

Application guidelines

Danfoss Light Commercial Refrigeration Compressors **GLT80TDC**

Direct Current, 24-42V, Mobile Applications



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Many vehicles for transportation of goods or recreation, such as trucks, caravans, boats, cars, etc. are often equipped with cooling appliances and air conditioners. The compressors for such mobile applications must be designed to operate from a low voltage DC power supply. These compressors must also be compact in their dimensions, highly reliable and yield high performances.

GLT80TDC is an answer to the needs of users requiring comfort and reliability in their travelling, either on holidays, at work or in any other circumstance where a DC powered air conditioner is utilised. The GLT80TDC is designed to operate silently, efficiently and reliably even up to angles of tilt of 20°, and works with the environmentally friendly refrigerant R134a. Its design is based on the "L" series, which has been successfully present in the market since 1964, and has had sales of more than 200 million units.

GLT80TDC is designed for capillary tube expansion and can be powered at 24 and 42V DC, and also at 12V with some restriction. Each unit is supplied with a dedicated electronic driver (FDC3), which features all the protections for both the battery and the driver itself, including the compressor motor. The driver automatically adjusts itself to the voltage of the power supply.

Evaporating temperature range: -25°C to +10°C.
Condensing temperature range: up to 65°C. Pull-down peak: 70°C.

Ambient temperature range: -10 to 55°C (65°C at starting).

In case of ambient temperature lower than 0°C, an oil heater will be needed.

The electronic control unit FDC3 is supplied with the exclusive Serial Port Interface (SPI), featuring a RJ45 telephone type connector. SPI allows the electronic driver to be connected to a computer for programming purposes using the FxC programming package (hardware and software, provided by the manufacturer upon request), and allows the communication with an Electronic Integral Manager of the appliance (EIM), and making the compressor work in slave mode.

FDC3 electronic driver includes Smart Speed® as programming option, which is a plug-in system for automatically self adapting compressor speed to current thermal load in refrigerating appliances.

Smart Speed® reduces number of thermostat cycles by minimizing compressor speed, enlarging on-time at every thermostat cycle, so that start/stop energy losses are substantially reduced. Lowest speed yields also highest evaporating temperature, and so highest C.O.P. and lowest energy consumption. Pull-down is done at maximum programmed speed, so pull-down time is very short with respect to fixed speed systems. No design parameters neither of the compressor nor the appliance are required to be programmed, so Smart Speed® can be easily used in all appliances with no design efforts.

FDC3 electronic driver includes Sleep and Sleep Energy Saving as programming option, which are plug-in systems specially conceived for mobile air conditioners avoiding any other electronic device. Sleep and Sleep Energy Saving make the air conditioner work for four hours since start-up. Sleep Energy Saving makes the compressor run at maximum programmed speed during the first hour, when highest cooling capacity is needed, and lowers progressively the compressor speed up to minimum velocity three hours later. Maximum comfort and minimum energy consumption are thus achieved.

GLT80TDC starting capability is as low as 10 V under any balanced pressure; it also admits a certain remaining differential pressure when thermostat off-time is abnormally short. For improving even more the starting capability, FDC3 electronic driver can be programmed with a 3 minutes minimum thermostat off-time. The delay is a programming option which can be easily enabled by means of the FxC programming kit.

FDC3 also includes a 1 second filter at the thermostat input to prevent the appliance from wrong operation due to typical micro switching produced by vibrations in those appliances that fit tilt switches at the thermostat circuit. So, analogical filtering is not needed.

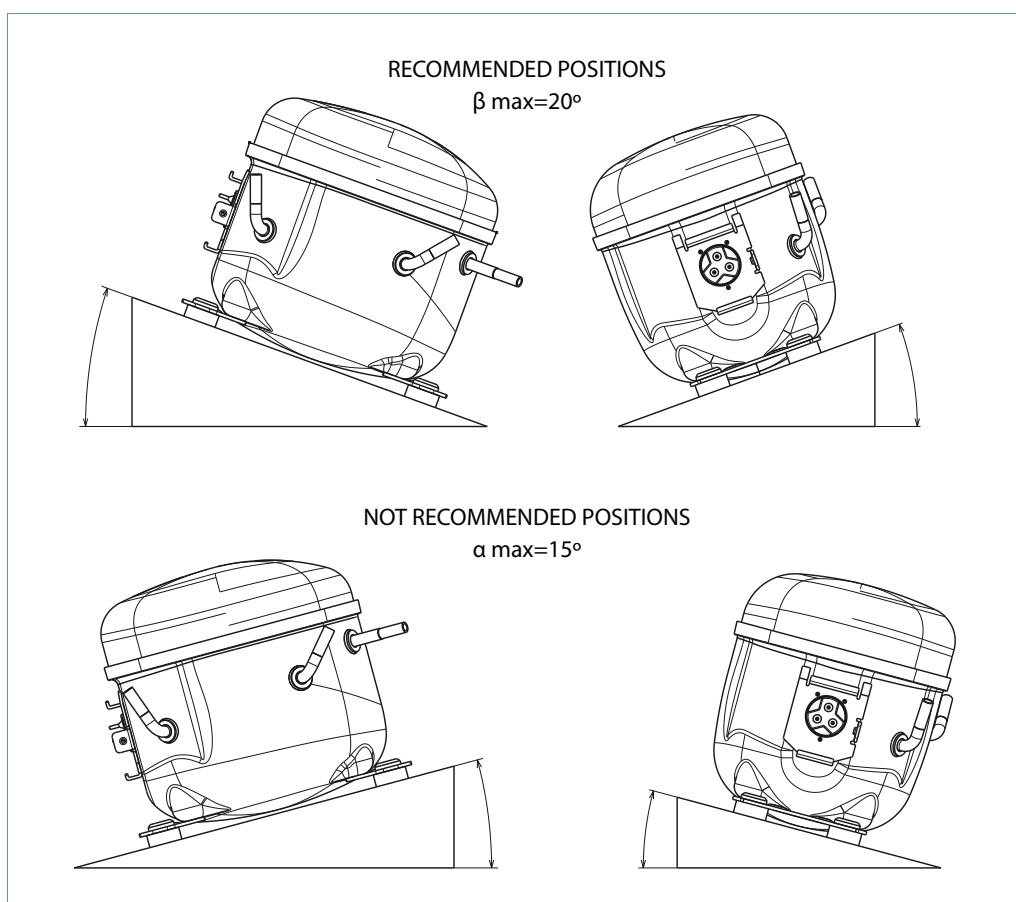
Installation and application

Maximum tilt angle

The maximum tilt angle allowed in GLT80TDC compressor (stopped or running) in any of the 2 below mentioned recommended positions is 20°, and maximum tilt angle in the 2 below not recommended position is 15°. Apart from this specification, below diagrams show the recommended and not recommended positions while the compressor is running in the application.

If compressor has been stopped during a certain period of time with an inclination higher than 15°, it is strongly recommended to not start up the compressor immediately after coming back to the correct position. We recommend waiting at least 30 minutes before starting up the compressor.

Fig 1. Maximum tilt angle



Off-road applications

GLT80TDC compressor is not designed for off-road mobile applications. If you are interested

in this type of mobile applications, it has to be specifically approved by the manufacturer.

Wiring and Connections

General rules

GLT80TDC must always be powered through the dedicated electronic driver FDC3, which is supplied with the compressor as a separate device.

NEVER CONNECT THE COMPRESSOR HERMETIC PINS (FUSITE) TO THE TERMINALS OF A BATTERY OR ANY OTHER DC OR AC SOURCE DIRECTLY.

DO NOT TRY TO FIT AN ELECTRONIC DRIVER OTHER THAN THE FDC3. THE COMPRESSOR WILL NOT OPERATE AND IRREVERSIBLE DAMAGE MAY OCCUR.

The FDC3 driver is directly connected to the battery poles as well as to the compressor pins. It checks battery voltage and adjusts itself to the voltage value for proper compressor operation, or switches itself off if the battery voltage is not adequate. The driver also controls the compressor speed.

ALWAYS RESPECT THE POLARITY OF THE BATTERY WITH THE POWER INPUT TERMINALS OF THE ELECTRONIC DRIVER

The unit is protected against damage caused by wrong polarity of the supply. The compressor will not run correctly if it's wrongly connected.

"-" NEGATIVE POWER INPUT TERMINAL OF THE ELECTRONIC DRIVER SHOULD BE EARTHED, TO THE CHASSIS OF THE VEHICLE AS WELL AS THE APPLIANCE FRAME*

A FUSE MUST BE PLACED BETWEEN THE "+" POLE OF THE BATTERY OR DC POWER SUPPLY AND THE "+" POWER INPUT TERMINAL OF THE ELECTRONIC DRIVER*

12V SYSTEMS: 30A FUSE
24V SYSTEMS: 30A FUSE
42V SYSTEMS: 20A FUSE

* In some special vehicles chassis is connected to "+" terminal of the battery instead of "-" terminal (positive reference systems). In such cases "+" should be understood as "-" and vice-versa. In systems powered by a variable DC source, the fuse should be selected following the rules above mentioned, considering the maximum voltage at the variable DC Source.

Voltage drop in the power leads

To avoid excessive voltage drop in the leads, their length and cross section must be related to the voltage supply as indicated in Table 1.

Table 1: Maximum length of leads (m)

Cross section mm ²	Rated Operating Range		
	12 - 14 V	24 - 28 V	36 - 42 V
4	2.5	2.5	3
6	4	4	6
10	6	6	9

If any kind of connector or switch is placed between the battery poles and the power terminals of the electronic driver, its resistance should be less than 10mΩ. If the resistance is higher than 5mΩ, the maximum length of the wires indicated in Table 1 should be halved or the cross section doubled.

In case of using a long cable to connect battery and electronic driver, it is recommended using a cable with low inductance.

Wiring and Connections

Wiring Diagram

The FDC3 electronic driver features a terminal board where all connections are made. The terminal lay out is described in Figure 2:

Fig 2: FDC3 wiring scheme

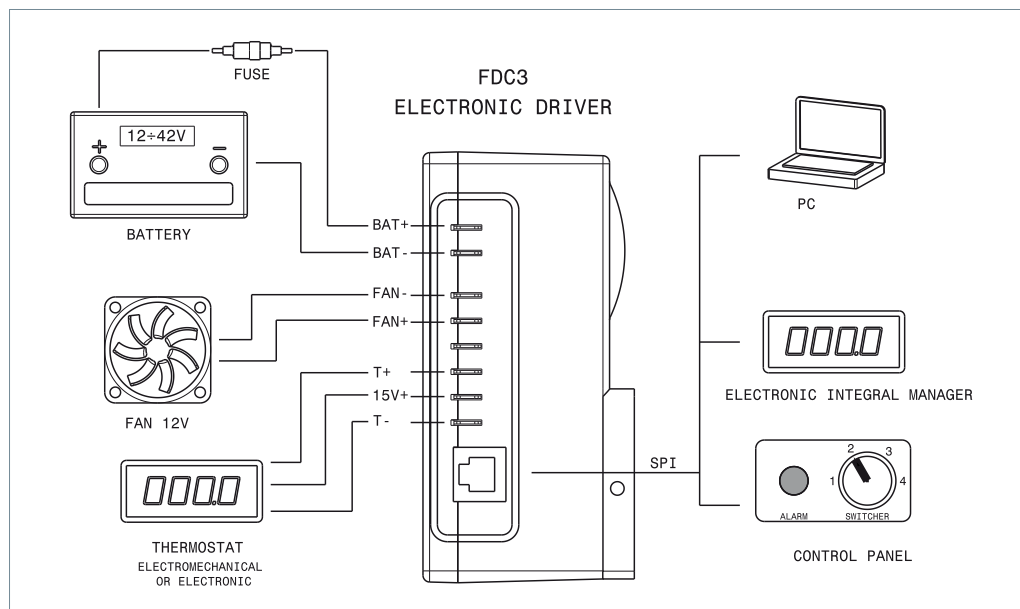
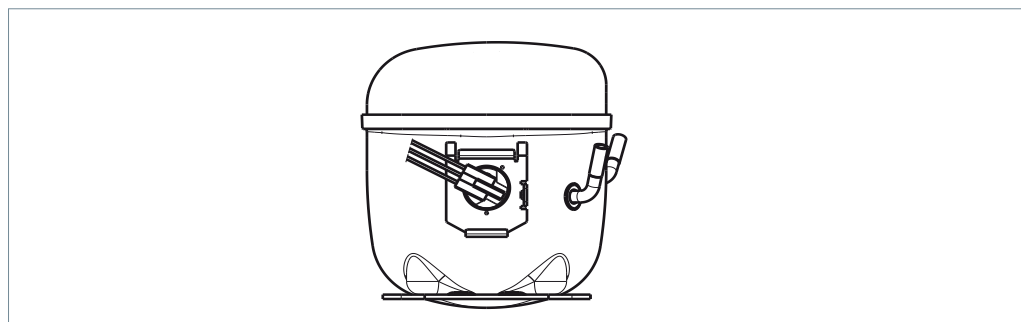


Fig 3: Connection of FDC3 driver to the compressor



The serial port interface

The electronic control unit FDC3 is supplied with the exclusive Serial Port Interface (SPI), featuring a RJ45 telephone type connector. This port allows the electronic driver to be connected to a computer for programming purposes using the FxC programming package (hardware and software) provided by the manufacturer upon request. Optionally, the SPI can be configured to:

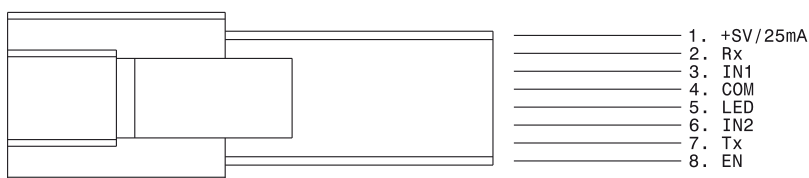
- Install a LED to display the intervention of any alarm.
- Set up either the compressor speed or the battery protection level, through physical connections between IN1, IN2 and COM.

- Connect the electronic driver as slave to an Electronic Integral Manager of the appliance with serial communication capabilities (Rx, Tx and COM), to allow working with variable speed. SPI provides a 5 V output, limited to 25mA, to power up the EIM.

TO PROGRAM THE ELECTRONIC FDC3 DRIVER BY MEANS OF THE FxC PROGRAMMING KIT THE FDC3 DRIVER MUST BE POWERED BY THE BATTERY.

Figure 4 Shows the RJ45 male connector which can be plugged to the SPI and the usage of each terminal in it.

Fig 4: SPI terminals



Operating voltage

GLT80TDC is designed to operate in a wide range of DC voltages, supplied either by a battery or by any other kind of filtered DC power supply.

DC VOLTAGE SUPPLY ALLOWED: 10V to 42.4V

Functional modes

• Standard (Default):

From the value of the applied voltage, the electronic driver automatically decides the rated voltage range of the supply. Three possible ranges are considered:

12 to 14V: actual voltage is below 17V
 24 to 28V: actual voltage is within 17 and 33V
 36 to 42V: actual voltage is within 33 and 42.4V

• Special (programming option):

The compressor can be powered by a variable DC source as, for instance, a photovoltaic panel, in which the output voltage strongly depends on the intensity of sunlight radiation. In these special cases the driver should be programmed with rated, minimum and maximum voltages. These values should be within the allowable DC voltage power supply (10 V to 42.4V).

Rated voltage and voltage limits are programmed by the appliance manufacturer by means of a PC connected through the serial port to the driver Serial Port Interface, using the FxC programming package provided by the manufacturer upon request.

Battery protection system

There is a protection system for the battery that prevents the compressor from operating if the available voltage becomes too low. The battery protection level should be set up as following:

• By programming:

Voltage limits for battery protection can be freely set, by the customer for every system (12-14V, 24-28V, 36-42V or special) by means of the serial

port of a PC connected to the SPI port of the electronic driver using the FxC programming package provided by the manufacturer upon request. In that option cut-out and cut-in values must respect the rule defined by Table 2.

In Table 2, ΔV is the difference between cut-out and cut-in, that is, the cut-in value is the result of adding ΔV to the cut-out value.

Table 2. Limits of battery protection parameters

Rated voltage range (V)	Cut-out (V)		ΔV	
	min	max	min	max
12-14	9,0	12,0	1,0	1,5
24-28	20,0	26,0	2,0	3,0
36-42	34,0	40,0	2,0	3,0
Special	9,0	40,0	1,0	3,0

• Externally, using COM, IN1 and IN2 of SPI:

· This option prevents from the possibility of setting up the speed externally using COM, IN1 and IN2 of SPI as defined in point 6.

· The external battery protection set up option must be previously programmed for external adjustment of the protection limits.

· Voltage limits are set up by means of a PC through its serial port connected to the

electronic driver SPI. It can be done by the customer itself using the FxC programming package.

· The cut-out (battery voltage at which the driver stops operating) and the cut-in (battery voltage at which driver re-starts operation after a cut-off) values are set up by connecting the SPI connector terminals IN1 and IN2 to COM. according to the connection made, four protection levels can be selected as shown in Table 3.

Table 3. IN1, IN2 and COM connection for battery protection set up 0=open connection; 1=shortened

Protection level	Protection limits (V)		Rated operating voltage range					
	Connection to COM		12-14 V		24-28 V		36-42 V	
	IN1	IN2	cut-out	cut-in	cut-out	cut-in	cut-out	cut-in
Standard	0	0	10,0	11,5	22,0	24,5	36,0	38,5
Low	1	0	9,0	10,5	20,0	22,5	34,0	36,5
High	0	1	11,0	12,5	24,0	26,5	38,0	40,5
Very high	1	1	12,0	13,5	26,0	28,5	40,0	42,5

It is possible to operate the compressor at fixed or variable speed under different running modes, options and parameters. The electronic driver is supplied by the manufacturer with standard running mode and external control of the speed, with minimum speed of 2,000 rpm. and maximum speed 3,500 rpm. Default running mode, options and parameters can be changed to optimize compressor performance for a given appliance, by programming, connecting a PC to the SPI by means of the FxC programming package provided by the manufacturer upon request. Running modes and options are:

• **Standard mode:**

Compressor speed is a fixed programmed value or switched externally from programmed minimum and maximum value in four steps. The switch should be connected to the SPI and should remain plugged during compressor operation.

When setting up a fixed speed, maximum speed can be limited by the available battery voltage in the following way, maximum speed would be:

- 2,000 rpm when the battery voltage is equal to the cut-in voltage.
- Programmed fixed speed when the battery voltage is equal to or greater than the maximum nominal voltage (14V, 28V and 42V for 12V, 24V and 42V systems respectively).
- A linear function of the battery voltage in the range between the cut-in and the maximum nominal voltages.

This option is particularly useful for eutectic plates systems.

If external switching is programmed, the speed is set up by the connection of the SPI connector terminals IN1 and IN2 to COM for minimum, maximum speeds, and two intermediate velocities according to Table 4:

Table 4. External selection of the velocity
0=Open connection
1=Shortened

Connection to COM		Speed of the motors (rpm)
IN1w	IN2	
0	0	Smin
1	0	Smin+1/3 (Smax-Smin)
0	1	Smin+2/3 (Smax-Smin)
1	1	Smax

External speed set up option must be previously programmed for external adjustment of its minimum (Smin) and maximum (Smax) limits.

External switching prevents from the possibility of setting up the battery protection externally using COM, IN1 and IN2 of SPI as defined in point 5.

• **Smart Speed® mode:**

Compressor will run at variable speed at its highest performance depending of the current thermal load. The speed can be limited by a fixed programmed value and even more by the available battery voltage as described in standard mode. The speed can also be limited by external switching in the same way as described in standard mode.

NO SWITCH (MANUAL I/O, TILT, ETC.) IS ALLOWED TO BE CONNECTED IN SERIES WITH THE THERMOSTAT. IF ELECTRONIC THERMOSTATS ARE TO BE FIT, AVOID THOSE THAT INCORPORATE MANUAL I/O SWITCH AND/OR STARTING DELAY.

• Sleep mode:

Compressor will run during four hours after start-up. The speed can be limited by a fixed programmed value and even more by the available battery voltage as described in standard mode. The speed can also be limited by external switching in a similar way as described in standard mode according to table 5:

Table 5. External selection of the velocity
0=Open connection;
1=Shortened

Connection to COM		Speed of the motors (rpm)	Sleep mode
IN1	IN2		
0	0	S_{min}	off
1	0	S_{min}	on
0	1	S_{max}	off
1	1	S_{max}	on

If off sleep mode is selected, the appliance will run continuously at selected fixed speed S_{min} or S_{max} .

• Sleep Energy Saving mode:

Compressor will run during four hours. During first hour compressor will run at selected speed. During next three hours speed will decrease up to 2,000 r.p.m. Programming Sleep Energy Saving is done in the same way as Sleep.

• Slave mode:

Under this mode, variable speed is controlled by an Electronic Integral Manager of the appliance (EIM) permanently connected to the electronic

driver FDC3 through the SPI, using its serial communication capability. The EIM reads the current temperature inside the appliance, compares it with the set point temperature, and decides if the compressor should operate or not, and if so, at which speed. The EIM communicates how the compressor should operate and, eventually, records and displays any abnormal circumstance that might occur. For details about the communication protocol, please contact Danfoss.

IF ANY VARIABLE SPEED MODE IS TO BE PROGRAMMED, CHECK CAREFULLY FOR TUBES, CONDENSER AND EVAPORATOR RESONANCES. NATURAL FREQUENCIES SHOULD BE 75 Hz UP TO AVOID VIBRATIONS.

In order to program the electronic driver FDC3, a personal computer together with the FxC programming package are required (provided by the manufacturer upon request). To this purpose, perform the following steps:

1. Install the programming software, following the instructions of the wizard.
2. Connect the programming interface to a PC using the serial cable supplied with the hardware.
3. Power on the programming interface using the AC/DC adapter supplied with the hardware.
4. Connect the FDC3 electronic driver to the programming interface using the double RJ45 cable supplied with the hardware.
5. Run the programming file FDC.exe.
6. From the top menu, load an existing configuration and go to step 9, or go through step
 7. Select the running mode, options and parameters, between:
 - 7.1 Standard mode.
 - 7.1.1 Select maximum fixed speed and enter a value within 2,000 and 3,500 r.p.m. as described in point 6, if desired select speed limited by available battery voltage, or
 - 7.1.2 Select external switcher connected to SPI and enter low and high speed values within 2,000 and 3,500 r.p.m. as described in point 6. External speed selection is incompatible with external battery protection (step 8.2).
 - 7.2 Smart Speed® mode. Select maximum fixed speed or external switcher connected to SPI and proceed as described in 7.1.1 or 7.1.2 respectively.

7.3 Sleep and Sleep Energy saving modes. Select maximum fixed speed or external switcher connected to SPI and proceed as described in 7.1.1 or 7.1.2 respectively.

7.4 Slave mode

8. Select the battery protection mode and the protection parameters from:

8.1 Internal protection: choose between normal and special voltage systems.

8.1.1 For normal voltage systems, enter cut-out, cut-in and maximum voltage values for every voltage system, accounting for the limits shown in Table 2 of point 5.

8.1.2 For special voltage systems, enter cut-out, cut-in and nominal and maximum voltage values accounting for the limits shown in Table 2 of point 5.

8.2 External protection. Protection values are shown in Table 3 of point 5. External protection is incompatible with external speed selection (step 7.2).

9. Select thermostat delay 3 minutes for improved starting.

10. Click "Apply". The FDC3 electronic driver is now programmed and ready to drive the compressor.

11. From the top menu, save the current configuration if desired.

12. To program another FDC3 unit, plug it in, apply current configuration or return to step 6 to change configuration.

13. Click exit to finish.

Protections and alarms

GLT80TDC is electronically protected against a number of possible malfunctions and failures:

- Battery discharge: refer to point 5 for details.
- Fan over current: protects the compressor and the electronic driver against fan over current due to start or running overload, or short-circuit.
- Starting failure: if the running speed is not achieved during the starting sequence, the unit stops and retries the start up after one minute.
- Compressor overload: This protection operates when the compressor speed drops below the set up speed, or when the current drawn in is excessive, thus preventing the appliance from operating under overload conditions, causing refrigerating overload or compressor failure.
- Electronic driver overhead: In case the temperature of the electronic components of the control becomes too high, an internal sensor will stop the unit.

When the alarm is on, ten automatic attempts to restart the compressor will be available. In case of battery protection, the number of automatic attempts to restart is unlimited. Once the sequence of automatic attempts to restart the compressor is finished, the unit will remain permanently unable to operate until it is switched off and on again from the power supply. The intervention of the thermostat during the sequence of automatic restart attempts interrupts and resets the sequence.

The SPI can be configured in a way that a LED can be connected between terminals 3 and 4 (see Fig. 2 in point 3) in order to display the intervention of any alarm, and to identify its cause. The visualisation consists of a sequence of flashes of the LED repeating every 5 seconds, until the cause of the alarm disappears. The code of the flashing sequence corresponding to each alarm is indicated in Table 6:

Table 6. Alarm codification

No. of flashes	Type of failure
1	Battery protection
2	Fan over current
3	Starting failure
4	Compressor overload
5	Electronic driver overhead
7	Internal error

In case of an alarm display, if the FDC3 electronic driver is connected as a slave to the appliance's Electronic Integral Manager (EIM) through the

SPI, a digital alarm code will be transmitted to the EIM, which in turn will manage the information for displaying and acting purposes.

Compressor Cooling

GLT80TDC should always be fan cooled. FDC3 electronic driver has its own fan to cool its power components -. Best results are obtained when both, but enough compressor and driver are

cooled with fresh air coming directly fresh air is needed in the surroundings of the electronic driver to be cooled properly from outside, before being heated up in appliance condenser.

Technical Data

Compressor		
Displacement	cm ³	8.10
Diameter	mm	24.29
Stroke	mm	17.48
Net weight	kg	10.2
Oil type		ISO VG 22 ESTER
Oil charge	cm ³	330

Reliability GLT80TDC pass following reliability tests:		
• High Temperature: according with CECOMAF GT-4002 standard		
• Wear: according with CECOMAF GT-4003 standard		
• ON/OFF: according with CECOMAF GT-4004 standard		
• Vibrations: according with ASTM 5728 Level I standard		

Application		
Application		MBP - HBP – A/C
Refrigerant		R134a
Evaporation temp. range	°C	-25 to +10
Expansion system		CAPILLARY
Compressor cooling		Fan
Max. ambient temperature	°C	43

Electrical		
Voltage	V DC	12 to 42
Voltage range	V DC	10 to 42.4

Motor		
Type		Brush-less, Sensor-less, PMM
Phase number		3
Pole number		6
Locked rotor current (12, 24, 42 V)	A	12, 12, 8
Resistance at 25°C (R-S/R-T/S-T)	Ω	0.36

Technical Data

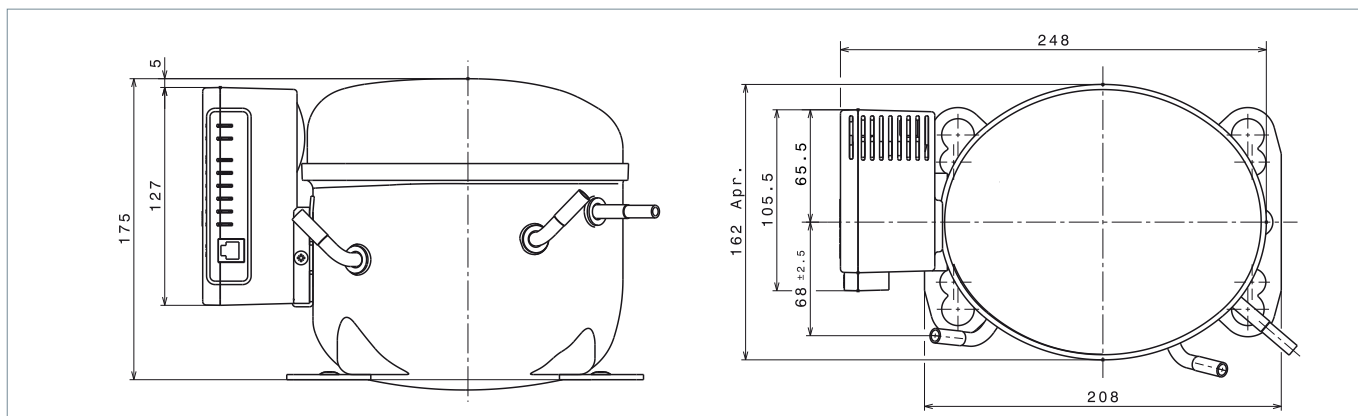
Electronic driver	
Model	FDC3
Type	Fully digital & programmable μ P based
Supported devices	12V/0.5A Fan Compressor speed or battery protection level switcher Alarm LED 15V/25mA electronic thermostat 5V/25mA Electronic Integral Manager
Communication port	Serial Port Interface (SPI)
Communication capabilities	RS-232 serial port 2-digit, 4-level switcher Alarm LED
Compressor speed selection	By programming or switching*
Battery protection level selection	By Programming or switching* *only one at a time
Protections	Battery protection Fan over current Starting failure Compressor overload Electronic driver overheat Fan over current Starting failure Compressor overload Electronic driver overheat
Programmable running modes	Standard Smart Speed Sleep Sleep Energy Saving Slave
Setup by default	Running mode: Standard Speed selection: external switcher Lower/higher speed: 2000/3500 r.p.m. Battery protection: fixed voltage level; standard system Cut-out (12/24/42 V systems): 12/22/38,5 V Cut-in (12/24/42 V systems): 10.8/20.0/36.2 V 3 minutes thermostat delay: on

Nominal performance at	rpm	2000	2500*	3000*	3500*
Cooling capacity	W	577	712	842	968
Cooling capacity	kCal/h	497	613	725	834
Input power	W	247	315	388	468
EER	kCal/(Wh)	2.01	1,95	1.87	1.78
COP	W/W	2.34	2,26	2,17	2,07
Current	A	10.3	13.1	16.2	19.5

Test Conditions		
Evaporating temperature	$^{\circ}$ C	+7,2
Condensing temperature	$^{\circ}$ C	55
Liquid temp. entering expansion	$^{\circ}$ C	32
Ambient and return temp.	$^{\circ}$ C	35
Voltage	V DC	24
*Only for voltage supply	V DC	24-42

Technical Data

Fig.5: GLT80TDC outline drawing



Performance data

r.p.m.	T evap = -25°C		T evap = -10°C		T evap = +7,2°C	
	Q (W)	COP	Q (W)	COP	Q (W)	COP
2,000	116	1.15	264	1.64	577	2.34
2,500	142	1.13	330	1.62	712	2.26*
3,000	168	1.11	395*	1.58*	842	2.17*
3,500	192	1.09	454*	1.54*	968	2.07*

r.p.m.	T evap = -25°C		T evap = -10°C		T evap = +7,2°C	
	Pe (W)	I (A)	Pe (W)	I (A)	Pe (W)	I (A)
2,000	101	4.21	162	6.75	247	10.3
2,500	127	5.29	204	8.5	315*	13.1*
3,000	152	6.33	251*	10.5*	388*	16.2*
3,500	177	7.38	296*	12.3*	468*	19.5*

Condensing temperature = 55°C

Ambient and suction temperature = 35°C

Liquid subcooling = 9K

Test voltage = 24V DC

*Only for 24-42V DC voltage supply

Supply

GLT80TDC compressor including FDC3 electronic driver (120 pieces pallets).

Danfoss Commercial Compressors

is a worldwide manufacturer of compressors and condensing units for refrigeration and HVAC applications. With a wide range of high quality and innovative products we help your company to find the best possible energy efficient solution that respects the environment and reduces total life cycle costs.

We have 40 years of experience within the development of hermetic compressors which has brought us amongst the global leaders in our business, and positioned us as distinct variable speed technology specialists. Today we operate from engineering and manufacturing facilities spanning across three continents.



Our products can be found in a variety of applications such as rooftops, chillers, residential air conditioners, heatpumps, coldrooms, supermarkets, milk tank cooling and industrial cooling processes.

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