REFRIGERATION PARTS SOLUTION

“Do It Yourself” Kit
Assembly and Installation Manual

Full Gauge Digital Thermostat Retrofit Kit
Digital Thermostat Upgrade for Danfoss BD Series of DC Compressor Systems with Analog Thermostat

Part Number 011-1021

Manual Version 1.0 – August 2014

TABLE OF CONTENTS

List of Parts: Complete List (included with Kit)

Item	Part No.	Qty	Description
1	015-0000	1	SS Mounting Bracket for Digital Thermostat
2	015-0010	1	Full Gauge (SPDT) Digital Thermostat
3	015-0012	1	Full Gauge NTC Temperature Probe
4	017-2000	1	1 1/4" x 1/4" Fast Acting AGC Fuse - 2 amp
5	017-2011	1	10 amp In-Line Fuse Holder
6	017-3101	1	16 amp Rocker Switch (SPST) – 125 vdc
7	055-0041	1’	Foam Insulation Adhesive Tape – 2” width
8	241-0001	12’	Multi-conductor Cable - 18/4
9	290-0001	3	Insulated Female Spade Electrical Terminal – 22-18 ga., 1/4" Tab Size
10	290-0005	2	Insulated Female Spade Electrical Terminal – 22-18 ga., 3/16" Tab Size
11	290-0021	1	Insulated Female Spade Electrical Terminal – 16-14 ga.
12	290-0212	1	Adhesive Lined Heat Shrink Butt Connector – 16-14 ga.
13	290-0902	2	Double Male-Female Adapter – 1/4” Tab Size
14	400-0381	4	Phillips Pan Head Tapping Screws – 18-8 SS, #4 x 1/2”
15	400-0912	5	Small Cable Tie – 4"
16	NA	1	CD Manual

Required Tools

The following tools are required and are not included with the kit.

- Electric drill and assorted drill bits
- Jig saw and fine tooth saw blade
- Matches, Butane lighter, or heat gun
- Pencil
- Scissors
- Small flat blade and Phillips screwdrivers
- Tape measure or ruler
- Wire crimping pliers
- Wire cutter and stripper

Introduction

Any small DC refrigeration system using a Danfoss BD series of DC compressors controlled by a "dial" or analog thermostat will benefit with an upgrade from the standard thermostat to a Full Gauge electronic digital thermostat. Using the Full Gauge digital thermostat allows complete control of both the set point and differential of the thermostat operation. The set point is the temperature at which the system will turn off, and the differential added to the set point will be the temperature at which the system will turn on.

The Full Gauge thermostat has advanced features that add to the functionality of the system. This document will describe the basic installation, wiring, and programming of a Full Gauge controller to regulate a small refrigeration system.

The Danfoss DC compressor used in small refrigeration systems requires a control module to run. The control module shown below has eight terminals for wiring connections.

The essential connections for simple operation consist of:

1. DC Power: The DC power is to be provided by adequately sized wires connected to the control module terminal connections labeled large "+" and "-". The positive wire of the pair must be protected at the source by an appropriate sized circuit breaker or fuse. A table of fuse or circuit breaker size is included at the end of this manual.

2. Thermostat: The thermostat wiring terminal connections on the control module are labeled "T" and "C".

3. Fan: There should also be fan or water pump wiring on the module terminal connections "F" and small "+". This circuit has a continuous current capacity of 1/2 amp and a peak capacity of 1 amp.

Optional wiring connections consist of:

1. LED: A diagnostic light emitting diode (LED) can be connected between module terminal connections "D" and small "+".

2. Battery voltage protection: A resistor (R2) may be connected between module terminal connections "P" and "C". The value of the resistor determines the

shut off voltage. A table of the resistor values for low battery protection is included at the end of this manual.

3. Speed control: The compressor speed can be changed by adding a resistor (R1) in series with the thermostat. If the system came with a resistor, the original resistor value is usually the best choice and should be retained unless there is a good reason to change it. Usually the manufacturer of the equipment has determined the best compressor speed for the particular system to make it as efficient as possible. Faster is not necessarily better, sometimes speeding up the compressor results in less efficiency. A table of resistor values for various compressor speeds is included at the end of this manual.

When upgrading from an analog thermostat, additional wires must be added to power the Full Gauge thermostat from the compressor control module. The Full Gauge thermostat power supply wire will attach to the existing power supply wires on the large "+" and "-" terminals on the control module. Adapter terminals included in the kit will allow the large "+" and "-" terminals to be shared. An inline fuse holder with a 2 amp fuse will connect in series with the positive wire at the compressor module. The power leads attach to Full Gauge thermostat connections 7 and 8. These connections are polarity insensitive.

The thermostat wire connections on the control module will remain the same ("T" and "C"), but the thermostat end of the wires will attach to the Full Gauge thermostat connections 10 and 11.

The temperature-sensing probe will attach to the Full Gauge thermostat connections 3 and 4. If necessary, extend the probe wires with small gauge wire. It is best to solder and heat shrink the wiring connections if additional length is required.

Preparation: Making Electrical Wiring Connections

Please read the following section carefully before proceeding with the assembly and installation of the kit.

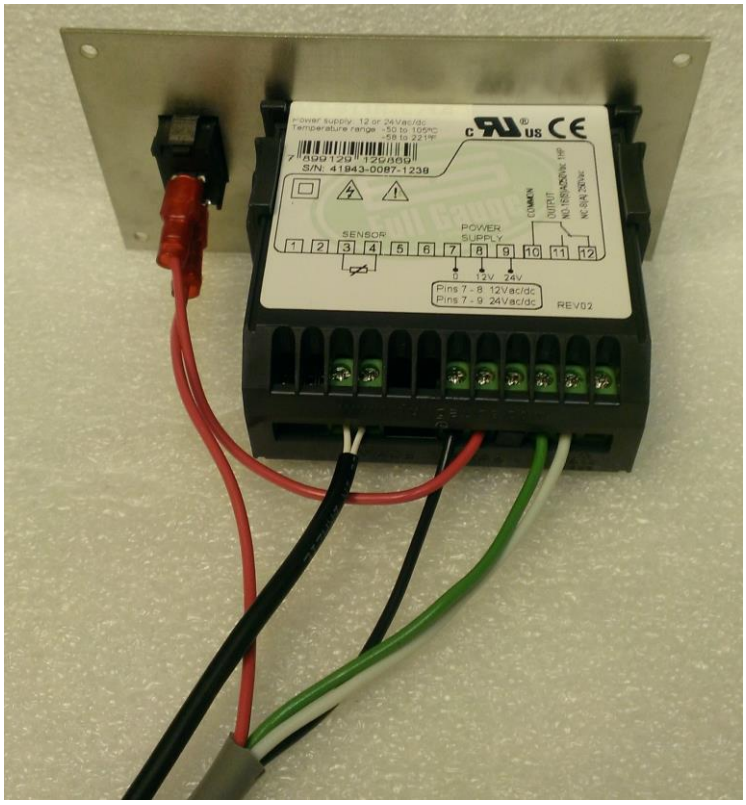
To connect wiring to the Full Gauge digital thermostat connection terminals, strip 3/16" of the insulation from the wire ends of the multi-conductor cable before inserting them into the appropriate wiring connection terminal. Avoid having any loose strands of wiring that may contact other terminals and cause short circuits.

Wire ends that are attached to the wire electrical terminals will have 1/4" of insulation stripped from the wire end before the terminal is crimped to the bare wire strands. The wire electrical terminal also requires a second crimp to squeeze the barrel of the terminal to the wire insulation, making a mechanical connection to relieve the strain on the metal-to-metal crimped electrical connection.

Assembly: Electrical Wiring Connections

Connection on the Full Gauge Thermostat End

1. Locate the stainless steel thermostat mounting bracket (015-0000) and mount the On/Off rocker switch (017-3101) and the Full Gauge digital thermostat (015-0010) into the bracket. The "O" on the On/Off rocker switch should be below the "I". The switch will pop right in into the smaller hole of the bracket. Remove the plastic bracket on the digital thermostat, insert the thermostat through the larger hole from the front side of the bracket, and reattach the plastic bracket to the thermostat on the back side of the bracket.



Thermostat Electrical Wiring Connections
(Shown assembled with the On/Off rocker switch in the mounting bracket)

2. The temperature probe (015-0012, two white wires in black sheath on left side) attaches to the Full Gauge thermostat connections 3 and 4.

3. The positive (+) 12 volt wire of the multi-conductor cable (241-0001, red) connects to the bottom terminal of the rocker switch (017-3101) on the far left through an insulated female spade terminal (290-0005). The top terminal of

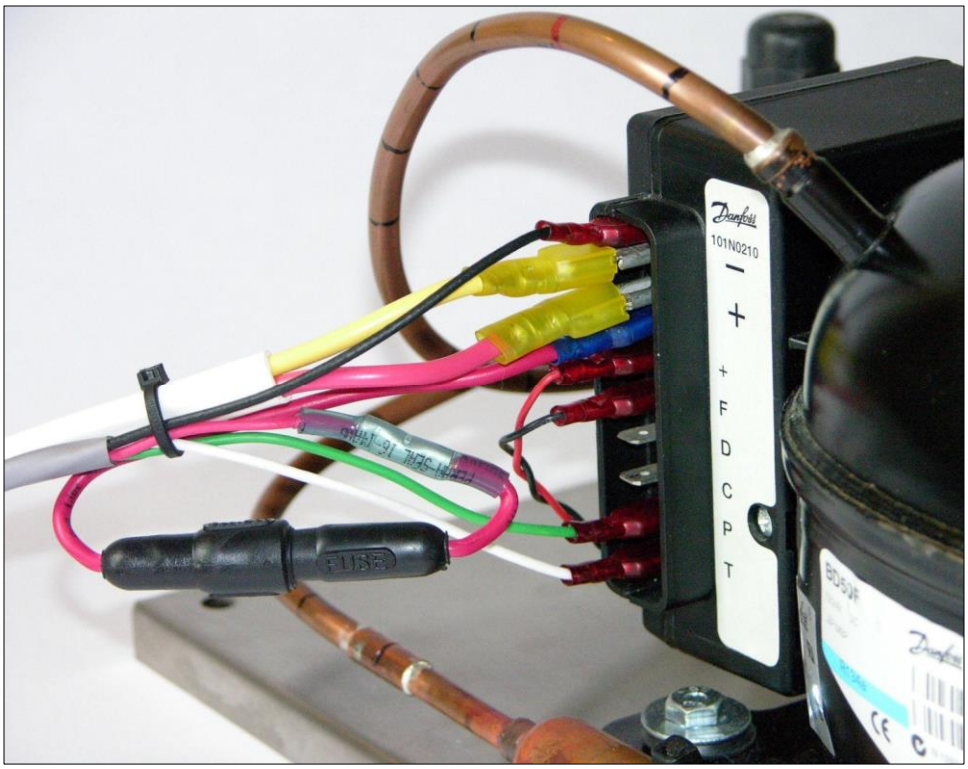
the rocker switch attaches via another insulated female spade terminal (290-0005) to a short length of wire (cut from red wire from the multi-conductor cable) which then attaches to connection 5 on the Full Gauge thermostat (also red in the photo). The other end of the positive, red wire of the multi-conductor cable will connect to the Danfoss compressor control module large "+" connection terminal in a later step.

4. The negative (-) 12 volt wire of the multi-conductor cable (241-0001, black) attaches to the Full Gauge thermostat connection 7. The other end of the negative, black wire from the multi-conductor cable will connect to the Danfoss compressor control module "-" connection terminal in a later step.

5. The thermostat wires (in this case, 241-0001, white and green) connect to the Full Gauge thermostat connections 10 (green) and 11 (white), and continue to the Danfoss compressor control module "T" and "C" connection terminals.

Connection on the Danfoss Control Module End

The wires (241-0001, red and black) supplying power to the Full Gauge thermostat use insulated female spade terminals (290-0001 and 290-0021) to connect to the double male-female adapter terminals (290-0902) included in the kit and "piggyback" with the Danfoss power supply cable (with a insulated female spade terminal) on the large "+" and "-" terminals of the control module.

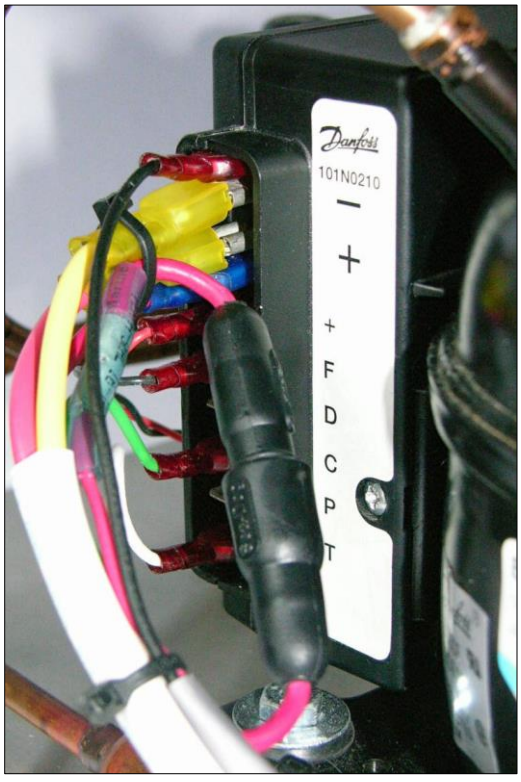


Danfoss Control Module Electrical Wiring Connections
(Also showing connections for condenser fan)

1. The Full Gauge negative (-) 12 volt DC supply wire (241-0001, black) connects with a female spade terminal (290-0001) to the double male-female adapter (290-0902) short terminal, and the Danfoss module 12 volt DC negative (-) supply wire (aka condensing unit 12 volt DC negative supply wire) insulated female spade terminal connects to the adapter long terminal. The orientation of the insulated spade terminals attached to the wires must allow room for the adapter terminal and the attached wire terminals to fit into the Danfoss control module connector housing. Align the insulated female spade terminals so the flat sides are facing each other. Insert the double male female adapter into compressor module "-" connection terminal.

2. The Full Gauge positive (+) 12 volt DC supply wire (241-0001, red) connects to a waterproof AGC inline fuse holder (017-2011) with an adhesive lined heat shrink butt connector (290-0212) before continuing to the Danfoss control module installation location. Heat the butt connector with a match, lighter, or heat gun after making the electrical connections to activate the adhesive and shrink the insulation around the wires, making a waterproof connection. If a 10 amp fuse is included with the fuse holder it should be discarded and replaced with the 2 amp fuse (017-2000) included with the kit. The 2 amp fuse will protect the wiring from damage due to possible accidental short circuits in the Full Gauge supply wiring. The other end of the AGC inline fuse holder connects to the double male-female adapter short terminal (2900902) with an insulated female spade terminal (290-0021). The Danfoss module 12 volt DC positive (+) supply wire (aka condensing unit 12 volt DC positive supply wire) insulated female spade terminal connects to the adapter long terminal. The orientation of the insulated female spade terminals attached to the wires must allow room for the adapter terminal and the attached wire terminals to fit into the Danfoss module connector housing. Align the insulated female spade terminals so the flat sides are facing each other, as described in the previous step. Insert the double male-female adapter into compressor module large "+" connection terminal.

3. The ends of the thermostat wires (2410001, green and white) that are attached to Full Gauge thermostat connections 10 and 11 connect to insulated female spade terminals (290-0001), which then attach to the Danfoss module connections "C" and "T" (green and white, in the photos).



4. Gather together the wires attached to the Danfoss control module and secure the wires to the condensing unit base with cable ties (400-0912) to prevent accidental wiring disconnections from the module due to inadvertent tugging on the wires during the life of the installation.

Determining Thermostat Temperature Settings

The digital thermostat for refrigeration systems utilizing a roll bond evaporator can be installed and programmed in either of two methods. In one method, the thermostat senses and regulates the temperature of the evaporator, which has a low setting with a large rise in temperature before the compressor restarts. The other method senses the box temperature with a moderate setting and a small rise in temperature before the compressor restarts.

Evaporator Temperature Regulation Setting

In systems regulating the evaporator temperature, attach the probe as shown in the section titled "Assembly: Temperature Probe Sensor Attachment". Choose a large flat area away from the evaporator tubes and near the exit of the suction line from the roll bond evaporator to mount the thermostat probe.

For box shaped roll bond evaporators, the outside area around the evaporator will be the refrigerator. An approximate setting to start with would be adjusting the setpoint (St1) to around 8°F, with a differential (P1) of around 12°F. These are starting points; the actual settings will have to be determined by the user. The settings are affected by the ratio between the box volume and the evaporator surface area. Once the settings are adjusted, it usually is not necessary to change them.

For flat or bent roll bond evaporators in freezer applications, the setpoint (St1) will probably be near or below zero °F., and the differential (P1) will be around 8 to 10°F.

Box Temperature Regulation Setting

In systems regulating the box temperature, attach the probe in a position in the insulated box near the middle and away from contact with the box walls or food placed in the box. The digital thermostat programming will require a setpoint (St1) setting of around 36°F, with a differential (P1) of about 2°F.

One disadvantage of sensing the box temperature to regulate the system is that when warm food is added to the box, the system will continue running even when the evaporator is as cold as possible, which is often the case if the evaporator is slightly undersized.

For systems with holding plate type evaporators, the box temperature must never be used to control the system. Continuing to run a holding plate system long after the plates are frozen causes extremely low suction pressures leading to oil migration and possible compressor failure.

Holding plate systems should have the digital thermostat probe attached to the plate in a manner and location that will sense the temperature of the solution in the plate as accurately as possible. This should not be on the top surface of the plate, as there is space above the plate solution to allow for expansion during freezing.

Usually the best place for thermostat probe placement is on the front or back surface, near a lower corner of the plate. The probe may be attached as described in the photo sequence in this manual, or the probe can be held against the backside of the plate with a piece of foam used between the box wall and the back of the plate to press the probe against the plate. It is important not to place the probe on the plate surface near where the evaporator tubing is located within the plate. This can be observed visually when the plate first cools from ambient temperature. The serpentine pattern of the tubing in the plate is visible in the frost pattern as the plate begins to chill, usually within 20 minutes of starting the system.

The holding plate system needs to run until the plate liquid is completely frozen, and not restart until the frozen plate completely thaws. The setpoint will need to be several degrees below the freezing point, to assure that all the solution is frozen. For refrigerator plates, this will be around 26°F., which requires a setpoint (St1) of around 22°F. For plates in freezer applications, the solution usually freezes at about zero degrees F., meaning that the setpoint (St1) will be about minus 4°F. The differential setting (P1) on both refrigerator and freezer plate thermostats is usually about 8 to 10°F.

Optimizing Temperature Settings

These settings are a starting point; they may be optimized by careful observation of system operation. Changing the values will change the run time and holdover time. At an optimum setting, maximum holdover time will be achieved with the minimum required run time. The values should be varied and records made of changes to determine the best settings for any individual system. This will be time consuming and should be left to the system operator to experiment with and determine the best settings.

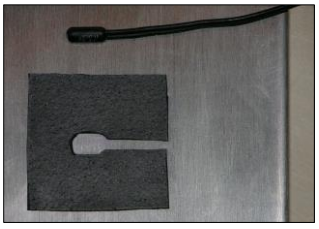
Installation: Mounting the Thermostat Unit

When mounting the thermostat in a bulkhead, cut a rectangular hole that measures 4 1/4" x 1 3/4". Feed the wiring through the hole from behind. Strip and connect the wires to the Full Gauge digital thermostat and the On/Off rocker switch after their assembly into the mounting plate. (The "O" on the On/Off rocker switch should be below the "I".) Push the wiring back through the hole until the mounting bracket is flush with the mounting surface, and secure with four #4 x 1/2" round head screws (400-0381). Drill pilot holes for the screws before driving them into the mounting surface.

Assembly: Temperature Probe Sensor Attachment

The thermostat must sense the temperature of what it is trying to regulate. Usually this will be the evaporator or holding plate temperature. The oval end of the temperature probe should be attached to the holding plate in an area that is out of the way of normal access to the food in the box, yet in an area that most accurately senses the state of the plate, either frozen or liquid. Holding plate systems need the condensing unit to run long enough to totally freeze the liquid in the plate, and then stay off until the frozen liquid has completely thawed before repeating the cycle.
One method of attaching the probe to the holding plate is shown in the photo sequence below. The attachment method is the same for roll bond evaporators. Additional attachment tips for roll bond evaporator applications are included at the end of the section.

1. Using scissors, cut three 2" long pieces of 2" wide foam insulation tape (055-0041). Cut one of the pieces of insulation as shown in photo on the right.

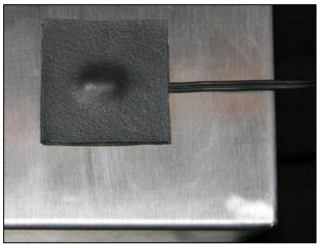


2. Clean the area on the surface of the plate where the probe is to attach. Use soap and water or a suitable solvent such as rubbing alcohol or acetone. The plate surface must be clean, warm, and dry for the insulation tape to adhere well.

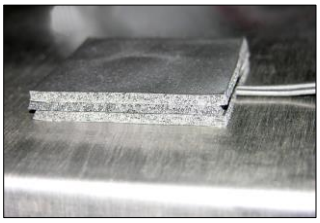
3. Remove the backing from the adhesive and attach to the surface of the plate. Rub well to assure maximum surface contact between the adhesive and the plate.

4. Lay the thermostat probe (015-0002) in the cut out of the foam insulation attached to the plate.

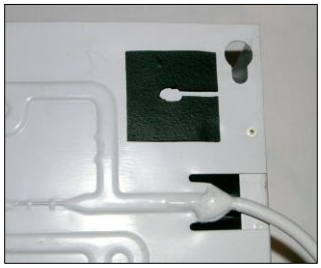
5. Remove the backing from another piece of foam insulation and attach over the probe on top of the first piece of insulation.

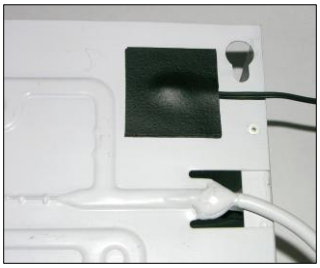


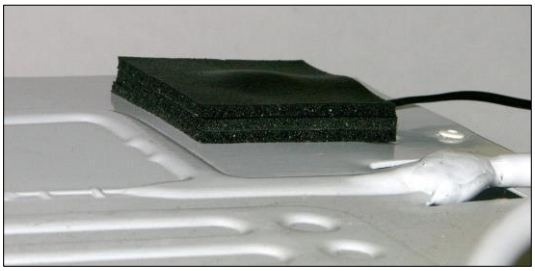
6. Attach the third piece of foam in the same manner as the second piece. Press the layers of foam tape together firmly to assure good contact between the layers.



The same foam tape method of probe attachment can be used on the roll bond evaporator. Mount the thermostat probe on a large flat area away from the evaporator tubes and near the exit of the suction line on the roll bond evaporator.







Digital Thermostat Configuration Instructions

There are four items that must be configured in the thermostat. The items are units (C or F), setpoint (the temperature to shutoff the compressor), differential (the temperature rise from setpoint to restart the compressor), and function (cooling or heating). The system must be powered on and the thermostat switch should be in the off position during the configuration process.

1. Configure the units as C or F (factory setting is F). Press the Up and Down arrow buttons at the same time and hold for 30 seconds until Uni is displayed on the thermostat. Release both buttons and then use the arrow buttons to select C or F. Then press the Set button to confirm.

2. Configure the setpoint (the temperature to shutoff the compressor). Press the Set button for 1 second until L is displayed Release Set and the setpoint temperature will be displayed. Use the arrow buttons to select the setpoint temperature. Then press the Set button to confirm and record the setpoint.

3. Configure the differential and select the function as cooling or heating (only cooling is valid and this is the factory setting). Press the Up and Down arrow buttons at the same time and hold for 5 seconds until **dif** is displayed on the thermostat. Release both buttons and then use the arrow buttons to select the differential temperature. Then press the Set button to confirm and continue to select the function which should now be displayed as Col or Hot. Use the arrow buttons to select Col. Then press the Set button to confirm.

This completes the configuration of the digital thermostat.

Wiring Tables

This section provides tables for wire dimensions, optional compressor speed control resistor values, optional battery voltage protection resistor values, and LED operational error codes.

WIRE DIMENSIONS

Wire Size		Max Length*			
AWG	Cross Section (mm)²	12 volt		24 volt	
		feet	meters	feet	meters
12	2.5	8	2.5	16	5
12	4	13	4	26	8
10	6	20	6	39	12
8	10	33	10	66	20

BD35F and BD50F

Fuse or Breaker Size	
12 volt	24 volt
15 Amps	7.5 Amps

Wire Size		Max Length*			
AWG	Cross Section (mm)²	12 volt		24 volt	
		feet	meters	feet	meters
10	6	8	2.5	16	5

BD80F

Fuse or Breaker Size	
12 volt	24 volt
30 Amps	15 Amps

* Round trip length between battery and compressor electronic control unit.

OPTIONAL COMPRESSOR SPEED CONTROL RESISTOR (R1) VALUES

Compressor Model	Electronic Unit	Resistor (R1) (Ω)	Motor Speed (RPM)
BD35F and BD 0F	101N0210 101N0220 101N0500	0	2000
		277	2500
		692	3000
BD50F ONLY	101N0230	1523	3500
BD35F and BD 0F	101N0300 with AEO	0	AEO
		173	2000
		450	2500
		865	3000
		1696	3500
BD80F ONLY	101N0280 with AEO	0	AEO
		203	2500
		451	3100
		867	3800
		1700	4400

Resistor is to be connected in series with the thermostat between "T" and "C".

OPTIONAL BATTERY VOLTAGE PROTECTION RESISTOR (R2) VALUES

For Danfoss BD35F, BD50F and BD80F compressors						
Resistor (R2) [kΩ]	12V cut-out [V]	12V cut-in [V]	12V max. Voltage	24V cut-out [V]	24V cut-in [V]	24V max. Voltage
0	9.6	10.9	17.0	21.3	22.7	31.5
1.6	9.7	11.0	17.0	21.5	22.9	31.5
2.4	9.9	11.1	17.0	21.8	23.2	31.5
3.6	10.0	11.3	17.0	22.0	23.4	31.5
4.7	10.1	11.4	17.0	22.3	23.7	31.5
6.2	10.2	11.5	17.0	22.5	23.9	31.5
8.2	10.4	11.7	17.0	22.8	24.2	31.5
11	10.5	11.8	17.0	23.0	24.5	31.5
14	10.6	11.9	17.0	23.3	24.7	31.5
18	10.8	12.0	17.0	23.6	25.0	31.5
24	10.9	12.2	17.0	23.8	25.2	31.5
33	11.0	12.3	17.0	24.1	25.5	31.5
47	11.1	12.4	17.0	24.3	25.7	31.5
82	11.3	12.5	17.0	24.6	26.0	31.5
220	9.6	10.9				31.5
no connection	10.4	11.7	17.0	22.8	24.2	31.5

Resistor is to be connected between "P" and "C".

OPTIONAL LED OPERATIONAL ERROR CODES

Number of Flashes	Error Type
5	Thermal cut-out of electronic unit (If the refrigeration system has been too heavily loaded, or if the ambient temperature is high; the electronic unit will run too hot).
4	Minimum motor speed error (If the refrigeration system is too heavily loaded, the motor cannot maintain minimum speed at approximately *1,850 rpm). *BD80F=2,450
3	Motor start error (The rotor is blocked or the differential pressure in the refrigeration system is too high (>5 bar)).
2	Fan over-current cut-out (The fan loads the electronic unit with more than 1A peak).
1	Battery protection cut-out (The voltage is outside the cutout setting).

Diode is to be connected between "D" and "+". Observe proper diode polarity.

RParts
DIY Kits Warranty

LIMITED WARRANTY

RParts DIY kits are warranted with the following conditions.

The warranty covers defects in materials and workmanship of kit components for a period of 6 months from the date of purchase. The warranty is limited to the actual cost of the defective component(s) and does not include coverage for any labor cost incurred in the removal or reinstallation of such component(s). Warranted component(s) shall be repaired or replaced at the sole discretion of the manufacturer. Shipping costs are not included.

This warranty does not include failure due to:

- improper installation
- abuse, misuse or improper maintenance
- rust/corrosion due to water exposure

Components expressly excluded from this warranty are:

- Danfoss power module
- Sea water pump

RParts shall not be liable for consequential damages resulting from the use of this product. Coverage for any incidental damage to vessel, equipment or supplies caused, either directly or indirectly, by the failure of any RParts component is specifically excluded. This warranty is valid only for components included with the kits and does not include RParts equipment or components of other manufacturers used in conjunction with the kits. The coverage herein described constitutes the whole, no other warranty written or verbal is authorized.

To obtain warranty service, obtain a return merchandise authorization (RMA) by sending an email to rma@rparts.com. When making a warranty claim, be sure to detail the problem encountered and include evidence of purchase date along with the order number, your name, address and telephone number.