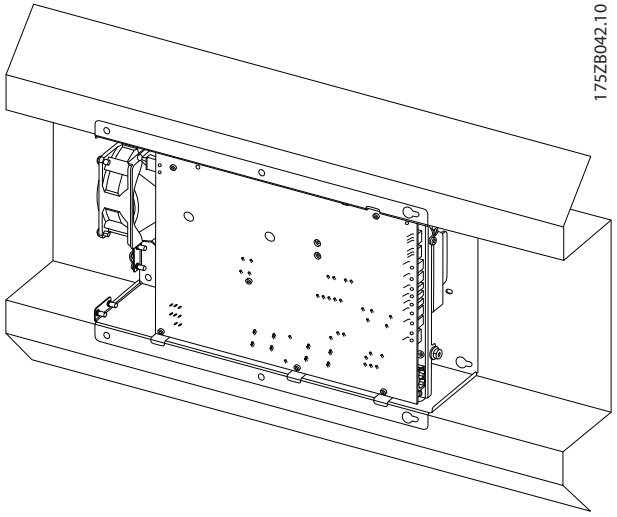

Illustration 2.7 Horizontal Installation in Mechanical Structure

⚠CAUTION

During mechanical installation of the drive make sure that no screws can touch electrical parts on the PCB. Screws touching the electrical parts on the PCB can cause personal injury and product damage.

2

2.3 Air Circulation/Cooling

The drive must be installed in a way that allows for free airflow. However short circuiting the airflow (warm air re-entering the drive's cooling fan) must be avoided (see *Illustration 2.8*). A clearance of 5 inches (12.7 cm) must be observed in both ends of the drive chassis. Install the drive in a location where coldest possible air can be drawn into the drive, i.e. from the bottom part of an outdoor unit. Counter flow (static pressure) must not restrict the operation of the internal cooling fan of the drive.

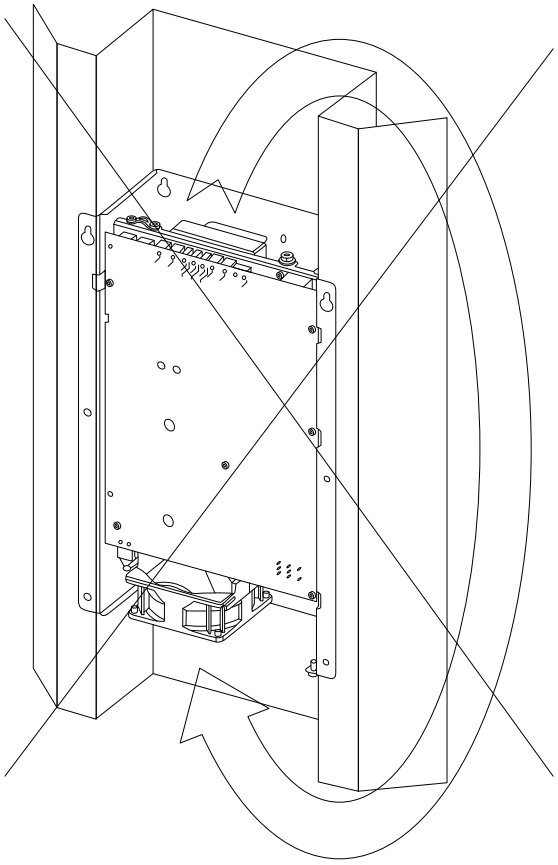

Illustration 2.8 Wrong Drive Airflow

2.4 Condensation and Dripping Water

The printed circuit board assembly of the drive is conformally coated and thus sufficiently protected against condensation during off time. Nevertheless, the drive should not be exposed to dripping water (rain) or condensing water slung around by the condenser fan. In outdoor units, it is recommendable to install the drive in a rain proof compartment.

2.5 Vibration and Mechanical Resonances

The mechanical structure (sheet metal) carrying the drive must be designed to withstand vibration and consequently resonances induced by the compressor or condenser fan. See vibration specification for the drive further down this document.

Also refer to *6.3.5.8 Frequency Cancelation* explaining the possibility to program bypass frequencies in the drive to avoid mechanical resonances of the structure.

3 Electrical Installation

3.1 Electrical Connection in General

NOTE

All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper conductors required.

3.2 Tightening Torque

Power supply plug terminals	1.5 Nm/1.1 lbf ft
Ground screw	3.0 Nm/2.2 lbf ft
Motor plug (compressor)	1.5 Nm/1.1 lbf ft
EMC clamp for motor cable	1.5 Nm/1.1 lbf ft

Table 3.1 Tightening Torque

3.3 Cable Quality and Dimensioning

Power supply cable
There is no need for using shielded cable for the supply of the variable speed drive.

Motor cable
The cable from the drive to the compressor (motor) must be shielded to comply with EMC regulations for conducted and radiated emissions in accordance with EN 55011 class A and EN 55014 (with ferrite). A proper ground connection of the shield in both ends is essential to obtain the best suppression of emissions. See also *3.6 Electrical Connections*.

Power Supply Cable Specification
Power connections must be made in accordance with local and national codes. 2-wire cable plus ground conductor, minimum AWG 10, voltage rating minimum 300 V, minimum temp. rating 105 °C/221°F

Min. circuit ampacity	3 t unit	30 A
	4 t unit	35 A
	5 t unit	40 A

Table 3.2 Power-supply Cable Specificatoin

Motor Cable Specification
Depending on the desired level of EMC compliance according to European or North American standards for radiated emissions such as EN 55014/55011 or FCC part 15, a suitable cable connection drive and compressor must be selected. It is recommended to use shielded cable under all circumstances.

Cable specification for installations in the EU:
4-wire cable with protective earth (PE) and shield (min 80% coverage), minimum cross section 4 mm^2 for 13 kW units and 6 mm^2 for 16 and 20 kW units, voltage rating 600 V.

Proper temperature rating of the cable must be observed. In installations with ambient temperatures above 30 °C maximum current derating applies, therefore high-temperature cable with 90 °C conductor temperature, e.g. Nexans Rheyflex is recommended. Copper type cable only. Maximum cable length 2 m.

Cable specification for installations in North America:
3-wire cable, minimum cross section AWG 10, voltage rating 600 V, temperature rating 221 °F/105 °C, 2/64 moisture resistant UL style 1230 standard bare copper type. In North America, standards for radiated emission are currently not enforced. Furthermore, FCC parts 15 regulations explicitly exempt air-condition devices. Maximum cable length 7 ft. Local compressor grounding.

Min. circuit ampacity	13 kW/3 t unit	30 A
	16 kW/4 t unit	35 A
	20 kW/5 t unit	40 A

Table 3.3 Motor Cable Specification

Sensor and Transmitter Cables
Refer to the documentation provided with the Danfoss sensors and transmitters.
For serial communication connections, see *4 Serial Communication (Modbus RTU)*.

3.4 Fuses/Circuit Breakers

Branch circuit protection
To protect the installation against electrical and fire hazard, all branch circuits in an installation must be short-circuited and over-current protected according to national and local regulations.

Short circuit protection
Danfoss requires using the fuses mentioned in *Table 3.4* to protect service personnel or other equipment in case of an internal failure in the unit or short-circuit on DC-link of the drive. The variable speed drive provides full short circuit protection in case of a short-circuit on the motor output in accordance with UL regulations.

Over-current protection
Overload protection must be provided to avoid overheating of the cables in the installation. Over-current protection must always be carried out according to national regulations (NEC Article 430 “Motors, Motor Circuits and Controllers” and NEC Article 440 “Air-conditioning and refrigeration equipment”).

Fuses

13 kW/3 t unit 176L0767 RLA 22A	max. fuse amperage 30 A
16 kW/4 t unit 176L0766 RLA 28A	max. fuse amperage 35 A
20 kW/5 t unit 176L0765 RLA 33A	max. fuse amperage 40 A

Table 3.4 Fuses

3

NOTE

Fuses of type class RK5 must be used in US installations.

Recommended circuit breakers

HVCR type fusible circuit breaker may be used, see rating above.

3.5 EMC Correct Installation

Follow these guidelines when compliance with EN 55011 cl. A or EN 55014 is required.

Good engineering practice to ensure EMC-correct electrical installation:

- Use only shielded/braided screened/armored motor cables and control cables. The shield should provide a minimum coverage of 80%. The shield material must be metal, not limited to but typically copper, aluminum, steel or lead. There are no special requirements for the mains cable.
- Connect the shield to ground at both ends for motor cables and control cables.
- Avoid terminating the shield with twisted ends (pigtails). Such a termination increases the high frequency impedance of the screen, which reduces its effectiveness at high frequencies. Use low impedance cable clamps (delivered with the drive) and EMC glands instead.
- Ensure good electrical contact between the de-coupling plate and the metal chassis of the variable speed drive.
- Where possible, avoid using unshielded/ unarmored motor or control cables inside cabinets housing the drive.

3.6 Electrical Connections

3.6.1 Routing of Motor and Supply Cable

Do not route supply, sensor and communication cables in parallel with the motor cable. Separate cables from each other as much as possible (see *Illustration 3.2*).
Furthermore, the motor cable should be kept as short as possible.
Do not route cables across the PCB (see *Illustration 3.1*).

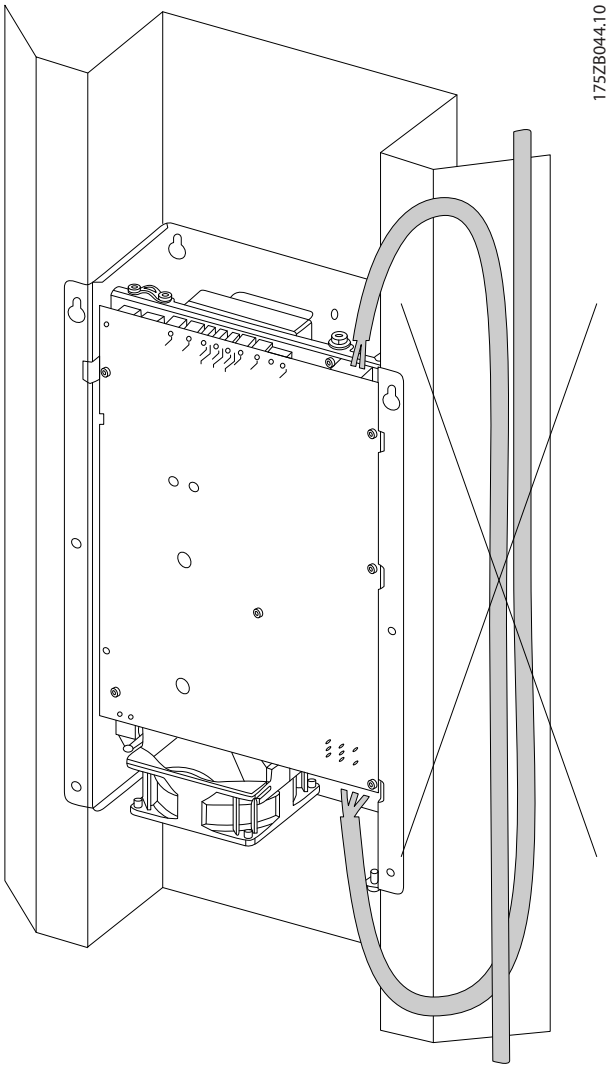

Illustration 3.1 Wrong Routing of Motor and Supply Cables

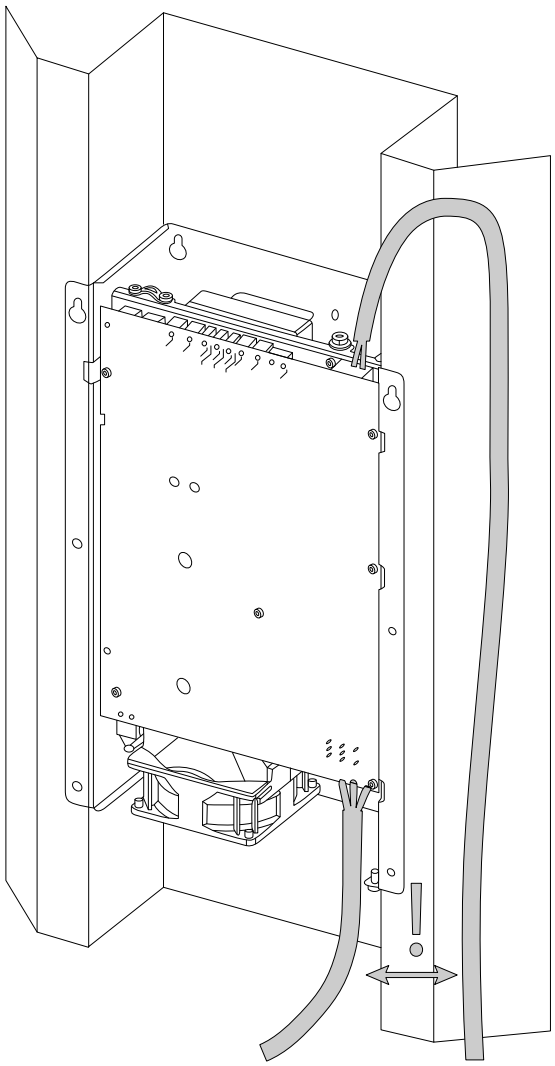

Illustration 3.2 Cable Separation

3

3.6.2 Power Supply Connection (Mains)

1. Connect the ground cable.
2. Connect L2 or L1 and N, see *Illustration 3.3*.

Mains cables must be dimensioned according to national and local standards.

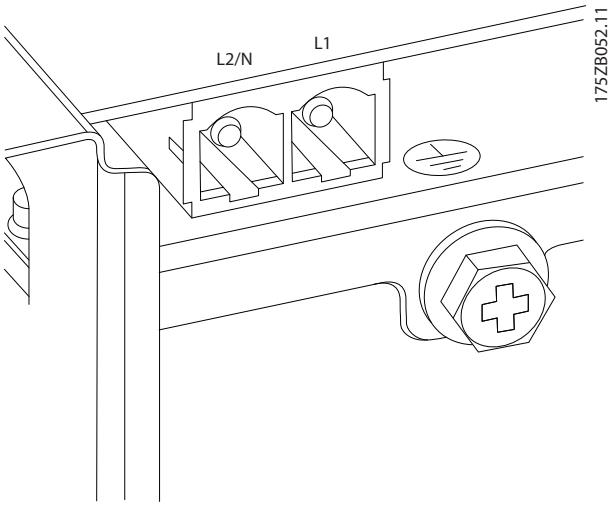

Illustration 3.3 Power Supply Connections

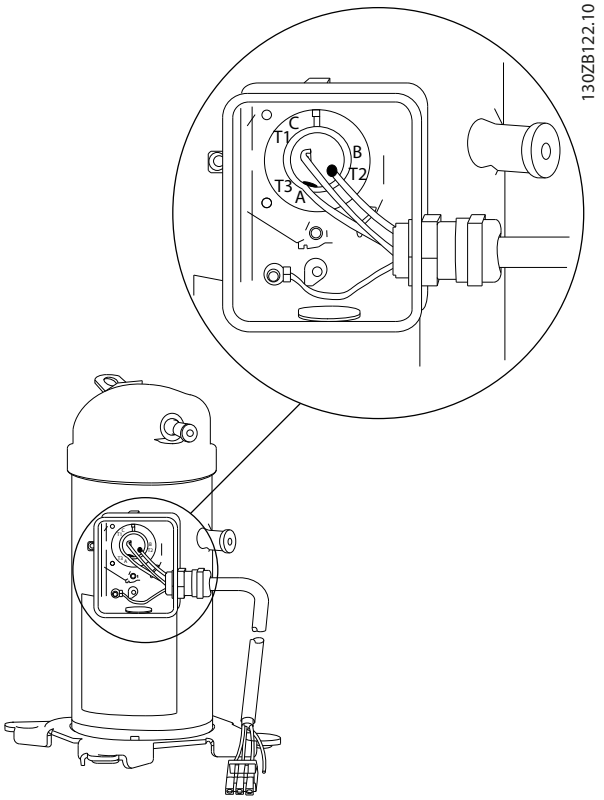

Illustration 3.4 Motor (Compressor) Connection, EU Models

3.6.3 Motor (Compressor) Connection

Danfoss offers different compressor models according to the desired level of EMC compliance for radiated emissions. Compressors for installations in the EU have a rectangular terminal box with provision for using EMC gland sets for shielded cable, while the models for installations in North America have a round shaped terminal box (see *Illustration 3.4* and *Illustration 3.5*).
The order of phases is inevitable in both cases. Always connect T1 on the drive with T1 on the compressor and T2 and T3 accordingly, see *Illustration 3.7*.
Observe maximum current ratings for spade type angular cable connectors according to manufacturer's product data.

EU models:
The terminal box provides punch outs on the right side for 25 mm glands and in the bottom for 28 mm glands. Connect wires for T1, T2, T3 and ground (PE) inside the terminal box and install EMC cable gland set accordingly.

NAM models:
Connect wires for T1, T2, T3 and local grounding.

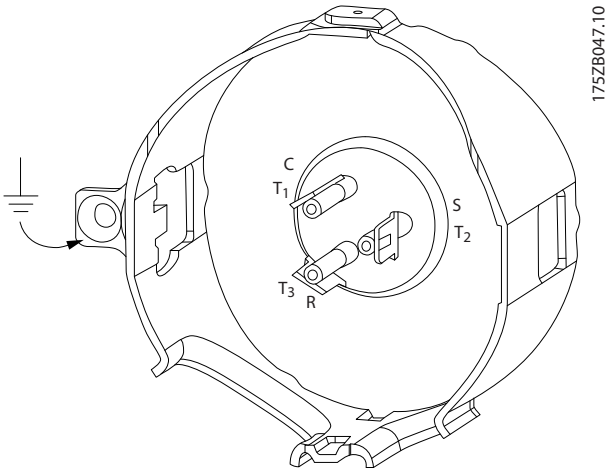

Illustration 3.5 Motor (Compressor) Connection, NAM Models

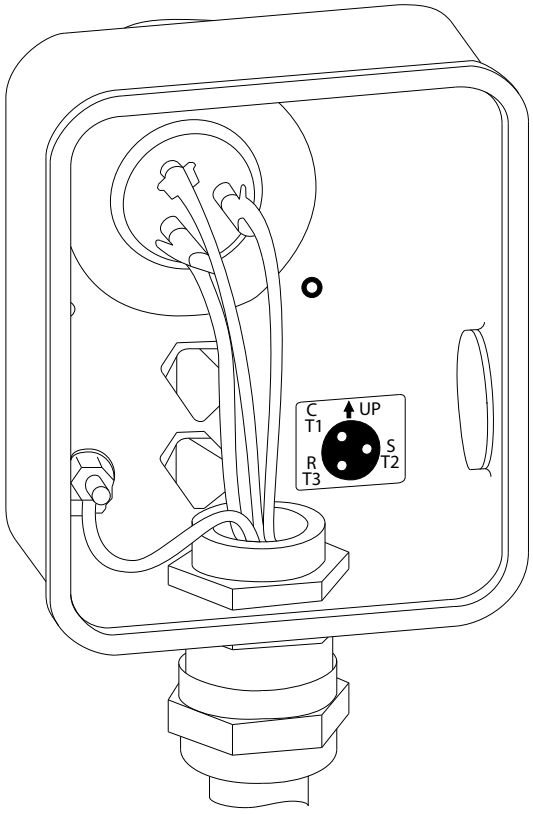

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Illustration 3.6 Connection Box, Europe/Asia

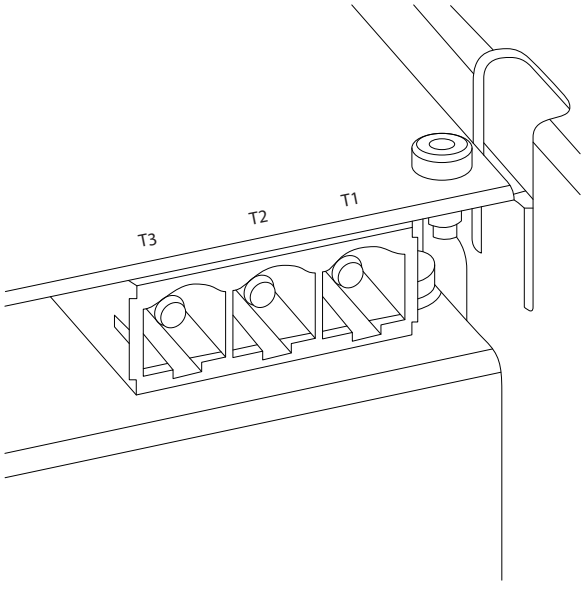

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Illustration 3.7 Motor (Drive) Connection

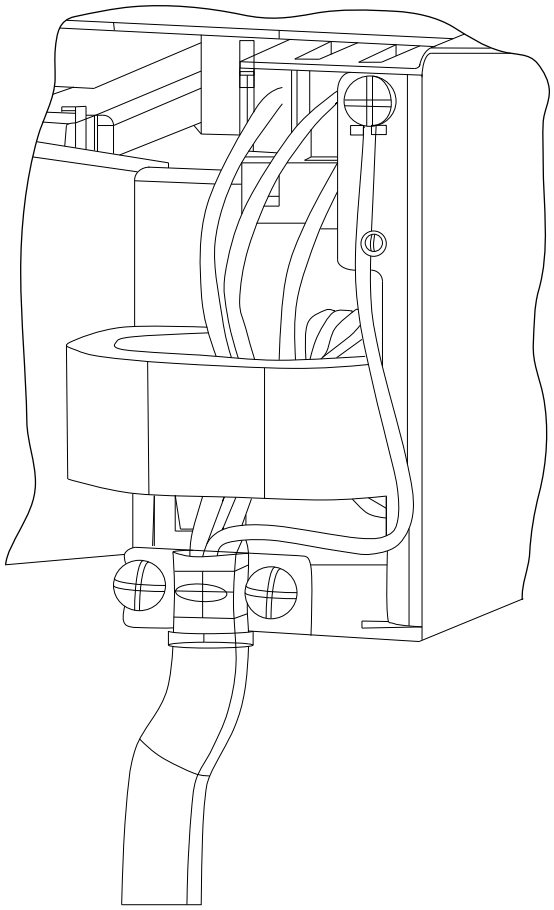

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Illustration 3.8 Wire Routing on Ferrite

Use of Ferrite on drive output terminals:

To comply with the most stringent standard for radiated emissions (EN 55011 cl. B) a ferrite must be installed at the output terminals of the drive as shown in *Illustration 3.8*. The motor phase wires (T1, T2, T3) must be wound twice around the ferrite, while the PE wire is directly connected to the chassis, see *Illustration 3.8*.

3

3.6.4 Sensor Connections

Connect the sensors as marked on the PCB, see *Illustration 3.9*:
Aux. temperature sensor (S aux.) (if applicable)
Compressor discharge temperature (Sd)
Ambient temperature (S amb.)
Compressor suction pressure (P0)
Compressor discharge pressure (Pc)

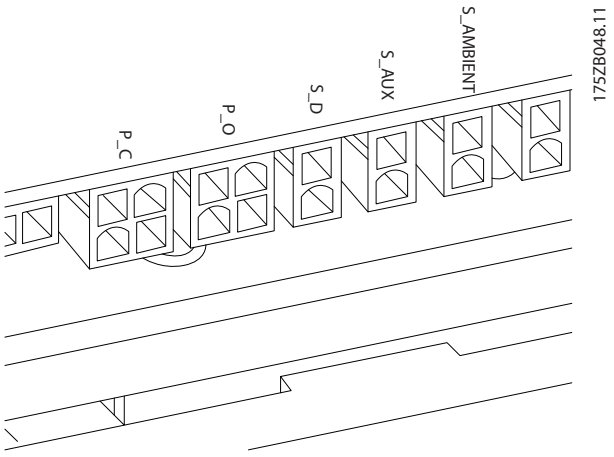


Illustration 3.9 Sensor Connections

3.6.5 4-way Reversing Valve Connection

The relay for the 4-way reversing valve is connected as shown and marked on the PCB, see *Illustration 3.10*.
Max. load:
250 V AC, 4 A
24 V DC, 4 A
See *3.6.10 Allocation of Connector Pins*.

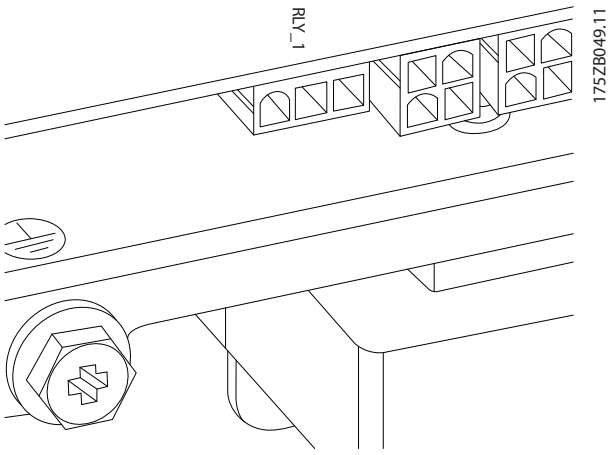


Illustration 3.10 4-way Reversing Valve Connection

3.6.6 Condenser Fan Motor Control Connection (EXT_FAN)

Two different control signals are available, 0-10 V (max. current 20 mA) analogue output and 24 V PWM duty cycle with scalable frequency, see Modbus register description in *5 Commissioning*. Connect the control signal of the condenser fan (or any other external device like a circulator pump) as shown and marked on the PCB, see *Illustration 3.11*.

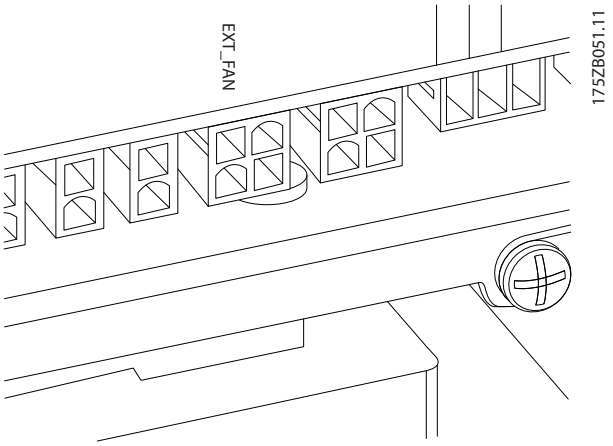


Illustration 3.11 Condenser Fan Motor Control Connection (EXT-Fan)

3.6.7 EEV Controller (HP Mode) Connection (EEV_2)

Connect the EEV Controller as shown and marked on the PBC, see *Illustration 3.12*.

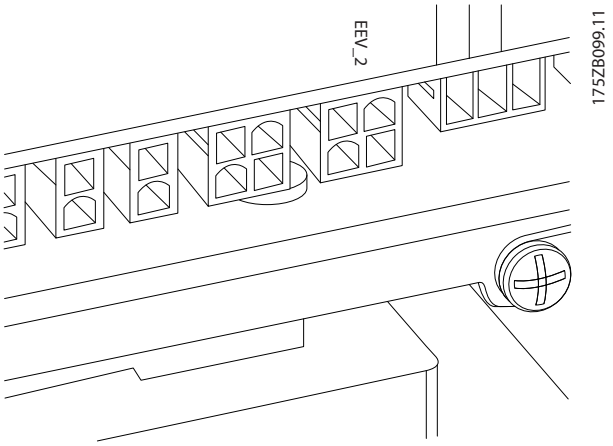


Illustration 3.12 EEV_2 Controller Connection

3.6.8 Serial Communication Cable Connection

Connect the RS-485 cable(s) to the PCB of the Variable Speed Drive as follows, see *Illustration 3.13*:

1. Attach the positive (+) polarity wire to the screw terminal.
2. Attach the negative (-) polarity wire to the screw terminal.
3. Attach the drain cable to the drain terminal (D).
4. Attach the cable with the shield to the compression clamp on the chassis.
5. Connect the other end of the RS-485 cable to the OEM Controller ensuring that the polarity of the wires matches the polarity at the drive.

The two 3-pole connectors are marked on the circuit board as “Master” which connects to the OEM Controller, and “EEV_1” which connects to the indoor EEV Controller (separate internal Danfoss bus).

The compression clamp is suitable to two sets of cable. Make sure to establish a good connection between the shield and the compression clamp and the chassis.

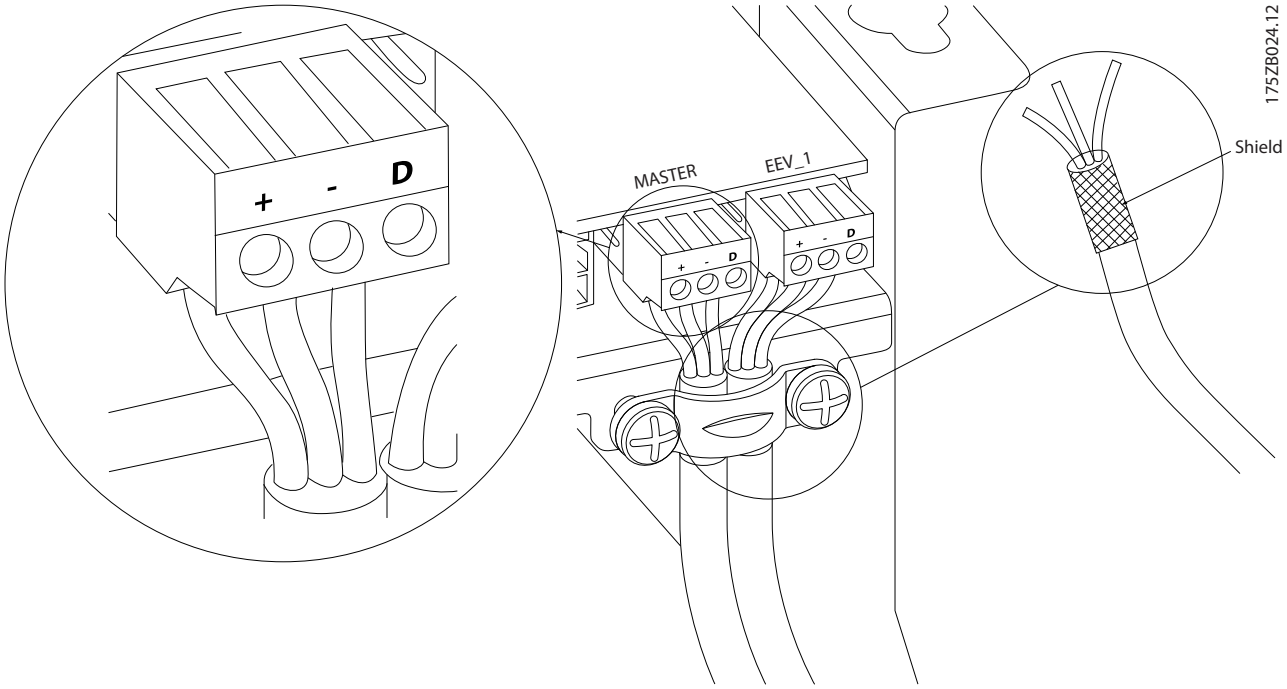


Illustration 3.13 Serial Communication Connection Cable

When selecting a transmission line for RS-485, it is necessary to examine the required distance of the cable and the data rate of the system. Losses in a transmission line are a combination of AC losses (skin effect), DC conductor loss, leakage, and AC losses in the dielectric. In high-quality cable, the conductor losses and the dielectric losses are on the same order of magnitude.

The recommended maximum Modbus cable length between the drive and the OEM Controller should not exceed 100 ft (30 m).

While the RS-485 specification does not specify cabling, the recommendation is 24 AWG shielded twisted-pair cable with a shunt capacitance of 16 pF/ft and 100 Ω impedance.It is also possible to use the same cable commonly in the twisted-pair Ethernet cabling. This cable is commonly referred to as Category 5 cable. The cable has a maximum capacitance of 17 pF/ft (14.5 pF/ft typical) and characteristic impedance of 100 Ω.

3.6.9 Connector Specification

All counterpart plugs listed in *Table 3.5* are of female type, all connectors installed on the PCB are of male type.

Connector	Poles	Manufacturer	Type	Color	Remarks
Supply (L1,L2)	2	Phoenix Contact	PC 16/2-ST-10,16	Green	Marked L1, L2
Motor (T1, T2,T3)	3	Phoenix Contact	PC 16/3-ST-10,16	Green	Marked T1, T2, T3
Indoor EEV Controller (EEV_1)	3	Dinkel	EC381R-4620-03P	Green	Marked RS-485, +, -, D
Modbus Master bus (MASTER)	3	Dinkel	EC381R-4620-03P	Green	Marked RS-485, +, -, D
Outdoor EEV Controller (EEV_2)	4	Molex	39-01-2040	White	
Condenser fan speed ref. (EXT_FAN)	4	Molex	39-01-2040	White	
Ambient temperature (S_AMBIENT)	2	Molex	39-01-2020	White	
Auxiliary temperature (S_AUX)	2	Molex	39-01-2020	White	
Compressor discharge temp. (S_D)	2	Molex	39-01-2020	White	
Compressor suction pressure (P_0)	4	Molex	39-01-2040	White	
Compressor discharge pressure (P_C)	4	Molex	39-01-2040	White	
Reversing valve relay (RLY_1)	3	Molex	39-01-4030	White	
Cooling fan (INT_FAN)	3	Molex	39-01-4030	White	
Crimping contact		**Manufacturer**	**Type**		
All connectors		Molex	39-00-0213		
Alternative manufacturer			see manuf. reference lists		

Table 3.5 Connector Specification

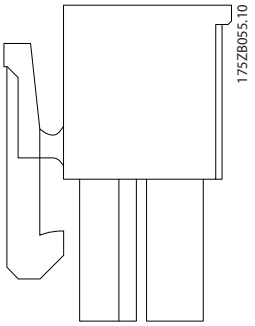


Illustration 3.14 2-pole Connector

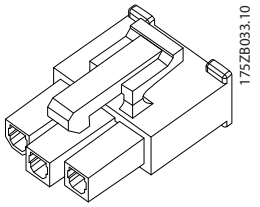


Illustration 3.15 3-pole Connector

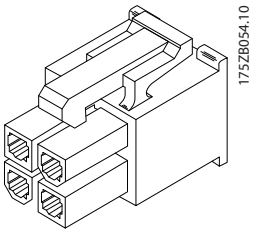


Illustration 3.16 4-pole Connector

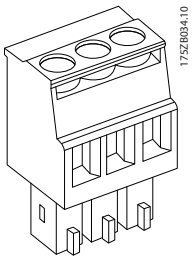


Illustration 3.17 Bus Connector

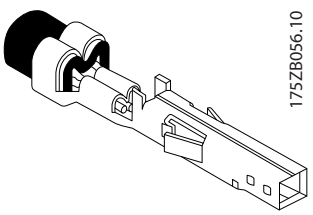


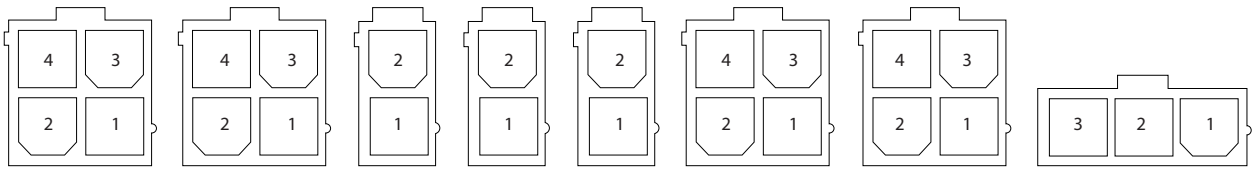
Illustration 3.18 Crimping Contact

3.6.10 Allocation of Connector Pins

The position of the connector pins for sensors, transmitters, serial communication, etc. is shown in *Illustration 3.19*.

NOTE

All connections are seen from the cable side



EEV_2	EXT_FAN	S_AMBIENT, S_AUX, S_D	P_O	P_C	RLY_1
1 Ground	1 Ground	1 PT1000	1 Ground	1 Ground	1 NC
2 + (RS485)	2 0-10V	2 PT1000	2 Signal	2 Signal	2 COM
3 - (RS485)	3 PWM		3 +5V	3 +5V	3 NO
4 +24V	4 not used		4 not used	4 not used	

Illustration 3.19 Allocation of Connector Pins

3.6.11 Overview Wiring Diagram

The following 3 wiring diagrams show typical system configurations for an AC system (see *Illustration 3.20*), a combined AC/HP system (see *Illustration 3.21*) and a ground source heat pump system (see *Illustration 3.22*), with all Danfoss components.

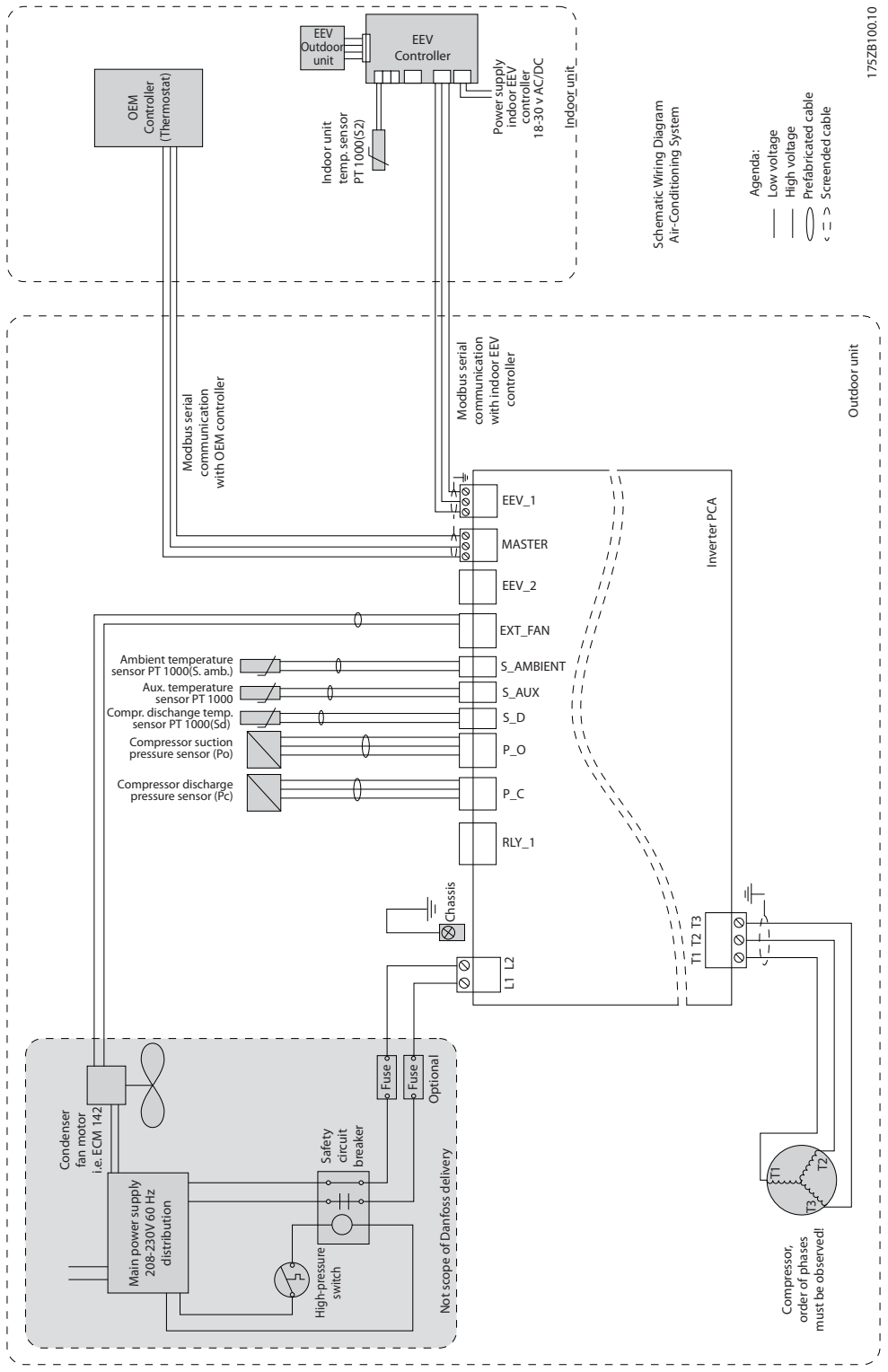


Illustration 3.20 AC only System

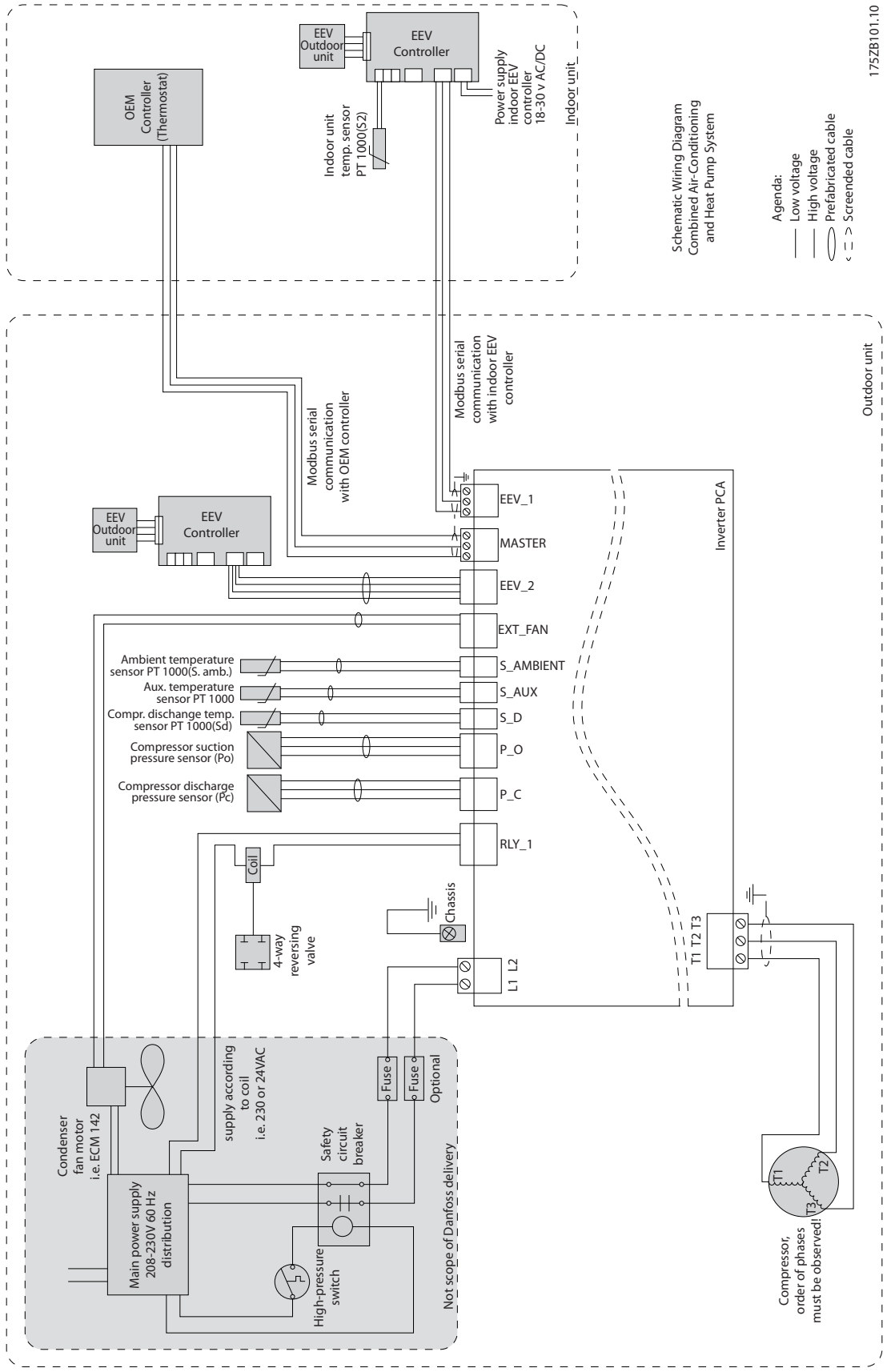


Illustration 3.21 Combined AC/HP System

3

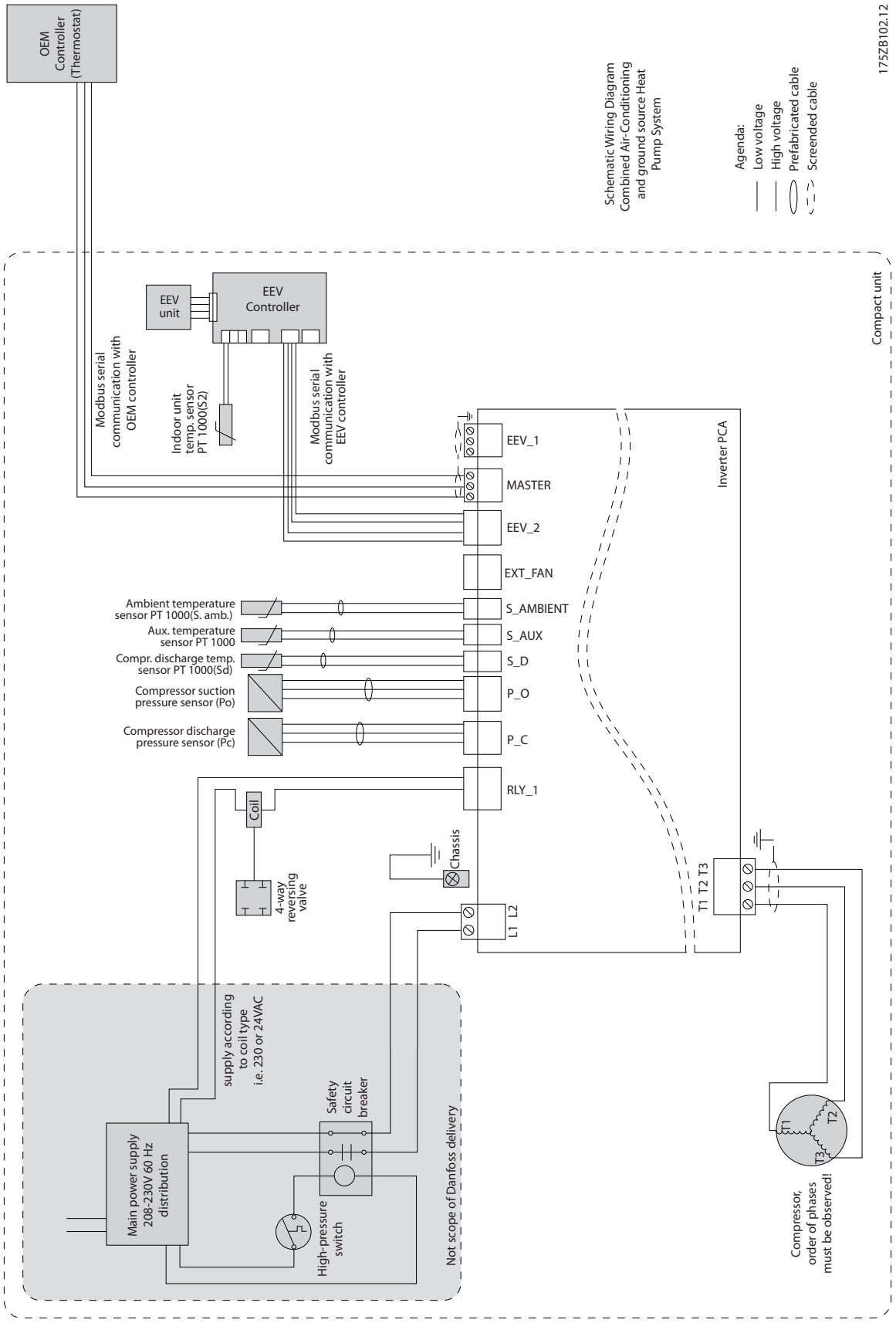


Illustration 3.22 Ground Source Heat Pump System with one EEV

4 Serial Communication (Modbus RTU)

General

The serial communication bus is used to receive Modbus Slave Messages from an external source. In normal operation, this will be a Modbus Master usually called the "OEM Controller". When not in service, the OEM or manufacturing can access the device for configuration or service, see *Illustration 4.1* and *Illustration 4.2*.

NOTE

The Modbus communication is available after the drive has performed an internal test routine, approximately 15 seconds after power up.

The Modbus implementation has been designed to conform to the Modbus Standard Protocol.

For details, refer to

- Modbus Application Protocol Specification, V1.1b
- Modbus Over Serial Line Specification and Implementation Guide, V1.02
- Modicon Modbus Protocol Reference Guide
  PI–MBUS–300 Rev. J

Also visit *www.modbus.org*

For details about setting up the Modbus serial communication, refer to the *Modbus RTU Communication Setup Manual*.

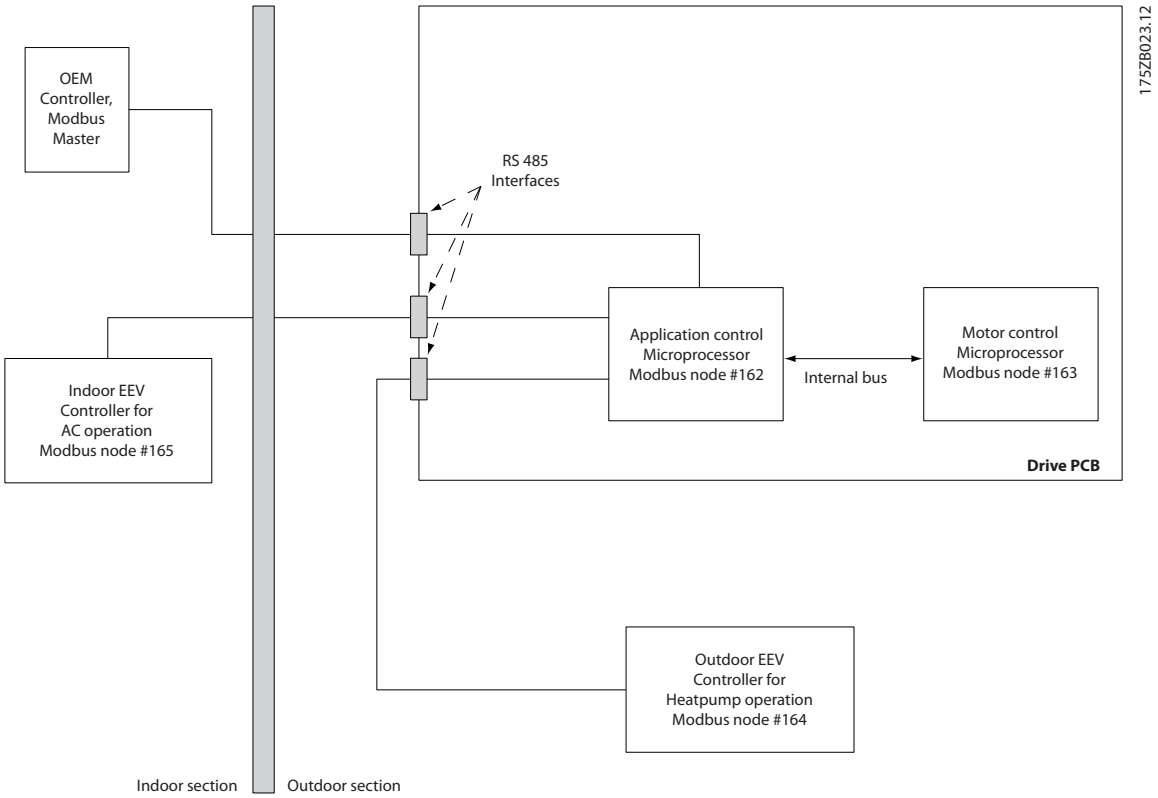


Illustration 4.1 Modbus Communication Set-up, for AC only, and Combined AC/HP Systems

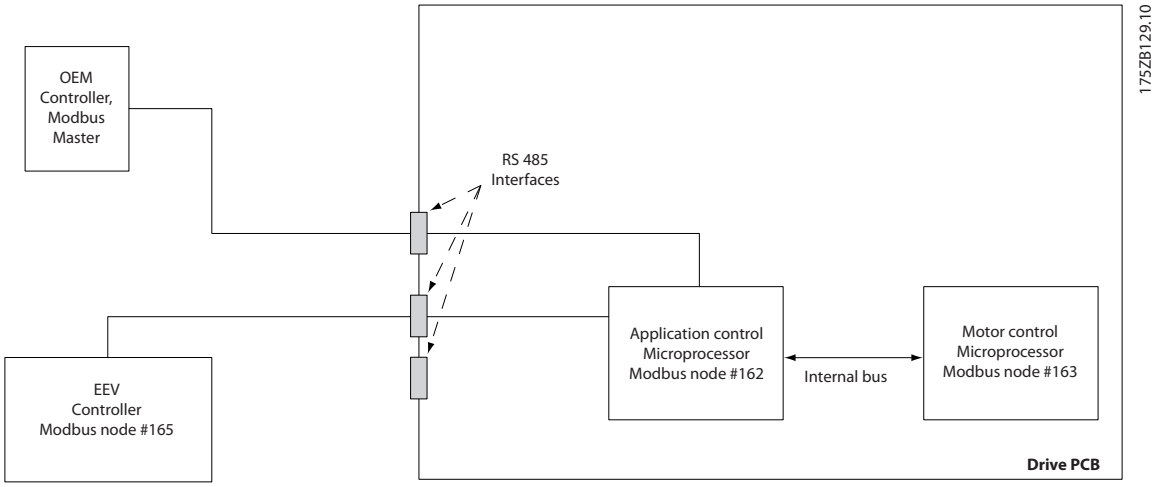


Illustration 4.2 Modbus Communication Set-up for Ground Source Heat Pump Systems

5 Commissioning

5.1 Initial Configuration of the Performer VSD sub-system

System components offered by the OEM, such as outdoor units, indoor units/air handlers, evaporator modules or furnaces are often manufactured in different locations and first merged into a complete system at the end user's site. Furthermore, numerous combinations of such components are feasible. Therefore it is extremely important to prepare the components during manufacturing for a late merge in the field.

Alternatively, the configuration of each individual component can be made in the field. This can be done with Danfoss Update tool or Modbus tool allowing programming the drive, application controller and EEV Controller via the serial communication interface (Modbus RTU).

This functionality can also be incorporated in the OEM Controller by establishing a protected service menu, allowing accessing all Modbus registers.

Individual solutions can be worked out in cooperation with the product support team.

5.2 Drive Setup

The variable speed drive including the embedded application controller and the EEV Controller(s) can be individually configured by setting various parameters (Modbus registers). This manual is limited to the drive parameters. For the application controller and the EEV Controller(s), refer to the separately provided documentation.

NOTE

Changing the setting of some registers requires re-booting before the setting becomes effective. For details, refer to the *Modbus RTU Communication Setup Manual*.

The timeouts and response times of Modbus messages to and from the drive is in accordance with the Modbus standard.

In the following chapters, the drive parameters are described by the register number.

5.2.1 Drive Parameters (Modbus Registers, node 162)

Register 40001-40010, PCA Bar Code (read only)
These registers (10) allow reading the bar code information on the PCA, which is also found on the product identification label on the drive chassis.

Register 40011-40020, Ordering code (read only)
These registers (10) allow reading the Danfoss ordering code, which is also found on the product identification label on the drive chassis, typically starting with 176L…..

Register 40021 and 40022, Operation Time Counter (read only)
These registers allow reading the accumulated time the drive has been powered. The value is given in seconds.

Register 40101-40110, AOC Software Version (read only)
These registers (10) allow reading the software version number for the application oriented microprocessor.

Register 40111-40120, AOC Registers Version (read only)
These registers (10) allow reading the registers version number for the application oriented microprocessor.

Register 40121 and 40122, Drive Status
These registers describe the exact operation condition of the system in a 32 bit structure. See separate description in *7 Fault Conditions, Messages and Causes*.

Register 40131, OEM Reset
Setting this register to logic "1" resets the drive to the OEM defaults (configuration defaults set by the OEM in production) stored in the EEPROM.

Register 40132, Danfoss Reset
Setting this register to logic "1" resets the drive to the Danfoss defaults (factory defaults as listed in this manual and Modbus register map files)

Register 40133, Overwrite Defaults
Setting this register to logic "1" allows overwriting the factory defaults. This should only be done with assistance from Danfoss.

NOTE

Do not set registers 40132 and 40133 to logic "1" at the same time.

Register 40134, Test Register
This register has been created as a test tool to verify proper Modbus communication. To test the communication, write any value between 0 and 65535 to the register and verify that the same value is successfully reported back from the slave node (drive).

Register 40135, Drive Reboot
Setting this register to logic "1" initiates a reboot sequence; this equals cycling power to the drive.

Register 40141, OEM baud rate (default 19200)
This register allows setting the baud rate for the Modbus serial communication.

Value		
	0	9600 kbps
	1	19200 kbps

Table 5.1 OEM Baud Rate

Register 40142, OEM Parity
This register allows setting the Parity of the Modbus protocol.

Value		
	0	None
	1	Odd
	2	Even (default)

Table 5.2 OEM Parity

Register 40143, OEM Stop Bits
This register allows setting the number of stop bits of the Modbus protocol.

Value		
	1	1 stop bit (default)
	2	2 stop bits

Table 5.3 OEM Stop Bits

Register 40144, Drive AOC Address (def. 162, min 1, max 247)
This register allows setting the bus address (node address) of the application oriented microprocessor of the drive. The default address is 162 and can be set to a value between 1 and 247.

Register 40145, Drive MOC Address (def. 163, min 1, max 247)
This register allows setting the bus address (node address) of the motor oriented microprocessor of the drive. The default address is 163 and can be set to a value between 1 and 247.

NOTE

The same address must be set in MOC register 40145.

Register 40146, EEV Indoor Unit Address (def. 165, min 1, max 247)
This register allows setting the bus address (node address) of the EEV Controller in the indoor unit. The default address is 165 and can be set to a value between 1 and 247.

NOTE

Must be set to the same value on EEV Controllers.

Register 40147, EEV Outdoor Unit Address (def. 164, min 1, max 247)
This register allows setting the bus address (node address) of the EEV Controller in the outdoor unit (if applicable, in systems with 2 EEV's only). The default address is 164 and can be set to a value between 1 and 247.

NOTE

Must be set to the same value on EEV controllers.

Register 40148, OEM Communication Timeout (def. 20 sec, min 0 sec, max. 3600 sec)
The time set in this register determines the duration from loosing communication with the OEM controller to stopping the system. When communication is reestablished, the drive will resume operation automatically. Setting this register to 0 sec. means that the drive will not stop in case of loosing communication.

Registers 40499 and 40500, Sensor S_AUX
These registers allow reading the temperature reading of the auxiliary sensor input S_AUX in degrees centigrade (°C); in case a PT 1000 sensor is connected.

Register 40501-40550, OEM Data registers
Danfoss has established 50 OEM registers that the OEM customer can use freely to store product information. All registers are of type unsigned 16.

5.2.2 Drive Parameters (Modbus Registers, node 163)

Register 40101-40110, MOC Software Version (read only)
These registers (10) allow reading the software version number for the motor control oriented microprocessor.

Register 40111 and 40120, MOC Registers Version (read only)
These registers (10) allow reading the register version number for the motor control oriented microprocessor.

Register 40131, OEM Reset
Setting this register to logic "1" resets the drive to the OEM defaults (configuration defaults set by the OEM in production) stored in the EEPROM.

Register 40132, Danfoss Reset
Setting this register to logic "1" resets the drive to the Danfoss defaults (factory defaults as listed in this manual and Modbus register map files)

Register 40133, Overwrite Defaults
Setting this register to logic "1" allows overwriting the factory defaults. This should only be done with assistance from Danfoss.

Register 40134, Test Register
This register has been created as a test tool to verify proper Modbus communication. To test the communication, write any value between 0 and 65535 to the register and verify that the same value is successfully reported back from the slave node (drive).

Register 40145, Drive MOC Address (def. 163, min 1, max 247)
This register allows setting the bus address (node address) of the motor control oriented microprocessor of the drive. The default address is 163 and can be set to a value between 1 and 247.

Register 40201 and 40202, Compressor Power Consumption in kWh (read only)
These registers allow reading the power consumption of the compressor.

Register 40203 and 40204, Compressor Power in kW (read only)
These registers allow reading the input power to the compressor.

Register 40205 and 40206, Supply Voltage (read only)
These registers allow reading the supply voltage (line voltage) applied to the drive.

Register 40207 and 40208, Inverter Temperature (read only)
These registers allow reading the internal inverter temperature measured in the power module of the drive in °C.

Register 40209 and 40210, UDC Voltage (read only)
These registers allow reading the DC voltage in the intermediate circuit of the drive.

Register 40211 and 40212, Internal Fan Speed (read only)
These registers allow reading the speed of the integrated cooling fan in the drive in a percentage.

5.3 Condenser Fan Speed Reference Output

When the condenser fan speed control mode is selected in the application controller the drive calculates the optimum fan speed for efficiency optimization and provides a speed reference output signal for the variable speed condenser fan motor. When the speed control is deselected the output can be used to control any other external device such as a circulator pump in a ground source heat pump, simply by using the Modbus external speed register and the control signal describe hereinafter.

The following signals are simultaneously available:

- Analog output 0-10 V
- Frequency duty cycle output 24 V PWM, 0-10 kHz

Reg. 41609 and 41610, Outdoor fan capacity PCT min

Reg. 41611 and 41612, Outdoor fan capacity PCT max

Reg. 41613 and 41614, Outdoor fan control signal freq

5.4 Crankcase Heating

The variable speed drive comprises an electronic crankcase heating, by injecting a DC voltage to the compressor motor. The resulting current heats the motor windings and therewith effectively prevents refrigerant from accumulating in the compressor sump. An additional heating belt is not required.

Register 40479 and 40480 Crankcase heating on temperature (min 50 °F/10 °C, max +77 °F/+25 °C)
This register allows setting the temperature at which the crankcase heating is activated. Setting register 40481 to value "0" deactivates the crankcase heating function permanently (default is "1"/ON).

The temperature equals the ambient temperature measured by the drive in the outdoor unit.

NOTE

The crankcase heating is not active when power is disconnected to the drive as well as when the compressor is in operation. Crank case heating will also not be active when drive is stopped because of an alarm.

The power consumption of the crankcase heating is approximately 40 W.

5.5 Ambient Temperature Source

The ambient temperature value can be provided from a sensor connected directly to the drive, or it can be sent to the unit via Modbus from the OEM controller.

Register 40216, Thermo in Ambient Temperature
An internal analog value from the ambient temperature sensor connected to the drive at the S_Amb input. (-999 °C if not connected).

Register 40225, Thermo In External Ambient Temperature
The OEM controller writes the ambient temperature via Modbus. When using the Modbus ambient temperature signal, the OEM controller it must update the signal at least every 60 s. Otherwise the drive goes into safe mode.

Register 40484, Thermo Setup Ambient Temperature Source
Selects the source of ambient temperature used by software control algorithms (Crankcase Heating and Outdoor Fan Control).

0 = 40216 Thermo In Ambient Temperature

1 = 40225 Thermo In External Ambient Temperature

Default value of the register is 0, and therefore a temperature sensor must be connected to the drive as default unless this register is set to 1. It is important that the ambient temperature value is a true measurement of the ambient temperature outside the enclosure containing the compressor and the drive. This value is used for (crankcase heating and fan control).

5

5.6 Pressure sensor scaling

When using other pressure sensors than Danfoss AKS sensors (specified in the sensor selection guide), the pressure configuration registers must be changed to match the range of the used sensors.

Register 41601 and 41602, Suction pressure min

Register 41603 and 41604, Suction pressure max

Register 41605 and 41606, Condenser pressure min

Register 41607 and 41608, Condenser pressure max

All pressure calculations in the drive is done in an absolute pressure scale (atmospheric pressure = 1bar).
Example: Absolute pressure range 0-20 bar ⇒ pressure min = 0 and pressure max = 20.

If a pressure sensor with a gage pressure range is used (atmospheric pressure = 0 bar), the min and max pressure must be added with 1 to compensate for the offset in the range when configuring the sensor.
Example: gage pressure scale 0-20 bar ⇒ pressure min = 1 and pressure max = 21.

5.7 Normal Operation

NOTE

After connecting power to the drive, wait at least 15 seconds until the initialization is completed before accessing the Modbus communication.

Mandatory commands:
To operate the system a minimum number of commands must be provided by the OEM
Controller:

- Start
- Stop
- Reboot
- Setpoint and room temperature (in closed loop operation)
- Capacity request (in open loop operation)

Optional Commands:

- Dehumidification Mode

Optional available information:
The drive and the EEV Controller(s) allow reading a large number of data to be polled by the Modbus Master (OEM Controller), such as:

- Product identification
- Operation status (alarms and warnings)
- Operation data
  - Power consumption
  - Compressor speed
  - Pressure and temperature values
  - Etc.

6 Embedded Application Controller “Thermo Control”

6.1 Introduction

The Residential Variable Speed Drive system is consisting of compressor, variable speed drive, application controller, Electronic Expansion Valves (EEV), EEV controller and sensors.

Variable Speed Drive and EEV controller are set to be able to communicate using Modbus RTU protocol. Communication details are available in the *Modbus Communication Set-up Manual*. Establishing the communication and configuring the system requires individual parameters settings. These settings must be done through the OEM controller or any other PC tool, using the Modbus communication.

This chapter describes the operation modes of the application controller. Included is also the parameter lists and parameter descriptions.

6.2 Applications

6.2.1 Generic AC

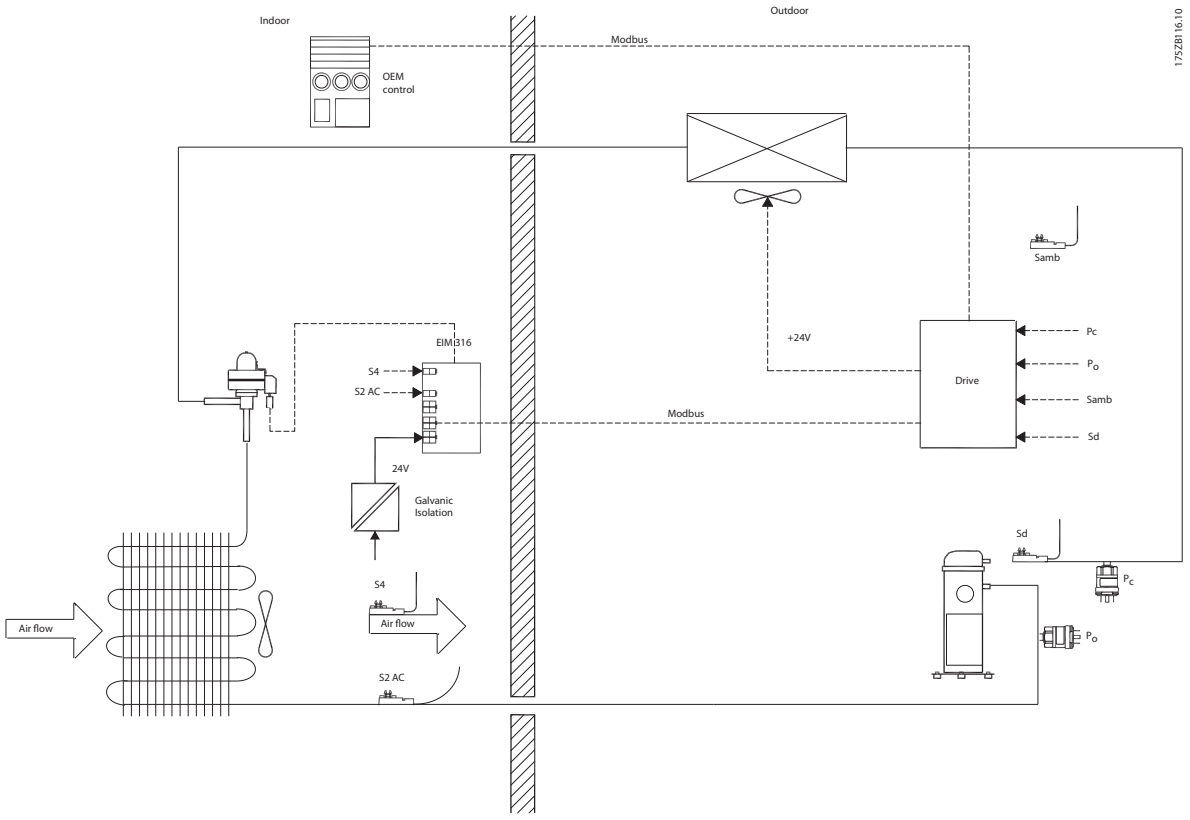


Illustration 6.1 Generic AC

6.2.2 Generic AC/HP (Reversible)

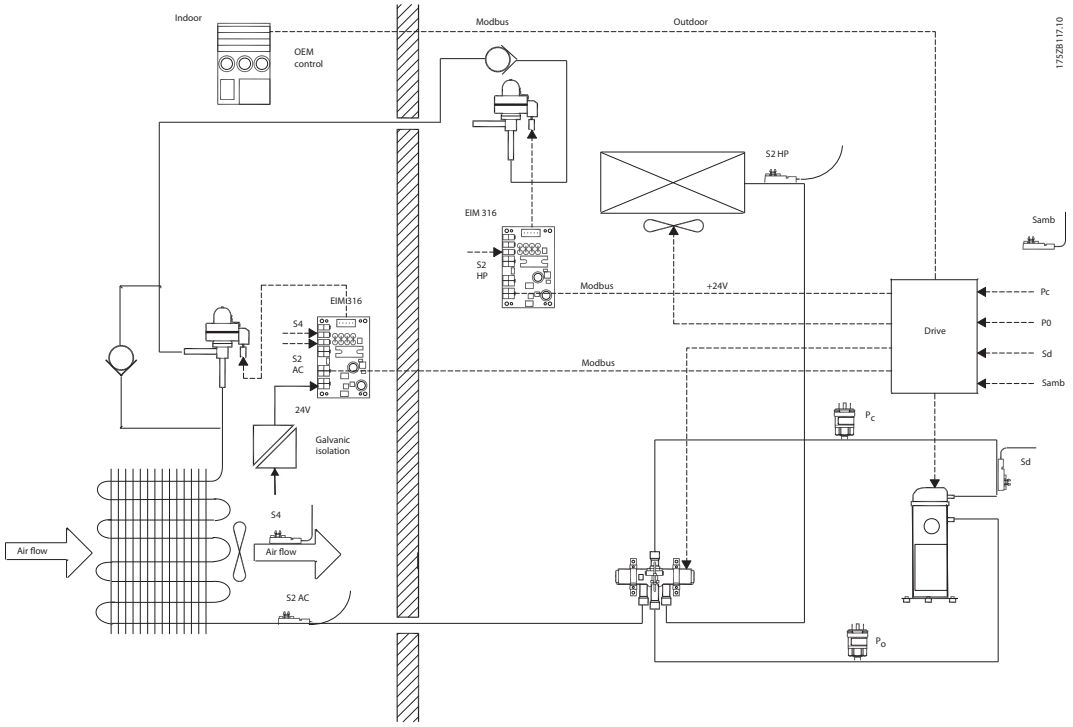


Illustration 6.2 Generic AC/HP (Reversible)

6.2.3 Ground Source Heat Pump (Reversible)

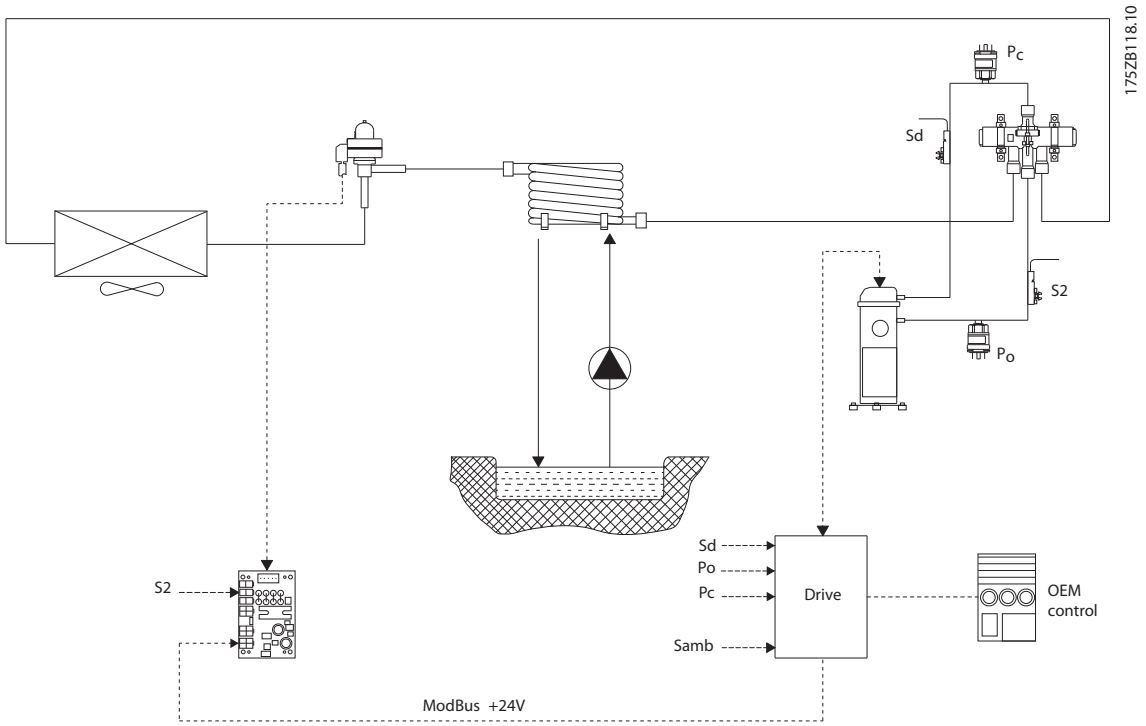


Illustration 6.3 Ground Source Heat Pump (Reversible)

6.3 Application Controller

6.3.1 Introduction

The Thermo Controller is an integrated part of the VLT Inverter Scroll CDS 801 system. The purpose of the application controller is to control the speed of the compressor to a given load of the system. It also controls the speed of the condenser fan (outdoor unit), both in A/C mode, Defrost and HP mode. It is possible to select various control modes for the compressor and the condenser fan. It communicates with the EEV controllers, the OEM controller and sets the relay for the 4-way valve. The Thermo Controller has several built-in safety functions to protect the compressor.

The following paragraphs describe the application controller functionality and safety functions.

6.3.2 System Modes

System modes are:

- Off
- AC (cooling)
- HP (heating)
- Defrost

The system mode is selected by setting a value in the THERMO_IN_MODE register.

6.3.2.1 Off

To set the system off:

set THERMO_IN_MODE = 0

The compressor and condenser fan shut down and the indoor and outdoor EEVs close the valves.

The application controller continuously polls the EEVs for their status register. If the status register polling fails, the EEVs go into autonomous mode and attempt to control superheat.

In autonomous mode, the EEV attempts to control the superheat without Modbus communication. If an additional suction pressure sensor is not connected to the EIM316, the EIM316 will not have a suction pressure signal, and will go in to error mode (Valve opening = 80 % of average value).

6.3.2.2 AC

In cooling mode, the Indoor EEV is active and receives the suction pressure signal over the Modbus from the Thermo Control controller. The outdoor EEV is inactive.

In AC mode, the system sets the 4-way valve to operate the indoor unit as evaporator and the outdoor unit as condenser.

The indoor EEV controller actively controls the superheat on the indoor evaporator.

The outdoor EEV valve will be closed.

The Thermo Control controller continuously polls the EEVs for their status register. If the status register polling fails, the EEVs go into autonomous mode and attempt to control superheat.

To set the system in AC mode:

set THERMO_IN_MODE = 1

When conditions for start up are met:

- The restart timer has elapsed
- The requested compressor speed is higher than the minimum allowed speed

The system go into a start-up sequence. The start-up sequence is described in *6.3.5.1 Start-Up Sequence*.

6.3.2.3 HP

In Heat Pump mode, the outdoor EEV is active, and receives the suction pressure signal over the Modbus from the Thermo Control controller. The indoor EEV is inactive.

In HP mode, the system sets the 4-way valve to operate the indoor unit as condenser and the outdoor unit as evaporator.

The outdoor EEV controller actively controls the superheat on the outdoor evaporator.

The indoor EEV valve will be closed.

The Thermo Control controller continuously polls the EEVs for their status register. If the status register polling fails, the EEVs go into autonomous mode and attempt to control superheat.

To set the system in HP mode:

set THERMO_IN_MODE = 2

When conditions for start up are met:

- The restart timer has elapsed
- The requested compressor speed is higher than the minimum allowed speed,

The system go into a start-up sequence. The start-up sequence is described in *6.3.5.1 Start-Up Sequence*.

6.3.2.4 Defrost

The purpose of Defrost mode is to allow the OEM controller to perform an efficient defrost routine. In Defrost mode, the EEVs and 4-way valve work identically to AC mode.

To set the system in Defrost mode:
set THERMO_IN_MODE = 3

There is no specific control algorithms for defrosting, compressor speed and fan speed must be handled by the OEM controller. However, the limitations from the compressor protection is different from AC mode. This allows the OEM controller to execute a defrosting sequence with good performance.

6.3.3 Compressor Capacity Control

The compressor speed control can be done through different strategies. The compressor control strategy is selected by setting the THERMO_IN_COMPRESSOR_MODE.

6.3.3.1 Single Loop Room Temperature Control

In single temperature control, the Inverter Scroll CDS 801 system attempts to maintain a temperature, typically a room temperature, see *Illustration 6.4*.

The reference and the room temperature are sent from the OEM controller.

The Thermo Control controller calculates the necessary compressor speed and condenser fan speed.

To set the compressor control to single temperature closed loop control:

Set THERMO_IN_COMPRESSOR_MODE = 0
The Thermo Control controller reads the reference from
THERMO_IN_ROOM_TEMPERATURE_SET_POINT
and the actual room temperature from
THERMO_IN_ROOM_TEMPERATURE.

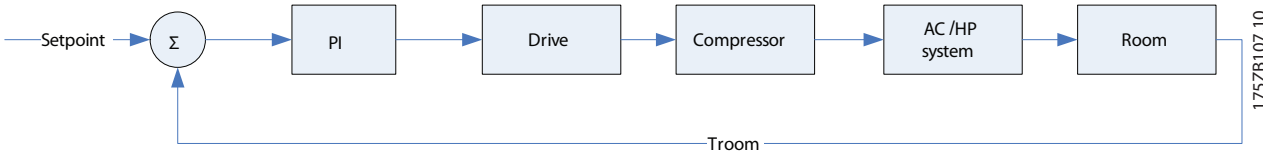


Illustration 6.4 Single Loop Room Temperature Control

6.3.3.2 Open Loop/ External Speed Control

In external speed control (see *Illustration 6.5*), the compressor speed is set externally from the OEM controller through the Modbus.

When in external speed mode, the compressor derating and safety envelope functions are still active and takes precedence over the external speed signal.

To set the compressor speed control into external speed control:

Set THERMO_IN_COMPRESSOR_MODE = 2

The external speed % is set in the THERMO_IN_COMPRESSOR_EXTERNAL_SPEED_PCT register.

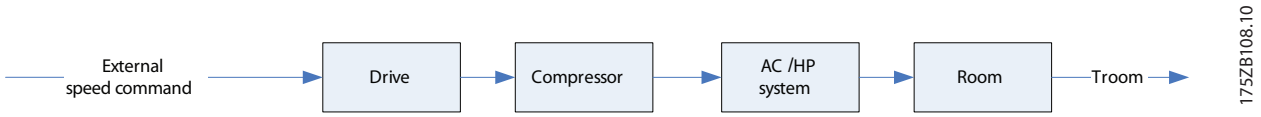


Illustration 6.5 Open Loop/External Speed Control

0% Speed request = 0 Hz, and start will not be allowed until 60 s later. (control restart timer).
1% Speed request = 15 Hz
100% Speed request = 70 Hz, see *Illustration 6.6*
Can be overruled by derating functions (explained in *6.3.5.5 Derating*).

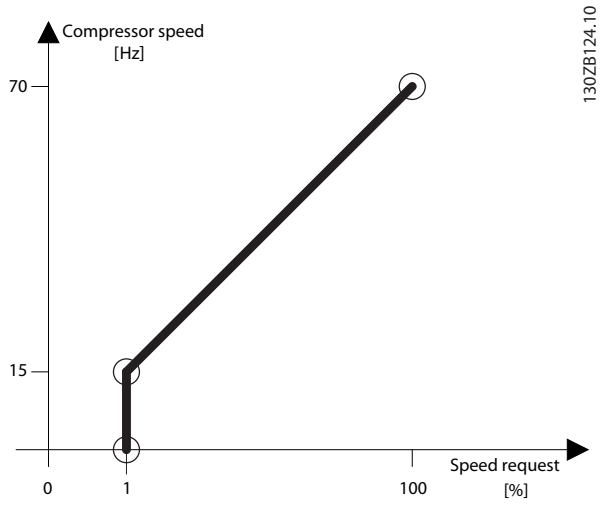


Illustration 6.6 Compressor Speed vs. Speed Request

6

6.3.4 Condensing Pressure Control

The outdoor fan speed control can be done through different strategies. The fan control strategy is chosen by setting the THERMO_IN_FAN_MODE register. The fan speed control strategy depends also on the system mode: AC vs. HP. If the system is in AC mode, the outdoor fan controls the condensing pressure/temperature. This temperature has to be higher than the ambient temperature, so that the condenser can reject heat. If the system is in HP mode, the outdoor fan controls the evaporator pressure/temperature. This temperature has to be lower than the ambient temperature, so that the evaporator can absorb heat. Fan speed control is illustrated in *Table 6.1*.

Mode	THERMO_IN_FAN_MODE	System mode = AC (and defrost)	System mode = HP
Optimal COP	0	Pc,ref = f(P0)	P0 = f(Pc)
Delta T	1	Tc,ref = Tamb + delta T (delta T = 7K)	T0,ref = Tamb – delta T (delta T = f(T0min, Tamb))
External Speed	2	Fan speed = THERMO_IN_FAN_EXTERNAL_SPEED_PCT	
Bypass	3	Fan speed = THERMO_IN_FAN_EXTERNAL_SPEED_PCT	

Table 6.1 Condensing Pressure Control

6.3.4.1 AC Mode

In AC mode, the fan controls condensing pressure, since the outdoor unit works as condenser.

Optimal Pressure Ratio Control

In Optimal COP mode, the fan speed control attempts to maintain a constant pressure ratio

Pc/P0 = constant

across the compressor, see *Illustration 6.7*. This ratio is the theoretically optimal pressure ratio for the Inverter Scroll CDS 801 compressor.

To run Optimal COP mode:

Set THERMO_IN_FAN_MODE = 0

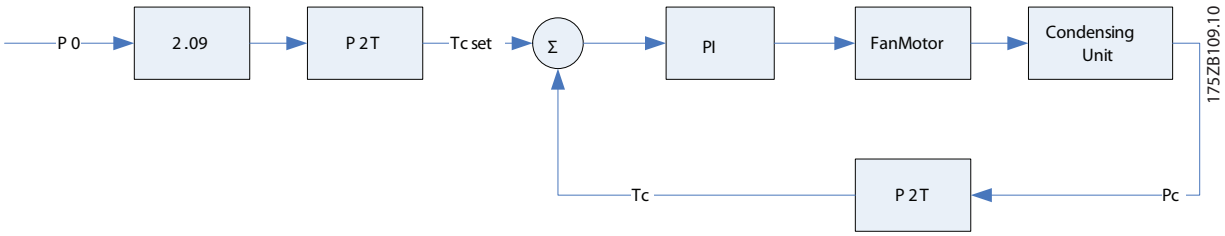


Illustration 6.7 AC Mode

Delta T Control

In Delta T mode, the fan speed control attempts to maintain a temperature difference of Delta T to ambient temperature, see *Illustration 6.8*.

In AC mode, the fan speed control attempts to maintain condensing temperature Delta T above ambient temperature.

To run Delta T mode:

Set THERMO_IN_FAN_MODE = 1

The temperature difference Delta T is set through the register THERMO_SETUP_DELTA_TEMP.

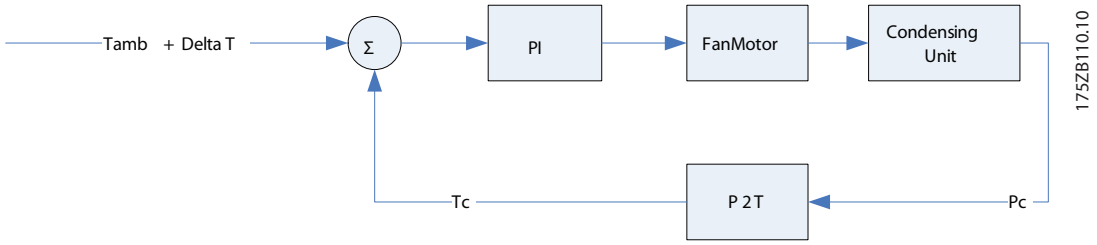


Illustration 6.8 Delta T Control

Open Loop/External Speed Control

In external speed control, the fan speed is set externally from the OEM controller through the Modbus. The speed can be overruled by the fan protection functions like min and max condensing pressure derating, see *Illustration 6.9*.

To set the fan speed control in to external speed control:

Set THERMO_IN_FAN_MODE = 2

The external speed % is set in the THERMO_IN_FAN_EXTERNAL_SPEED_PCT register.

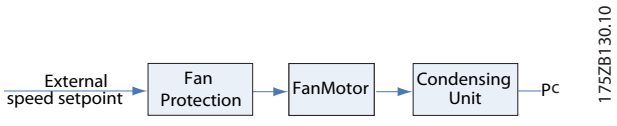


Illustration 6.9 Open Loop/External Speed Control

Bypass fan speed control

In Bypass speed control, the fan speed is set externally from the OEM controller through the Modbus. In the bypass mode the external speed is bypassing the fan protection functions, and will never be overruled by functions like min and max condensing pressure derating, see *Illustration 6.10*. To set the fan speed control in to bypass:

Set THERMO_IN_FAN_MODE = 3

The external speed % is set in the THERMO_IN_FAN_EXTERNAL_SPEED_PCT register.

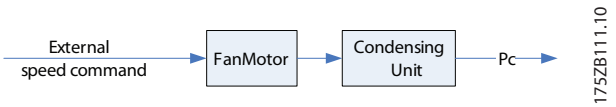


Illustration 6.10 Bypass Fan Speed Control

6.3.4.2 HP Mode

In HP mode the fan controls evaporator pressure since the outdoor unit works as an evaporator.

Optimal Pressure Ratio Control

In Optimal COP mode, the fan speed control attempts to maintain a constant pressure ratio

Pc/P0 = constant

across the compressor, see *Illustration 6.11*. This ratio is the theoretically optimal pressure ratio for the compressor.

To run optimal COP mode:

Set THERMO_IN_FAN_MODE = 0

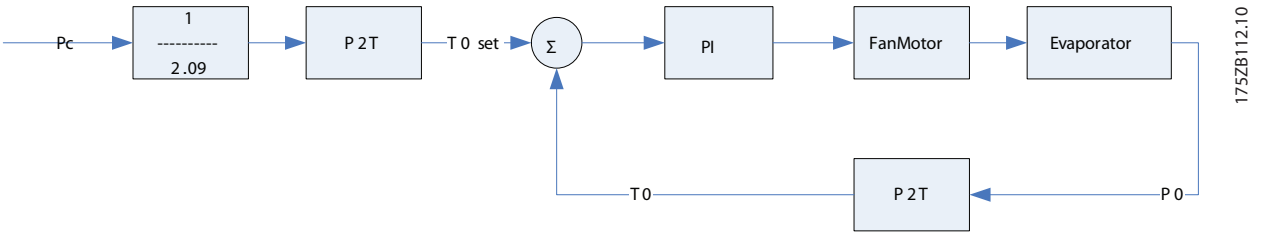


Illustration 6.11 HP Mode

Delta T Control

In Delta T mode, the fan speed control attempts to maintain a temperature difference of Delta T to ambient temperature, see *Illustration 6.12*.

In HP mode, the fan speed control attempts to maintain evaporator temperature Delta T below ambient temperature.

To run Delta T mode:

Set THERMO_IN_FAN_MODE = 1

The temperature difference Delta T is set through the register THERMO_SETUP_DELTA_TEMP.

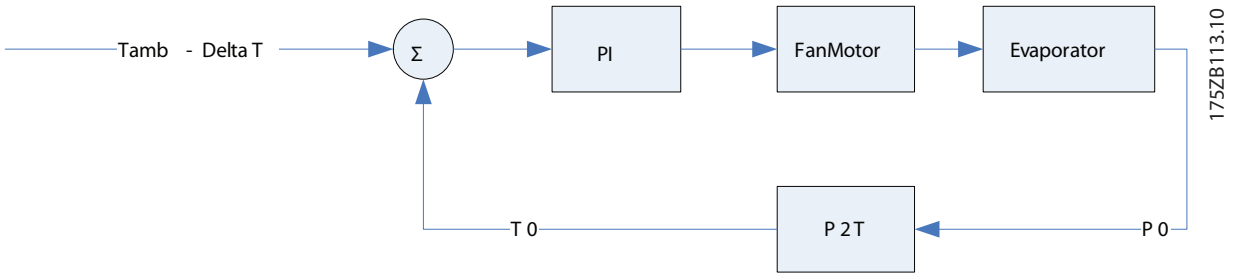


Illustration 6.12 Delta T Control

To transfer heat to the evaporator, a temperature difference is needed (evaporator temperature must be lower than the ambient temperature). Under cold ambient conditions this brings the suction pressure close(r) to the edge of the operating envelope. It is therefore important to make the temperature difference between evaporator and ambient as small as possible under cold conditions. The Delta T, (or the $T0_{ref}$) is therefore made dependent on the ambient temperature, see *Illustration 6.13*. *Illustration 6.13* shows how the set point for the Delta T control mode in HP system mode is a function of ambient temperature and $T0_{min}$. As the ambient temperature approaches the $T0_{min}$ line (see *Illustration 6.14*), the Delta T is lowered. This is done to prevent too low evaporator temperatures when the ambient temperature is low.

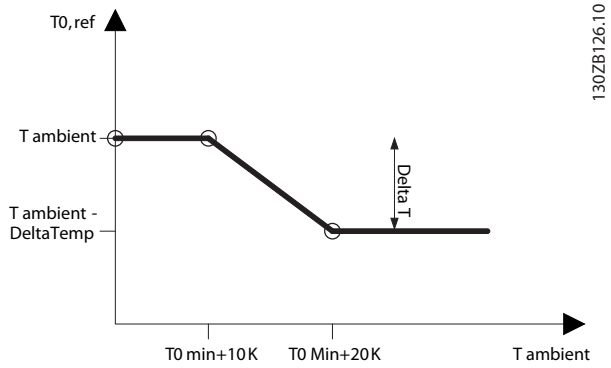


Illustration 6.13 $T0_{ref}$ = f(Tambient) in HP mode (Delta T)

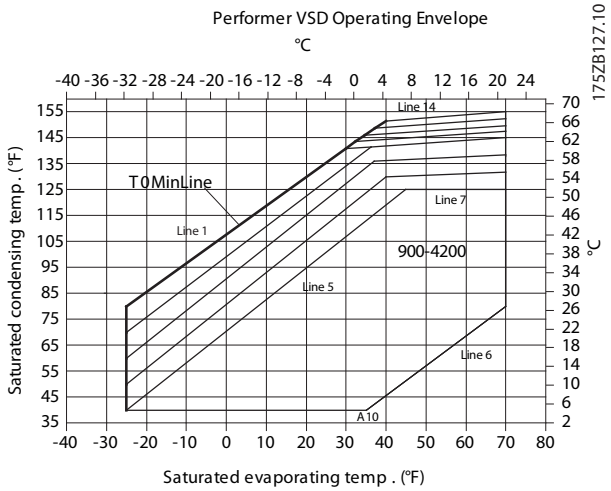


Illustration 6.14 Definition of $T0_{min}$ line. The $T0_{min}$ line is the leftmost line(s) of the envelope

Open Loop/ External Speed Control

In external speed control, the fan speed is set externally from the OEM controller through the Modbus. The speed can be overruled by the fan protection functions like min and max condensing pressure derating, see *Illustration 6.15*.

To set the fan speed control to external speed control:

Set THERMO_IN_FAN_MODE = 2

The external speed % is set in the THERMO_IN_FAN_EXTERNAL_SPEED_PCT register.

Illustration 6.15 Open Loop/External Speed Control

Bypass fan speed control

In Bypass speed control, the fan speed is set externally from the OEM controller through the Modbus. In bypass mode, the external speed is bypassing the fan protection functions, and will never be overruled by functions like min and max condensing pressure derating, see *Illustration 6.16*. To set the fan speed control in to Bypass:

Set THERMO_IN_FAN_MODE = 3

The external speed % is set in the THERMO_IN_FAN_EXTERNAL_SPEED_PCT register.

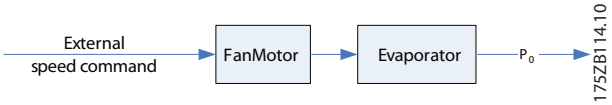


Illustration 6.16 Bypass Fan Speed Control

6.3.4.3 Defrost Mode

In Defrost mode the fan controls condensing pressure, since the outdoor unit works as a condenser. The same fan control options like in AC are available, when defrosting the outdoor coil.

6.3.5 Auxiliary Functions

6.3.5.1 Start-Up Sequence

When the system starts up from idle in AC or HP mode, the compressor follows a start up sequence, see *Illustration 6.17*. This sequence is defined by a ramp (2.7 Hz/s), start speed (THERMO_SETUP_START_UP_SPEED_HZ) and hold time for start speed (THERMO_SETUP_START_UP_HOLD_TIME_SEC).

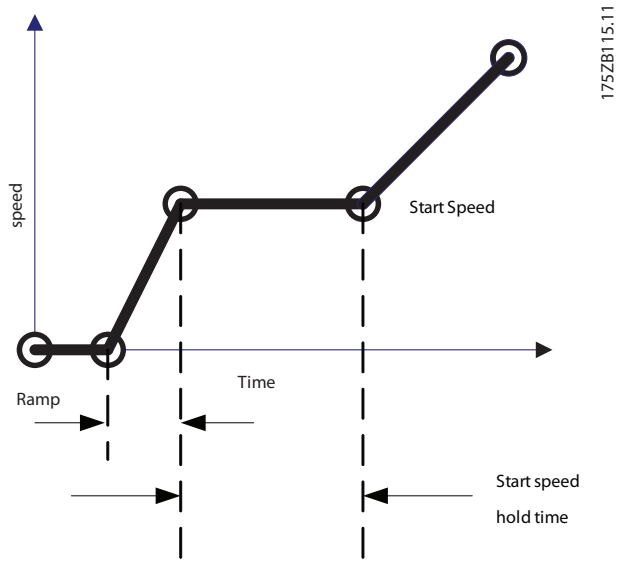


Illustration 6.17 Start-up Sequence

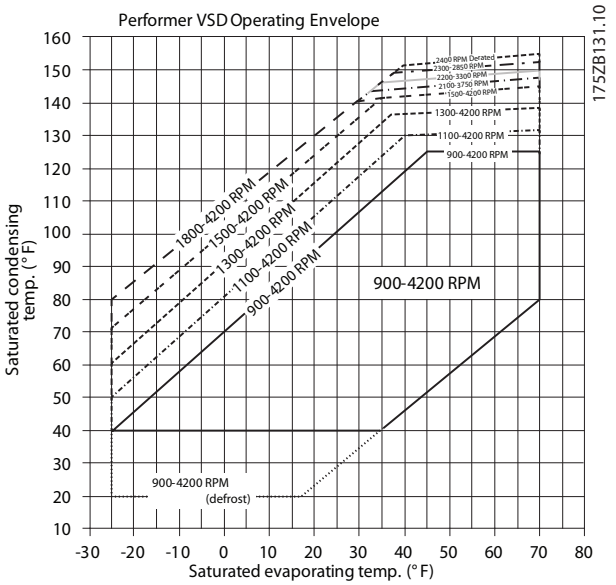


Illustration 6.18 Compressor Safety Envelope

When switching to and from Defrost mode, the start speed hold time is disabled. The compressor then ramps up continuously to the compressor speed setpoint and skips the start speed hold time. This allows for a more efficient defrosting.

6.3.5.2 Restart Timer

To increase compressor lifetime, there is a minimum time between compressor starts. This restart time (at least 1 minute) is defined by

Restart time register: THERMO_SETUP_RESTART_TIME_SEC

When switching to and from Defrost mode, the restart timer is disabled. This results in a quick switch in system mode and allows for a more efficient defrosting of the outdoor coil.

If the system mode is changed, or compressor is stopped and started too frequently, the drive will stop and raise an alarm. Only 6 compressor restarts within 600 s are allowed, there after the system will stop and raise an alarm.

6.3.5.3 Compressor Safety Envelope

Given the allowed ranges of suction pressure and condensing pressure, the compressor safety envelope defines the speed range (min and max RPM) that the compressor is allowed to run at, however limited by the over all compressor speed range 900-4200 RPM, see *Illustration 6.18*.

The compressor safety envelope takes precedence over any requested compressor capacity and external speed request. Crossing from one envelope to another will not stop the drive if it is running at a low compressor speed. Instead, the compressor speeds up to the minimum speed of the newly entered envelope.

When operating in Defrost mode, the envelope limits are extended to allow for a lower saturated condensing temperature (> 20 °F), which can be necessary when defrosting the outdoor coil. Because the envelope has an extension for defrosting, there is also a maximum duration of defrost allowed. The system can only operate for 1800 s in Defrost mode. If the OEM controller does not terminate the defrosting before the timer has elapsed, the system stops and raises an alarm.

6.3.5.4 Oil Return

The scroll compressor needs oil to be protected against wear. When running, oil leaves the compressor together with the refrigerant. The rate of oil loss is estimated as a function of compressor speed.

The oil return is executed if the speed stays below the oil return speed for a time defined by THERMO_SETUP_OIL_LOSS_TRIG_TIME_SEC. The oil return sequence is defined by the oil return speed THERMO_SETUP_OIL_RETURN_SPEED_HZ and the oil return hold time THERMO_SETUP_OIL_RETURN_HOLD_TIME_SEC.

6.3.5.5 Derating

The purpose of the derating functions is to keep the compressor and drive within the specified operating conditions, while still providing cooling/heating.

Derating is not an error condition. It only means that the requested speed cannot be accomodated at the moment, to keep the compressor and drive within specified operating limits.

Drive Power Derating
The compressor speed is limited to keep the drive power below its maximum power limit. This limit is a function of the line voltage input to drive.

In AC mode, the fan speed will be increased to keep the drive power below its maximum limit. This is done to lower condensing pressure and thereby power consumption.

Drive Temperature Derating
The compressor speed is limited to keep the drive temperature below its maximum limit.

Max Condensing Pressure Derating
The compressor speed is limited to keep the condensing pressure below its maximum limit. The maximum condensing pressure is a function of suction pressure, and part of the envelope protection.

In AC mode, the fan speed is increased to keep the condensing pressure below its maximum limit.

Min Condensing Pressure Derating
In AC mode, the fan has control over the condensing pressure. When the condensing pressure is lower than minimum, the fan speed decreases.

Min Suction Pressure Derating
If the suction pressure is lower than the minimum suction pressure, then the compressor speed decreases.

In HP mode, the fan speed also increases if the suction pressure is lower than the minimum.

6.3.5.6 Discharge temperature cut out

The discharge temperature is for 90 s allowed to be above the max. discharge temperature, after that the drive will stop and go into a safe mode condition. When the temperature has dropped below the allowed max. temperature, the drive automatically restarts when the restart timer has elapsed.

6.3.5.7 Max Suction Pressure (MOP)

When the suction pressure exceeds the maximum operating pressure, the EEV controller decreases its opening degree. If the suction pressure exceeds the maximum operating pressure for more than 90 s, the controller stops the compressor and restarts after the restart time has elapsed.

6.3.5.8 Frequency Cancelation

Variable speed systems sometimes are characterized by showing mechanical resonances at critical compressor speeds. Therefore Danfoss has established parameters to set 5 bypass speeds with individual bandwidths. If a mechanical resonance occurs, i.e. at 1600 RPM compressor speed, this speed can be set to one of the bypass frequencies. To define the bandwidth, a bypass range can be set, i.e. 200 RPM. In this example the compressor would not be operated between 1500 and 1700 RPM. If the system demand requires a speed of more than 1500 RPM, the drive remains at 1500 RPM, until the system demand exceeds 1600 RPM; then the speed is increased to 1700 RPM and vice versa.

Critical bypass speed can be set individually in the field using a Modbus service tool; however, it is recommended to search for resonances in the design phase of variable speed air-conditioning or heat pump systems.

The bypass speed can be set within the entire operation range of the drive from 900-4200 RPM. The controller can skip five speed ranges. Each range is specified as a centre frequency and a bandwidth.

6.3.5.9 System Status

The system status is expressed in the content of several Modbus registers. Also refer to *7 Fault Conditions, Messages and Causes*.

6.4 Thermo Controller Register Overview (Node 162)

All registers with name type of THERMO_SETUP_XXXXXX are stored in eeprom and can only be overwritten 1 million times. The same applies for 40201 - THERMO_IN_COMPRESSOR_MODE and 40202 - THERMO_IN_FAN_MODE, see *Table 6.2*.

Address	Name	Description
40201	THERMO_IN_MODE	System control mode:
		0 = off
		1 = AC
		2 = HP
		3 = Defrost
40202	THERMO_IN_COMPRESSOR_MODE	Compressor capacity control:
		0 = Single loop ; Room temp. control
		2 = External speed control
40203	THERMO_IN_FAN_MODE	Condenser/outdoor fan control:
		0 = Optimal compressor COP
		1 = Delta T
		2 = External speed control
		3 = Bypass
40204	THERMO_IN_PC	Condensing pressure [bar] from sensor connected to drive (absolute)
40206	THERMO_IN_P0	Suction pressure [bar] from sensor connected to drive (absolute)
40208	THERMO_IN_ROOM_TEMPERATURE	Room temperature [°C] from OEM controller
40210	THERMO_IN_ROOM_TEMPERATURE_SET_POINT	Room temperature [°C] setpoint from OEM controller
40212	THERMO_IN_COMPRESSOR_EXTERNAL_SPEED_PCT	Compressor external speed % command from OEM controller
		0% = off
		1% = Min speed. 100% = Max speed
40213	THERMO_IN_FAN_EXTERNAL_SPEED_PCT	Condenser outdoor fan external speed % command from OEM controller
40214	THERMO_IN_DISCHARGE_TEMPERATURE	Compressor discharge temperature [°C] from sensor connected to drive
40216	THERMO_IN_AMBIENT_TEMPERATURE	Ambient temperature [°C] from sensor connected to drive
40218	THERMO_IN_S4	Temperature [°C] signal from indoor EEV (not active yet)
40220	THERMO_IN_DRIVE_TEMPERATURE	Drive temperature [°C]
40222	THERMO_IN_LINE_VOLT	Input voltage to drive
40224	THERMO_IN_OIL_RETURN_SWITCH_ON	0: off, 1: on, will be reset to off when drive has been powered off
40225	THERMO_IN_EXTERNAL_AMBIENT_TEMPERATURE	[°C] Ambient temperature provided via Modbus from OEM controller.
40301	THERMO_OUT_COMPRESSOR_SPEED_HZ	Compressor speed command to motor control/drive
40303	THERMO_OUT_FAN_SPEED_PCT	Fan speed command to outdoor fan
		0% to 100%
40305	THERMO_OUT_FOUR_WAY_VALVE	Four way valve control to set the system in AC or HP mode
40306	THERMO_OUT_START_EEV_INDOOR	Command register to indoor EEV
		0 = stop
		1 = start
40307	THERMO_OUT_START_EEV_OUTDOOR	Command register to outdoor EEV
		0 = stop
		1 = start

Address	Name	Description
40308	THERMO_OUT_TRACKING_ERROR_PCT	If the compressor is running in external speed % control mode the tracking error is calculated
		The Tracking error is the difference between actual compressor speed % and external speed % command
		If not running external speed, the tracking error is set to 0
40309	THERMO_OUT_POWER_PCT	Actual Drive power in % of nominal power
40401	THERMO_SETUP_UNITTYPE	Unit type:
		0 = 3 Ton
		1 = 4 Ton
		2 = 5 Ton
40402	THERMO_SETUP_SYSTEM_CONFIGURATION	System Configuration
		1 = ID1 (not active)
		2 = ID2 AC/HP reversible
		3 = ID3 (not active)
		4 = ID4 GSHP reversible
		5 = ID5 (not active)
		6 = ID6 AC only
40403	THERMO_SETUP_COMPRESSOR_MINIMUM_SPEED_HZ	Minimum compressor speed
40404	THERMO_SETUP_COMPRESSOR_MAXIMUM_SPPED_HZ	Maximum compressor speed
40405	THERMO_SETUP_DELTA_HZ_PER_SEC	Allowed speed rate of change in Hz pr. s
40407	THERMO_SETUP_DELTA_TEMP	Delta temperature setting for fan “Delta T” control mode
40409	THERMO_SETUP_OIL_LOSS_TRIG_TIME_SEC	When running below oil return speed for more than this time, oil return is initiated
40410	THERMO_SETUP_OIL_RETURN_SPEED_HZ	Defined oil return speed
40411	THERMO_SETUP_OIL_RETURN_HOLD_TIME_SEC	Hold time for running at oil return speed
40412	THERMO_SETUP_START_UP_SPEED_HZ	Start up speed for system
40413	THERMO_SETUP_START_UP_HOLD_TIME_SEC	Hold time for start up speed
40414	THERMO_SETUP_RESTART_TIME_SEC	Minimum Time between repeated starts
40415	THERMO_SETUP_CANCEL_CENTER_HZ_1	Centre frequency #1 for speed range cancellation
40416	THERMO_SETUP_CANCEL_BANDWIDTH_HZ_1	Bandwidth #1 for speed range cancellation
40417	THERMO_SETUP_CANCEL_CENTER_HZ_2	Centre frequency #2 for speed range cancellation
40418	THERMO_SETUP_CANCEL_BANDWIDTH_HZ_2	Bandwidth #2for speed range cancellation
40419	THERMO_SETUP_CANCEL_CENTER_HZ_3	Centre frequency #3 for speed range cancellation
40420	THERMO_SETUP_CANCEL_BANDWIDTH_HZ_3	Bandwidth #3 for speed range cancellation
40421	THERMO_SETUP_CANCEL_CENTER_HZ_4	Centre frequency #4 for speed range cancellation
40422	THERMO_SETUP_CANCEL_BANDWIDTH_HZ_4	Bandwidth #4 for speed range cancellation
40423	THERMO_SETUP_CANCEL_CENTER_HZ_5	Centre frequency #5 for speed range cancellation
40424	THERMO_SETUP_CANCEL_BANDWIDTH_HZ_5	Bandwidth #5 for speed range cancellation
40425	THERMO_SETUP_PI_COMPRESSOR_AC_KP	Proportional gain for AC compressor capacity controller
40427	THERMO_SETUP_PI_COMPRESSOR_AC_TN	Integration time for AC compressor capacity controller
40428	THERMO_SETUP_PI_COMPRESSOR_AC_TT	Tracking time constant for AC compressor capacity controller
40429	THERMO_SETUP_PI_COMPRESSOR_HP_KP	Proportional gain for HP compressor capacity controller
40431	THERMO_SETUP_PI_COMPRESSOR_HP_TN	Integration time for HP compressor capacity controller
40432	THERMO_SETUP_PI_COMPRESSOR_HP_TT	Tracking time constant for HP compressor capacity controller
41609	OUTDOOR_FAN_CAPACITY_PCT_MIN	Minimum duty cycle that will be output by the fan controller
41611	OUTDOOR_FAN_CAPACITY_PCT_MAX	Maximum duty cycle that will be output by the fan controller
41613	OUTDOOR_FAN_CONTROL_SIGNAL_FREQUENCY	Set frequency of the condenser fan PWM signal
40479	THERMO_SETUP_CRANK_CASE_HEATING_ON_TEMP	Ambient temperature where crankcase heating is activated

Table 6.2 Thermo Controller Register Overview (Node 162)

7 Fault Conditions, Messages and Causes

The variable speed drive is featuring Modbus registers reflecting the exact operating conditions of the system:

- Normal Operation Status (reg. 40121 and 40122), the system operates without limitations.
- Derating Status (reg. 40123 and 40124), the system cannot operate at the quested capacity.
- Safe Mode Status (reg. 40125 and 40126), the system has encountered a condition that has made operation unsafe, e.g. loss of communication with the EEV controller or a sensor signal. In Safe Mode, the drive is running a constant speed of 2400 RPM until the problem is resolved and then automatically resumes normal operation.
- Alarm Status (Fault) (reg. 40127 and 40128), the system has encountered a severe exceptional condition and the compressor has been stopped. The alarm bit remains logic "one" for at least 120 s and the system will afterwards attempt to return to normal operation when the bit becomes logic "zero". In some cases (see individual alarms), the drive goes into a trip lock condition. To restart the system, it is necessary to cycle power to the drive or perform a reboot (register 40135). A reset alone does not clear this condition!

The statuses are expressed by individual sticky bits, which are set logic "1" as long as the particular status is present, see the following detailed explanations.

Normal Status (reg. 40121 and 40122):
Bit 0, Compressor Running
Whenever the compressor is running, this bit will be set. This is independent of control mode, speed or other operation conditions.

Bit 3, Crankcase heating
The crankcase heater is active; the drive injects a DC voltage into the compressor motor.

Bit 4, Control Start-up
The system is performing a start-up sequence, e.g. for proper oil distribution and is not (yet) following the required speed reference. During start-up, the compressor runs at 2400 RPM for 60 s and then returns to the requested speed.

Bit 5, Control Oil Return
The system has been running at less than 2400 RPM for 30 minutes and is automatically performing an oil return sequence. The thermo controller will ignore the requested reference and runs the compressor at 2400 RPM for 60 s to distribute oil in the system and then returns to normal operation.

Bit 6, Restart time
When the compressor is stopped, but system still powered on, the restart timer is activated. The restart timer will not allow the compressor to restart before 60 s after it was stopped.

Bit 28, Derating Active
The system is in a derating condition, read the Derating Status register for more information.

Bit 29, Safe Mode Active
The system is in a Safe Mode condition, read the Safe Mode Status register for more information.

Bit 30, Alarm Active
The system is in an Alarm condition, read the Alarm Status register for more information.

Bit 31, Alarm Trip Lock Active
The system is in an Alarm Trip Lock condition, read the Alarm Status register for more information.

Derating status (reg. 40123 and 40124):
Bit 0, Derating - Drive Temperature High
The temperature measured in the drive's power electronics has reached a critical level and the drive cannot maintain full capacity output. Therefore the drive slows the compressor down until the temperature is no longer critical. When temperatures have normalized the drive attempts to return to normal operation.

Bit 2, Derating - Suction Pressure Low
The suction pressure (P0) has reached a critical low value. To make the suction pressure recover, the drive has slowed down the compressor. When the pressure has normalized the drive will attempt to return to normal operation.

Bit 4, Derating - Condenser Pressure Low
The condenser pressure (Pc) has reached a critical low value. To increase the condenser pressure, the drive has slowed down the condenser fan speed. When the pressure has normalized the drive will attempt to return to normal operation. This function is only available in AC mode and system configurations with condenser fan control.

Bit 5, Derating - Condenser Pressure High
The condenser pressure (Pc) has reached a critical high value. To decrease the condenser pressure, the drive has slowed down the compressor. When the pressure has normalized the drive will attempt to return to normal operation.

Bit 6, Derating – Output Power Limit
The supply voltage has dropped below 208 V or an extreme operating condition, e.g. high condensing pressure has activated the derating function limiting the output power of the drive. The drive returns to normal operation when the supply voltage has recovered or operating conditions have normalized.

Safe Mode Status (reg. 40125 and 40126):
Bit 0, Safe Mode - EEV Indoor Failure
The communication with the indoor EEV controller has been interrupted and the EEV controller has switched to autonomous mode to maintain the superheating. The bit remains logic “one” for at least 60 s after the communication is reestablished, and the system will return to normal operation when the bit becomes logic “zero”. For information about EEV autonomous mode see EEV manual.

Bit 1, Safe Mode - EEV Outdoor Failure
The communication with the outdoor EEV controller has been interrupted and the EEV controller has switched to autonomous mode to maintain the superheating. The bit remains logic “one” for at least 60 s after the communication is reestablished and the system will return to normal operation when the bit becomes logic “zero”. For information about EEV autonomous mode see EEV manual.

Bit 2, Safe Mode - Ambient Temperature Invalid
The reading of the ambient temperature sensor (S amb.) is not within the specified sensor range of -60 to +100 °C (-76 to +212 °F). Possible causes are faulty wiring or a defect sensor. The bit remains logic “one” for at least 60 s and the system will afterwards return to normal operation when the bit becomes logic “zero”.

Bit 3, Safe Mode - Ambient Temperature not updated
40225 - External Ambient Temperature is selected as ambient temperature source and has not been updated within the last 60 s.

Alarm Status (reg. 40127 and 40128):
Bit 0, Alarm Peripherals Error
More than one Safe Mode condition is present.

Bit 1, Alarm Out of Envelope
The compressor has been operating outside the largest possible operation envelope for too long time (60 or 90 s depending on which envelope limit is violated). The system will restart by itself after the restart timer has elapsed (60 s). If 10 subsequent “Out of envelope” alarms occur because of a low suction pressure (P0), the drive will go into trip lock condition to prevent damage to the system.

Bit 2, Alarm - Over Current
The drive has encountered an over current event and has stopped operation. An over current can be triggered by a phase loss, locked compressor rotor, an earth fault, a short circuiting or a major drive error. An Earth fault triggers an immediate trip lock, while other occurrences may happen several times to trigger a trip lock condition.

Bit 3, Alarm – DC Link Voltage High
The drive has encountered an over voltage event (more than 450 V) and has stopped operation. An over voltage condition can happen due to a mains failure. 10 subsequent occurrences trigger a trip lock.

Bit 4, Alarm - Drive Temperature High
The drive has encountered an over temperature condition and has stopped operation. An over temperature occurs when the temperature measured inside the drive has reached a critical level (> 115 °C/239 °F). Possible causes are insufficient cooling due to a defect cooling fan, blocked air circulation or extreme high ambient temperature. This is an immediate trip lock condition.

Bit 5, Alarm – Supply Voltage Low
The supply voltage has dropped below 180 V and the drive has stopped the compressor. When the supply voltage has recovered, the drive resumes operation with derating of the output power.

Bit 6, Alarm - Discharge Temperature High
The compressor discharge temperature (Sd) has exceeded 138 °C/280 °F and the system has been stopped. When the temperature has normalized the drive will attempt to return to normal operation. 10 subsequent occurrences trigger a trip lock.

Bit 7, Alarm – Discharge Temperature Invalid
The reading of the discharge temperature sensor (Sd) is not within the specified sensor range of -60 °C to +200 °C (-76 °F to +392 °F). Possible causes are faulty wiring or a defect sensor. The system will stop operation and return to normal operation, when the problem has been fixed.

Bit 8, Alarm – OEM Communication Timeout
The OEM controller (thermostat) failed to read data within a given time, set in register 40148. The drive stops operating the system unless the time is set to 0 s, which disables this function. The drive automatically resumes operation when the communication has recovered and data is received from the OEM controller, though waiting 2 minutes after communication has been reestablished.

Bit 9, Alarm – MOC Safety
When the motor-control-oriented micro processor safety routines have encountered a fault (error) condition, the system stops for safety reasons and goes to a trip lock condition immediately.

Bit 10, Alarm – DC Link Voltage Low
The DC Link voltage in the drive has reached a critical low level and the drive has stopped operation. When the DC link voltage has recovered, the drive resumes operation.

Bit 11, Alarm – Suction Pressure Invalid
The reading of the suction pressure transmitter is not within the specified sensor range of 0 to 16 bar (0 to 232 psi). Possible causes are faulty wiring or a defect transmitter. The system stops operation and returns to normal operation, when the problem has been resolved.

Bit 12, Alarm - Condenser Pressure Invalid
The reading of the condenser pressure transmitter is not within the specified sensor range of 0 to 50 bar (0 to 725 psi). Possible causes are faulty wiring or a defect transmitter. The system stops operation and returns to normal operation, when the problem has been resolved.

Bit 13, Alarm – Condenser Pressure Low
If the condenser pressure remains at a critical low level after the start-up sequence, the drive reports an alarm.

This alarm indicated that the system has encountered a loss of charge. If this alarm is subsequently reported 10 times the drive goes into a trip lock condition.

Bit 14, Alarm - Defrosting Timeout
If the system has operated in system Defrost mode for more than 1800 s, the system stops. The drive enters a trip lock condition.

Bit 15, Alarm - Restart too frequently
The amount of times that the compressor speed has been 0 Hz within 600 s is counted. When the counter reaches the count of 6, the drive enters a trip lock condition.

Bit 31, Alarm – Internal Error
The drive has encountered an internal error, e.g. missing communication between the microprocessors. The drive goes immediately into a trip lock condition. It is likely that the drive will not recover from this condition!

NOTE

When operation the system in an open loop configuration (by means sending a speed reference to the Performer VSD application controller) the temperature controller in the Modbus Master (thermostat) controller should feature an Anti-Wind-up function that is activated whenever the drive is in derating mode! In derating mode, the system cannot satisfy the requested compressor speed and the integrator of the PID-controller should be stopped until the system has returned to normal operation.

8 Troubleshooting

Problem	Check	Yes/no	Action
The system does not start	Is the green LED on the drive PCB lit?	No	Check power supply to drive. If power is applied properly, but the LED is not lit, there is an internal fault in the drive. Replace the drive.
		Yes	Power is applied. Check next issue
	Is the green LED is blinking?	Yes	The drive indicates a problem. Read the status register for fault analysis.
		No	Check next issue
	Improper wiring between drive and compressor?	Yes	Fix the wiring while observing the order of motor phases
		No	Check next issue
	Does the drive respond to queries from the master controller?	No	• Is the baud rate set correctly? • Is the parity set correctly? • Is the number of stop bits set correctly? • Are the node addresses correct? (Default: Drive 162 and 163, EEVs 164 and 165) • Is the cable between motor and drive properly shielded?
		Yes	Check next issue

	Is a system status present that prevents the drive from starting? (read status register no. 40121)	Yes	• Cycle power to the drive (remove power for at least 1 minute)
			• Read the alarm register again and check if an alarm is still present. If yes, remove alarm conditions
			  • *Supply voltage low*: Check power supply
			  • *Over temperature*: Let the system cool down
			  • *Over current*: Replace compressor
			  • *EEV indoor failure*: Check wiring to indoor EEV controller
			  • *EEV outdoor failure*: Check wiring to outdoor EEV controller
			  • *Ambient temperature invalid*: Check wiring and function of ambient temperature sensor
			  • If *discharge temerature invalid*, check wiring and function of duscharge temperature sensor
			  • If *suction pressure invalid*, check wiring and function of suction pressure transmitter
			  • If *condenser pressure invalid*, check wiring and function of condenser pressure transmitter
			  • If *internal fault*, replace drive

Table 8.1 Troubleshooting Guide

9 Specifications

Supply	
Rated supply voltage 208-230/240 V (L1, L2) (min 180 V, max 264 V)	
Mains frequency 50/60 Hz, single phase	
Rated load amperage (RLA) (208 V):	22A, 13 kW/3 t unit
	28A, 16 kW/4 t unit
	33A, 20 kW/5 t unit
Power Factor @230 V, full load	> 0.98 (98%)
THiD	< 22%
THvD	< 3% (at typical mains impedance)
Earth leakage current (drive and compressor)	<10 mA
Stand-by power consumption	5W

Input power (at 208 V)	
13 kW/3 ton unit	4.5 kW
16 kW/4 ton unit	5.6 kW
20 kW/5 ton unit	6.7 kW

Cable length

The maximum allowable cable length between drive and compressor is 7 ft/2 m

Analog inputs (sensor inputs)	
Temperature	Pt 1000 sensor (AKS11)
Pressure	Ratio metric input 0.5-4.5 V, input resistance 10 kΩ (AKS32)

Digital output (condenser fan motor control), EXT_FAN:
PWM signal speed reference, duty cycle 15-100% speed.

Reversing valve relay, RLY_1:
NC/NO 3-pole relay, max. terminal load 250 V AC/24 V DC, 4 A

EEV Controller output (outdoor unit), EEV_2:
Internal power supply 24 V DC with ground RS-485 serial interface (Modbus)

RS-485 serial communication interface, MASTER and EEV_1:
According to Electronics Industry Association (EIA) standard.

Minimum power cycling time
The variable speed drive is equipped with an inrush circuit, limiting the starting (inrush) current when the system is powered up.

⚠CAUTION

Frequent cycling of power to the drive can damage the drive! Wait at least 5 minutes between cycles (connecting and disconnecting power to the drive).
The OEM must place an equivalent notice on the unit!

Internal cooling fan
High performance variable speed cooling fan, supply voltage 16 V. Nominal operating point 74 CFM (126 m3/h) @ 89Pa static pressure.

Environment

Enclosure
The enclosure type of the variable speed drive is open chassis (IP00, no NEMA rating, according to NEMA 250-2003)

Storage conditions	
Minimum storage temperature	-35 °F/-30 °C
Maximum storage temperature	140 °F/60 °C
Maximum storage humidity	95% rH, non condensing

Operating temperature	
Maximum temperature at cooling fan inlet	125 °F/52 °C (for full capacity)
Maximum temperature at cooling fan inlet	138 °F/60 °C (with capacity derating)
Minimum ambient temperature	-13 °F/-25 °C

Humidity
According to IEC 60721-3-3, class 3K4, 95% rH

Altitude
The max. operation altitude (referring to the ambient barometric pressure) is 6000 ft/2000 m

Corrosion
The variable speed drive has been designed to comply with corrosion standard ASTM B117

Pollution
The variable speed drive has been designed to comply with IEC 61800-1, IEC 61800-2, IEC 61800-4 and 61800-5-1. Pollution degree 2

Vibration
IEC 60068-2-6, 2007, environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal) IEC 60068-2-64, 1993, test Fh: vibration, broad-band Random (digital control) and guidance IEC 60605 series, equipment reliability testing
Test level:
Short term testing: 1.14 g RMS.
Long term testing : 0.99 g RMS.

Bump

Level	40 g, half-sinusoidal
Duration	10 ms
No. of pulses	500 in each direction (x-y-z) - of these, 250 along the positive direction, 250 along the negative direction. Total: 1500 pulses.

Table 9.1 Bump Specifications

Shock

Level	200 g, half-sinusoidal
Duration	1 ms
No. of pulses	6 in each direction (x-y-z) - of these, 3 along the positive direction, 3 along the negative direction. Total: 18 pulses.

Table 9.2 Shock Specifications

Immunity
In accordance with frequency converter standard IEC 61800-3

Harmonics
IEC 61000-3-12 and IEEE 519-1992

EMC
EN 55011 class A and EN 55014 (with ferrite)

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10 Special Operating Conditions

Derating at high ambient temperature/insufficient cooling
The drive is featuring an automatic derating function that is activated when the internal temperature measured in the drive reaches a certain threshold. This temperature is not necessarily directly related to the ambient temperature. In such case, the drive reduces the speed of the compressor to reduce heat losses in the drive. If the overtemperature does not clear, the drive eventually will stop and report a fault condition. Possible causes could also be a malfunction of the cooling fan or blocked airflow (leaves). See also *11 Maintenance*.

Derating at high installation altitude/low air pressure In case of installing the drive in an altitude greater than 2000 m/6000 ft. cooling may become insufficient, if the ambient temperature is at maximum at the same time (a very unlikely coincidence).

Derating under unusual refrigeration process conditions
See Operating Instructions for the application controller.

11 Maintenance

The Danfoss variable speed drive is maintenance-free over its entire lifetime, except the internal cooling fan, that eventually must be replaced depending on operation hours and conditions. When an over-temperature alarm occurs (see *7 Fault Conditions, Messages and Causes*), a possible cause could be a worn out or excessively contaminated cooling fan that does not provide sufficient air flow across the heat sink. If so, the fan must be replaced with an original spare part.

11.1 Replacement of Internal Cooling Fan

NOTE

Disconnect power to the variable speed drive and wait for 5 minutes before commencing maintenance!
The fan is connected to high potential!

1. Carefully unplug the supply cable by lifting the lock and retracting the plug (do not pull the cable to retract the plug), see *Illustration 11.2*.
2. Lift the flat on the air duct to unlock the fan and remove the fan (no tools required - see *Illustration 11.1*).
3. Insert the plug of the new fan, make sure the plug is locked.
4. Insert the new fan and click it onto the air duct.
5. Check that the fan runs properly after reconnecting power and resuming operation.

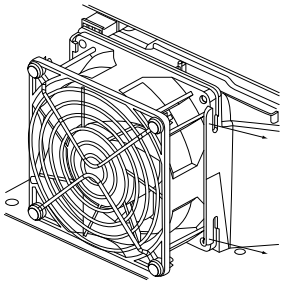

Illustration 11.1 Unlock and Remove the Fan

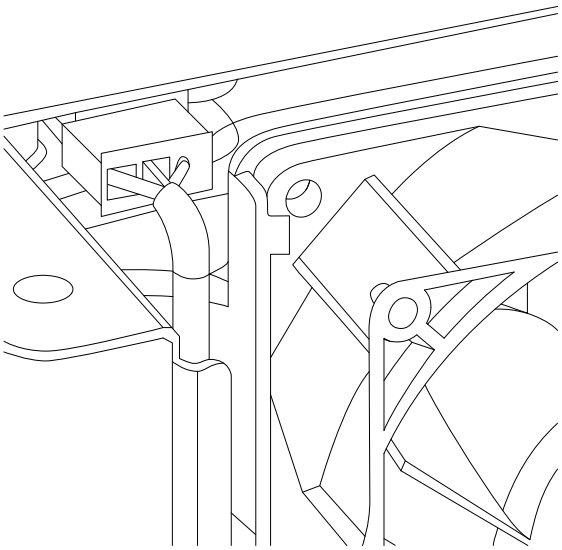

Illustration 11.2 Unplug the Supply Cable

11.2 Cleaning

It is recommended to periodically check the drive and especially the cooling fan for contamination with dust, debris (i.e. leaves), insects etc.

NOTE

Do NOT use a water hose, high-pressure cleaner or compressed air for cleaning purposes!
Using a water hose, high-pressure cleaner or compressed air for cleaning, can damage the drive.

To clean the inlet grid, use a soft cloth or brush to wipe of dust and dirt. Check proper function after cleaning.

12 Service and Spare Parts

Service policy

The Danfoss variable speed drive is not field repairable. In case of malfunction or damage (i.e. caused by lightning), the entire drive must be replaced with an original spare part.

⚠WARNING

ELECTRICAL HAZARD

Disconnect power and wait at least 4 minutes to discharge the DC-link capacitors before conducting service. Failure to disconnecting power and observing the waiting time can result in personal injury or death.

Spare part list

Replacement drive 13 kW/3 t unit	176L0767
Replacement drive 16 kW/4 t unit	176L0766
Replacement drive 20 kW/5 t unit	176L0765
Internal cooling fan all sizes (176L0767/176L0766/176L0765)	176L7003

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