TWIN-TURBINE CENTRIFUGAL COMPRESSOR

MODEL TT-300/TT-400

INSTALLATION AND OPERATION MANUAL

Danfoss Turbocor Compressors Inc.

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Proprietary Notice

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List of Acronyms

BMCC	Bearing Motor Compressor Controller
CSA	Canadian Standards Association
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EXV	electronic expansion valve
IGBT	insulated gate bipolar transistor
IGV	inlet guide vane
LED	light emitting diode
NTC	negative temperature coefficient
PCB	printed circuit board
PWM	pulse width modulation
SCR	silicon-controlled rectifier
UL	Underwriters Laboratories

Contents

Introduction

The purpose of this manual is to inform contractors, and original equipment manufacturers (OEMs) and their engineers of the recommended methods of installation and operation for the Danfoss Turbocor twin-turbine centrifugal compressor.

Tools

The following table lists the hand tools required to perform the procedures outlined in this manual.

Service Tools/Test Equipment:	
• T25 Torx bit and driver	• Precision slotted screwdriver
• 16mm, 17mm sockets and driver	• Phillips #2 screwdriver
• 14 mm deep sockets and driver	• Multimeter (600V) with ammeter clamp
• 13mm, 24mm combination wrenches	• Voltmeter
• Adjustable 14” wrench	• Level
• Torque wrenches - 200 in-lbs (22 Nm), 55 ft-lbs (75 Nm)	

Safety Precautions

Safety precautions must be observed during installation, start-up, and service of the compressor due to the presence of refrigerant charge and high voltage hazards.
Only qualified personnel should install, start up, and service this equipment.

Safety Guidelines

⚠ CAUTION

Compressor is pressurized with nitrogen to 25 psi. Pressure must be relieved through the Schrader valve on the compressor end cap prior to removing the blanking plates.

⚠ DANGER

This equipment contains hazardous voltages that can cause injury or death. Only qualified personnel should work on high-voltage electrical equipment.

Disconnect and lockout incoming electrical power before attempting installation or service of the equipment.

When replacing a compressor, the high-voltage capacitors must be discharged before opening any of the compressor access covers. Disconnect and lockout power and then wait 10 minutes for capacitors to de-energize before removing covers. Check that there is 0V between the + and - DC bus bars before touching any compressor parts.

Installation

Unpacking and Inspection

When unpacking the unit, carefully inspect it for visible signs of damage. Check for damaged / broken wires and loose bolts. Any damage should be reported to Danfoss Turbocor and the shipping company immediately. Damage should be specified on the waybill or transportation/freight forwarder documentation. Open all containers and verify all parts against the packing list. Report any shortages to Danfoss Turbocor.

Rigging Requirements

Care must be exercised at all times when rigging or handling the compressor to protect it from damage. Two eyebolts (one at each end) are provided for compressor rigging.

A spreader bar should be used to safely position the compressor into its final location. The rigging set-up is shown in Figure 1.

Figure 1 Rigging Set-up

Unit Placement

1. If mounting the compressor with the Danfoss Turbocor mounting kit, refer to “Appendix A Mounting Kit Instructions”; if not, install four isolation pads in accordance with the footprint dimensions given in Figure 2.
2. Mount the compressor onto the isolation pads. Ensure that the compressor mounting rails are properly isolated from the base frame once the attaching hardware is secured, i.e., the screw should not extend from the compressor mounting rails to the base frame; See Figure 3 and Figure 4
3. Check that the compressor mounting rails are level ± 3/16” (5mm) in the lateral and longitudinal planes.

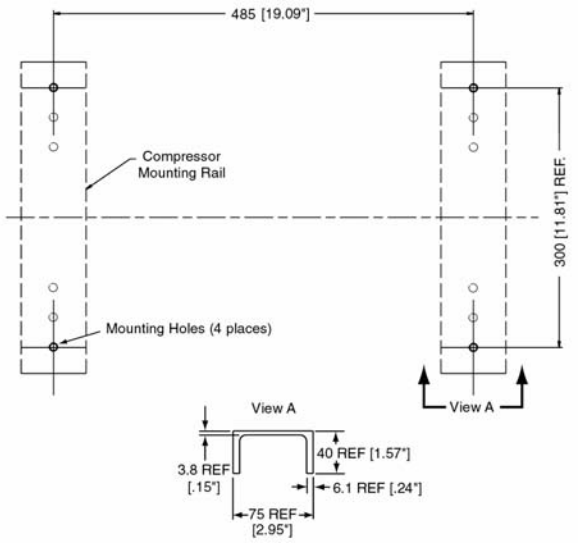


Figure 2 Mounting Details

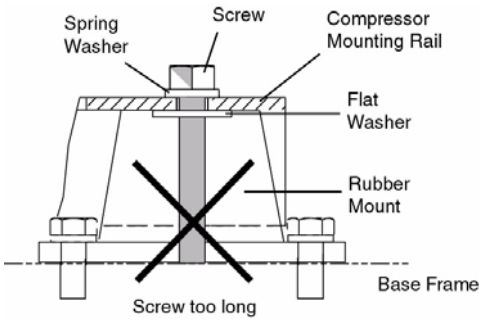


Figure 3 Incorrect Compressor Mounting Pad Installation

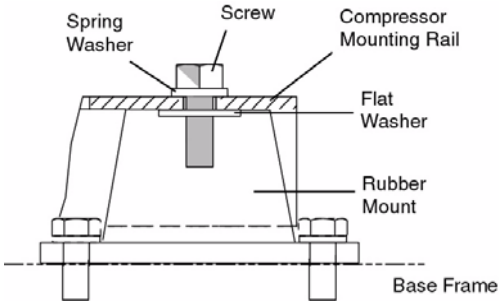


Figure 4 Correct Compressor Mounting Pad Installation

Piping Connections

⚠ WARNING

Install new o-rings when attaching the ball valves, non-return valves, or flanges to the compressor.

O-rings must be of type polychloroprene rubber (also known by the tradename Neoprene, compound # C1278 for R22/R134A refrigerant). O-ring grease must be silicone based and compatible with R134A or R22, as applicable.

Install a strainer in the suction line to prevent the ingress of foreign particles into the compressor.

⚠ WARNING

The motor-cooling line should be channeled from the liquid line; refer to Figure 5. The motor cooling port is equipped with an integral strainer to protect the cooling circuit from blockage. The motor-cooling line requires the installation of a service valve (not included) to enable refrigerant isolation during compressor servicing. For motor-cooling piping details, refer to paragraph 1.12 in “Appendix D: System Design Guidelines (R134a)”of the Application manual.

⚠ CAUTION

Compressor is pressurized with nitrogen to 25 psi (173 kPa) Pressure should be relieved through the Schrader valve on the compressor end cap prior to removing the blanking plates; refer to Figure 6.

1. Remove the blanking plates from the new compressor.
2. Check that the flange surfaces are clean and free from debris.
3. Attach the suction, discharge, and economizer (if applicable) valves according to the valve kit instructions in “Appendix B Valve/Flange Kit Installation Instructions”.

⚠ WARNING

Ensure that the discharge line is fitted with a non-return valve. During a surge condition or shutdown, the non-return valve prevents reverse flow into the discharge port which can cause damage to compressor components.
Dry-fit the pipework to the valves and verify that the connections are aligned and there is no strain on the joints.

4. Solder all joints according to approved practice ensuring that dry nitrogen is used at all times.
5. Attach the motor cooling connection at the rear of the compressor. Refer to Figure 6 for location.

6. Install a strainer in the suction line. It should be located between the compressor and the service valve, as close as possible to the suction port of the compressor.
7. Perform a leak test in accordance with industry standards.

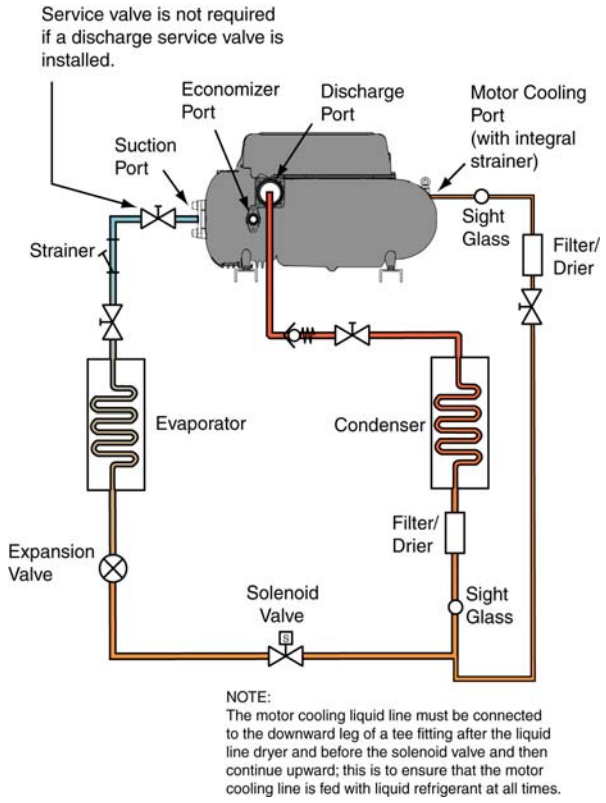


Figure 5 Typical Refrigeration Schematic

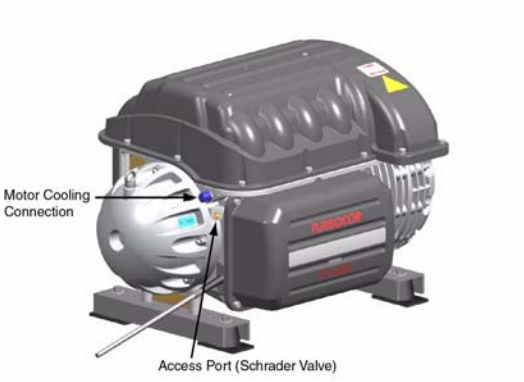


Figure 6 Motor Cooling Connection and Access Port

Control Wiring

The Compressor Interface module and associated cable enable communication of control and status signals between the compressor controller and external equipment. These signals include, amongst others, cooling demand, level sensor outputs, pressure/temperature sensor outputs, and expansion valve control loops.

Compressor Interface Module - Mounting Instructions

The Compressor Interface module (Figure 7) is designed to be installed on DIN EN 50022, 50035, or 50045 mounting rails. Using the module profile shown in Figure 8 as a guide, install the left foot of the module into the rail and press the right side of the module down until it engages the rail.

Control Wiring Connections

Figure 9 shows the control wiring connections to the Compressor Interface module. Table 1 provides details for the module pinouts.

⚠ WARNING

Ensure that the control wiring is attached to the appropriate terminals on the Compressor Interface module. Incorrect wiring of the terminals can severely damage the module and other components.

The Interface cable interconnects the compressor to the Compressor Interface module. For RS485 communication, the total length of the Interface cable and control wiring can be extended up to 100 meters (328 feet); refer to Figure 10. However, if the compressor is going to be monitored over an RS232 line, the total cable length between the compressor and the PC should not exceed 15 meters (50 feet). To connect the cable, plug the cable connector into connector J6 on the Interface module.

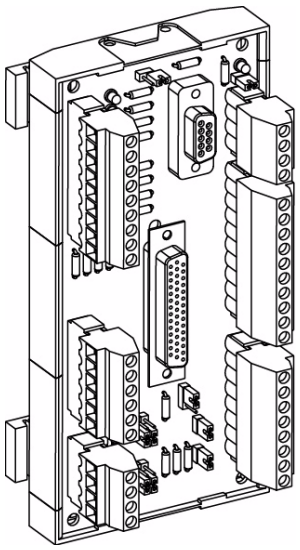
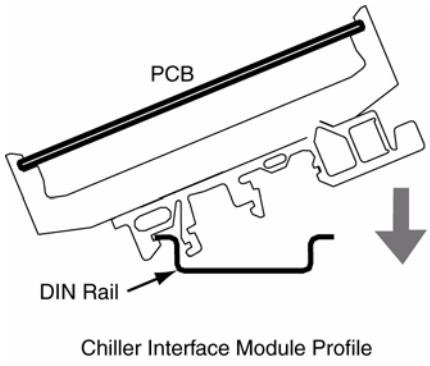


Figure 7 Interface Module



Chiller Interface Module Profile

Figure 8 Interface Module Installation

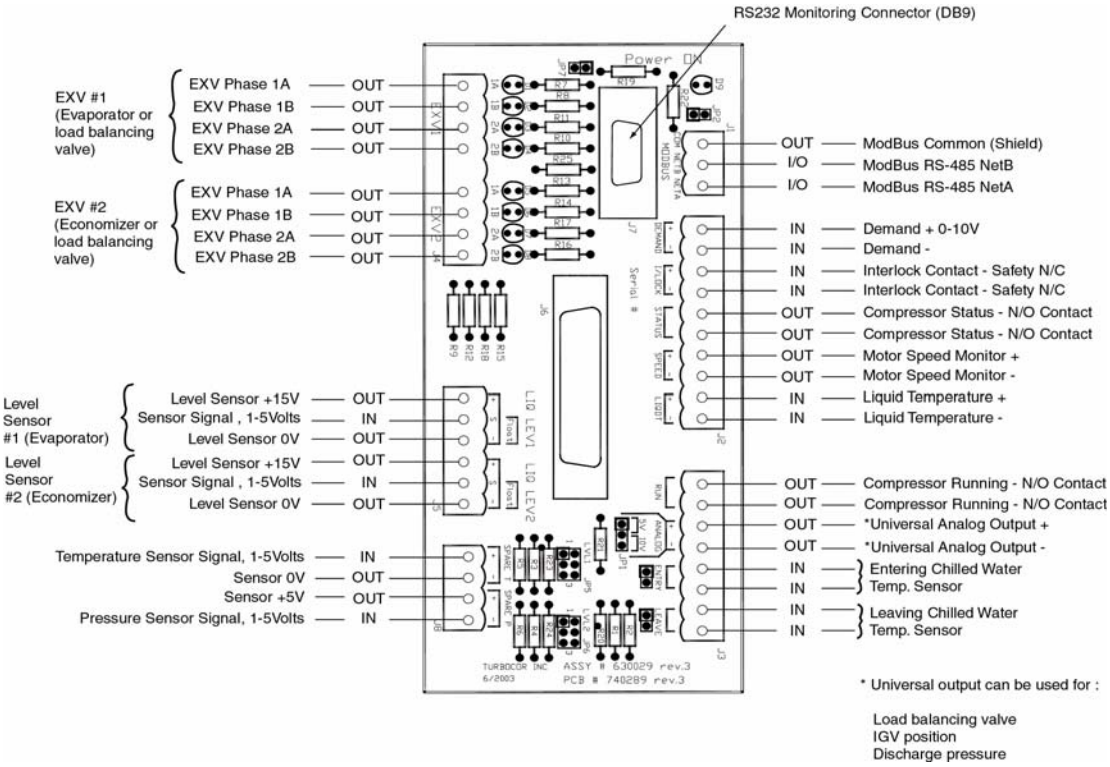


Figure 9 Typical Control Wiring

Table 1 Control Wiring Details

I/O	Description
COM (shield)	Shield for RS-485 communication.
ModBus RS-485 NetB/NetA	ModBus over RS-485 communication port.
EXV Phase 1A, 1B, 2A, 2B (Evaporator)	Optional output connections for controlling the main electronic expansion valve (evaporator).
EXV Phase 1A, 1B, 2A, 2B (Economizer)	Optional output connections for controlling the auxiliary electronic expansion valve (economizer or load balancing valve).
Level Sensor +15V (Evaporator)	Power supply for level sensor #1.
Sensor Signal (Evaporator)	Input from a level sensor to control the main expansion valve (evaporator).
Level Sensor +15V (Economizer)	Power supply for level sensor #2.
Sensor Signal (Economizer)	Input from a level sensor to control the auxiliary expansion valve (economizer).
Demand 0 - 10V	Analog input from customer-supplied controller to drive the compressor, i.e., 0 - max. kW input for the respective compressor model.
Interlock	Connects to a set of external N/C contacts that typically open in the event of loss of chilled water or air flow.
Status	An internal N/O contact that is closed during normal operation and opens in the event of a compressor fault. With circuit open, compressor will not restart until demand signal has been reset to 0 (via chiller/unit controller). Circuit rated at 1A @ 30 VDC/ 24VAC.
Motor Speed Monitor	Analog output indicating compressor RPM. 0 to 5.0V = 0 to 50,000 RPM.
Liquid Temperature	Reserved for future use.
Run	An internal N/O contact that is closed while the compressor is running. The speed at which the contact closes is user-configurable via the monitor program. Circuit rated at 1A @ 30 VDC/24VAC.
Analog	Universal analog output for load balancing valve, IGV position, or discharge prerssure. Operating range can be set to 0-5V or 0-10V via onboard jumpers.
Entering Chilled Water Temp.	Analog input indicating water temperature. The temperature sensor must be an NTC type 10K @ 25°C thermistor. Refer to the Application manual for thermistor specification..
Leaving Chilled Water Temp.	Analog input indicating water temperature. The temperature sensor must be an NTC type 10K @ 25°C thermistor. Refer to the Application manual for thermistor specification.
Spare T +/-	Reserved for future use. Refer to the Application manual for thermistor specification.
Spare P +/-	Reserved for future use.

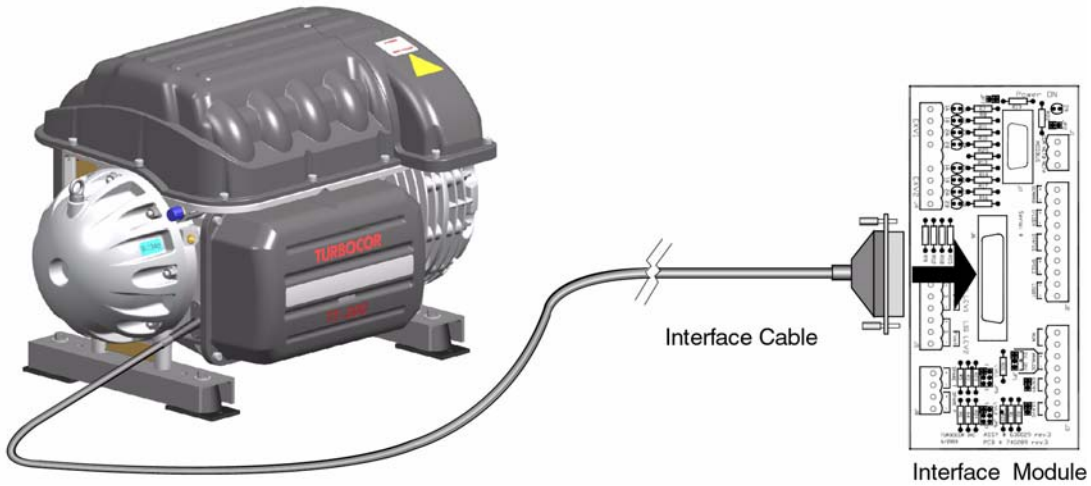


Figure 10 Compressor I/O Connections

Circuit Grounding

Improper grounding or voltage in circuits connected to the Compressor Interface Module can lead to component failures. In particular, the Interlock and analog output circuits are sensitive to improperly connected external circuits. See Figure 11.

Prior to connecting the control wiring to the Compressor Interface Module, check for improper grounding. Improper grounding can be identified by measuring the voltage between the customer's negative terminals and the ground (J1 COM) terminal on the Compressor Interface Module; refer to Figure 12. If the measured voltage is not zero, verify the source of the voltage. The most likely cause of voltage is insufficient insulation of the external circuit. In case of uncertainty of the grounding, connect the negative terminals of the external circuit to ground and then connect the external ground to the ground on the Compressor Interface Module.

Voltage-free Contacts

(Refer to Figure 13)

Prior to connecting the Interlock terminals of the Compressor Interface Module, measure the resistance across the customer's interlock terminals. Ensure that the interlock contacts are closed. The measured value should be less than 1 ohm.

Measure the voltage between each customer interlock terminal and the frame ground while the interlock contacts are open and closed. In either contact state, if the measured voltage is not zero, verify the source of the voltage. Do not connect the Interlock terminals until the voltage source is removed.

Control Wiring Connection Guidelines

To ensure proper control wiring techniques, follow these guidelines:

1. The ground reference of the external circuit connected to the Compressor Interface Module must be at the same potential as the ground reference on the Compressor Interface Module.
2. The Interlock circuit should be voltage-free, i.e., all external contactors/switches must not introduce current into the circuit.
3. Analog outputs (such as Motor Speed) must be received by the external circuit without sending current back to the Compressor Interface Module.
4. All interlock and analog output cables should be shielded with one end of the shield connected to the Compressor Interface Module ground. The other end of the shield must not be grounded as this would create a ground loop.

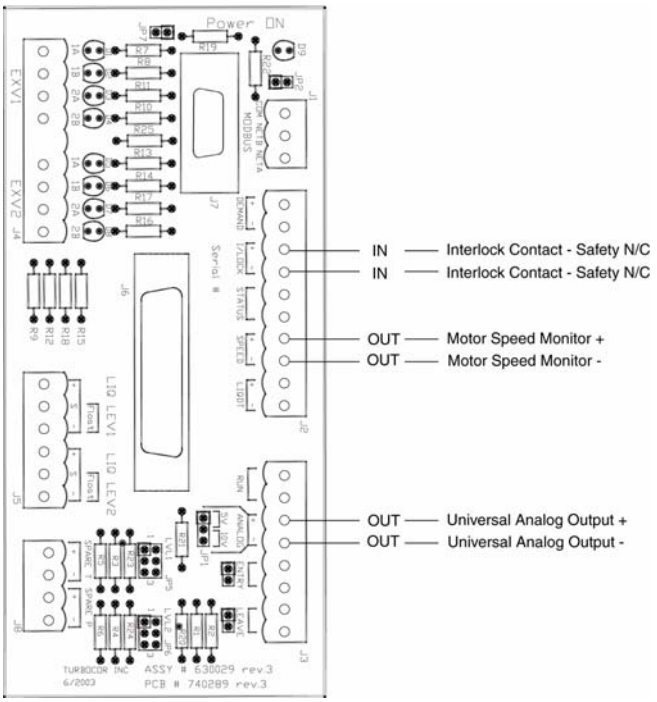


Figure 11 Interlock and Motor Speed Connections

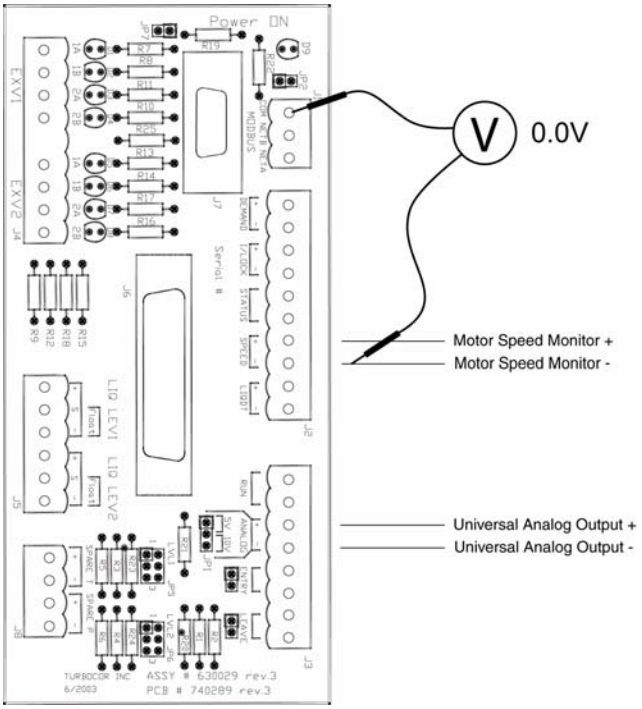


Figure 12 Analog Output Test

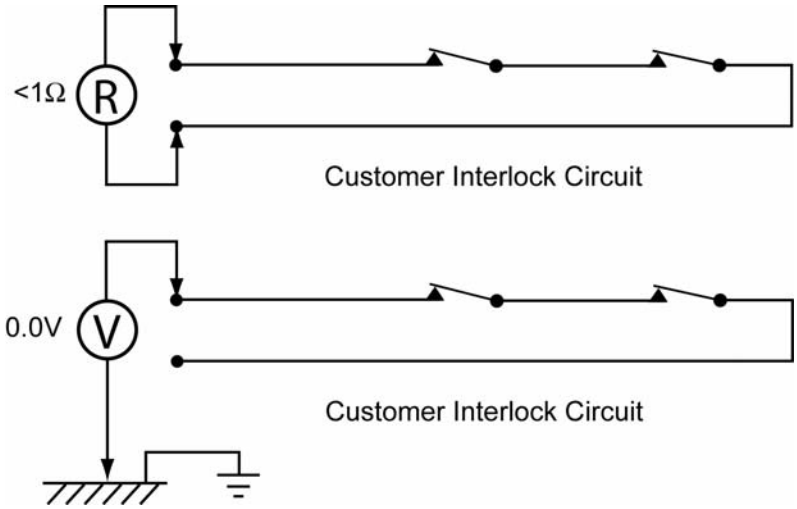


Figure 13 Interlock Circuit Tests

Power Wiring

This section describes the connection of the power wiring to the compressor.

NOTE:
The AC input cable should be CSA, UL, or CE approved, 3-wire with a common shield and single ground. It is recommended that the cable be double-jacketed, i.e., teck cable type. The cable must be rated for 90° C (194° F) minimum with a maximum current rating corresponding to the LRA value on the compressor nameplate.

Keep power cables and interface cables separate. Use metal cable glands for shielded cables.

If you are installing a Danfoss Turbocor line reactor, or EMI or harmonic filter in the mains input circuit, refer to the applicable installation instructions in “Appendix C Power Line Accessories Installation”.

Figure 14 shows a typical schematic for the compressor’s electrical connections.

1. Using a T25 Torx bit and driver, release the four captive screws that secure the mains input cover to the compressor. Lift away cover.
2. Insert a cable gland (customer-supplied) into the opening in the mains input bracket.
3. Fasten the cable gland to the bracket with the locknut.
4. Feed the AC input cable through the cable gland.
5. Attach the three terminal lugs to the compressor terminal studs as follows: (refer to Figure 15 and Figure 16.)

   Slide the terminal lug over the terminal stud so that it is in contact with the bus bar. Fasten the terminal lug with a flat washer, spring washer and nut. Tighten the terminal nuts to 192 in-lbs (21.7 Nm) using a 14 mm deep socket.
6. Attach the ground cable to the ground post on the compressor housing.
7. Attach and secure the ground nut to the ground post using a 13 mm combination wrench. Refer to Figure 17.
8. Tighten the gland nut to secure the cable to the mains input bracket.
9. Replace the mains input cover and secure it using four screws. Tighten the screws to 62 in-lbs (7 Nm).

Upon completion of the installation procedures, the next step is to commission the compressor. Refer to the next section.

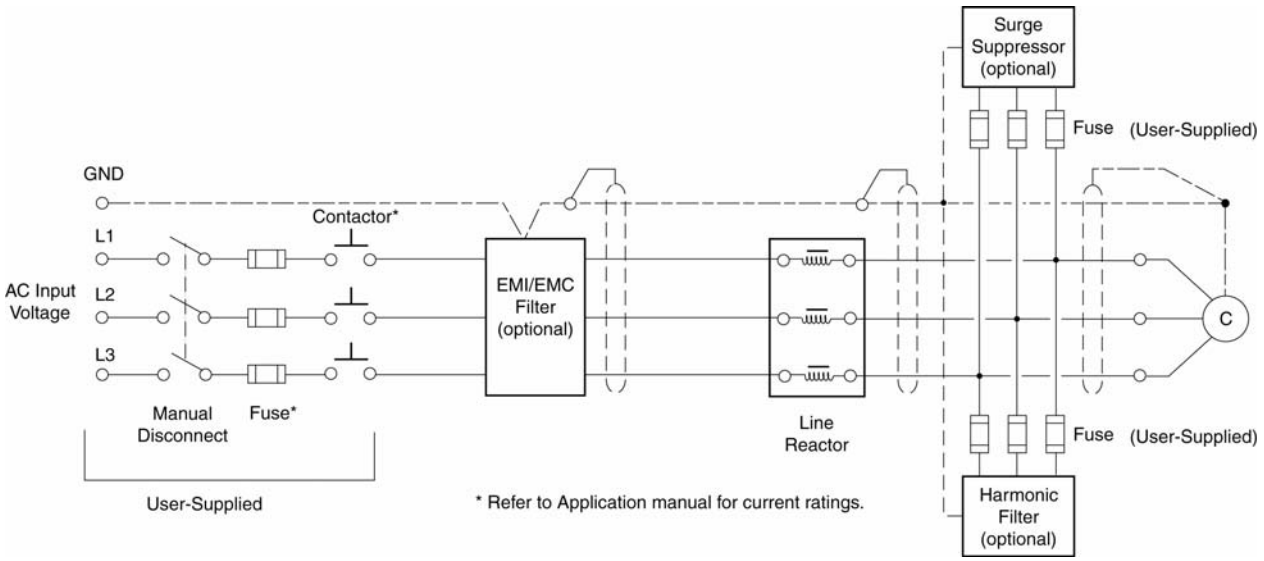


Figure 14 Typical Electrical Connections

Figure 15 Compressor AC Input Connections

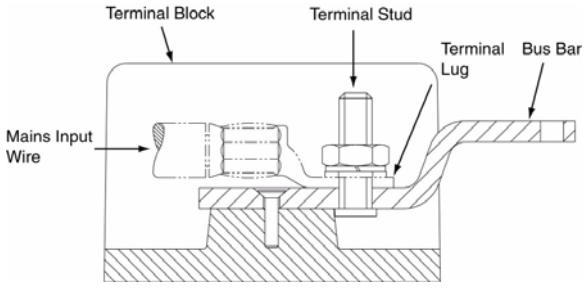


Figure 16 TT300 Terminal Connection Details

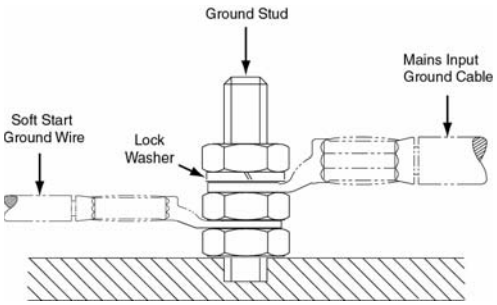


Figure 17 Ground Connection Details

Commissioning

The commissioning of the compressor is organized into three principal tasks:

1. Setting the I/O jumpers and performing initial checks.
2. Configuring the compressor via the Monitor Program.
3. Performing running checks

I/O Jumper Setup and Initial Checks

This section details the I/O jumper settings and the initial system checks.

Service Tools/Test Equipment:

- T25 Torx bit and driver
- Multimeter with ammeter clamp
- Precision slotted screwdriver
- 14mm deep socket and driver

I/O Jumper Settings

Check and set, if necessary, the jumpers on the Compressor Interface module as per application requirements; refer to Table 2 for details.

For all inputs that are not connected, install its associated jumper (For level sensors, install the jumpers between pins 2a and 3a, and pins 2b and 3b). Refer to Figure 18.

Table 2 Jumper Details

Jumper	Function and Set-up
JP1	Determines the operating voltage range (0-5V or 0-10V) of the ANALOG output. Set the jumper to the appropriate range.
JP2	ModBus termination jumper. Install the jumper if the ModBus connection is at the end of a run.
ENTRY	Install the jumper if there is no temperature sensor connected to the Entering Chilled Water analog input.
LEAVE	Install the jumper if there is no temperature sensor connected to the Leaving Chilled Water analog input.
JP5/ JP6	Jumpers J5 and J6 are used to match the characteristics of the liquid level sensors. **Voltage-type Level Sensor** - If using a voltage-type sensor with 15V supply and 0-5V signal, install jumpers between LVL pins 2a and 3a, and pins 2b and 3b. Connect the sensor leads to the +, S, and - terminals on the Interface module. Consult vendor documentation for sensor lead identification. **Resistive-type Float Sensor -** If using a resistive-type sensor, install jumpers between LVL pins 1a and 2a, and pins 1b and 2b. Connect the sensor leads to the - and S terminals on the Interface module. **Superheat Control** - For superheat control (adjustable via the compressor control monitoring program), install jumpers between LVL pins 2a and 3a, and pins 2b and 3b.
JP7	Reserved for future development. Jumper should remain off.

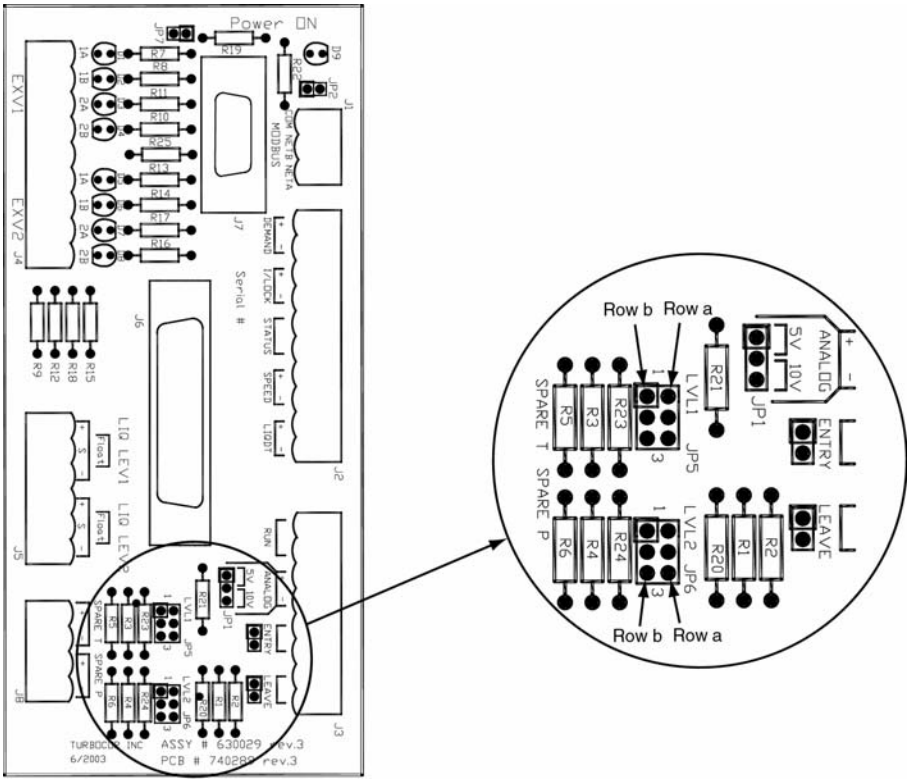


Figure 18 I/O Jumper Location

System Checks

This section covers the initial system checks.

Table 3 Initial Checks - Compressor OFF

Step	Procedure
	Verify the following:
1.	Compressor is powered OFF.
2.	Compressor is level ± 3/16” (5mm).
3.	External pipework is adequately supported and aligned to the compressor ports.
4.	Adequate service clearance around the unit.
5.	Electrical power and control wiring are connected in accordance with Danfoss Turbocor specifications and application requirements.
6.	Safety switches (OEM supplied) are connected to the interlock circuit and all contacts are closed.

Table 3 Initial Checks - Compressor OFF

Step	Procedure
7.	System was leak-tested, evacuated, and charged with refrigerant in accordance with industry standards.
8.	Compressor Interface module terminals are tight.
9.	Isolate mains power. Remove the top and mains input covers. Check that the mains input terminals and all mounting screws (DC bus, SCR, etc.) are tight. Replace the mains input and top covers. Refer to Figure 19.
10.	Remove the service-side cover. Check that all modules and cable connectors are secure. Check that the PWM module's heatsink mounting screws are tight and that the heatsink is firmly seated against the main compressor housing. Refer to Figure 19.
11.	Remove any foreign particles on the compressor.
12.	Continue the steps in Table 4.

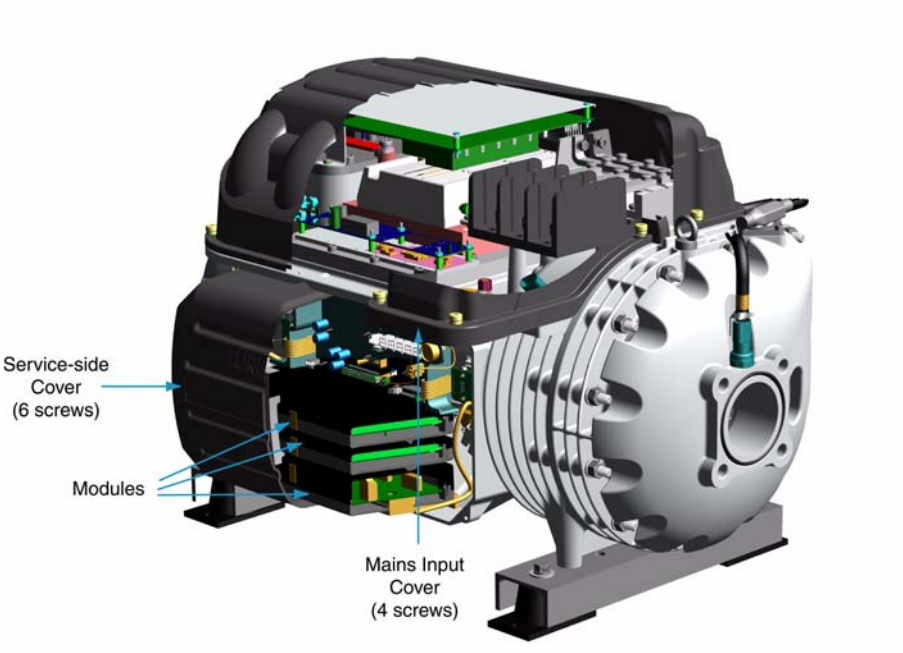


Figure 19 TT300 Compressor Details

Table 4 Initial Checks - Compressor ON

1.	Check that chiller/unit controller is in OFF mode before the mains power is switched on to the compressor. **Verify that the demand input to the compressor is zero.**
2.	Switch ON mains power.
3.	On the backplane, check the status of the following LEDs: (Refer to Figure 20.) 5V - illuminated 15V - illuminated 17V - illuminated 24V - illuminated
4.	Check that all DC voltages on the backplane are within the specified range, as follows: **P/S:** **Range:** +5V 4.9 - 5.1V +15V 14.7 - 15.6V +17V 16.6 - 17.5V (measured with respect to -HV) +24V 23.7 - 24.5V +250V 250 - 270V -15V -14.6 - 15.7V
5.	Replace the service-side cover.

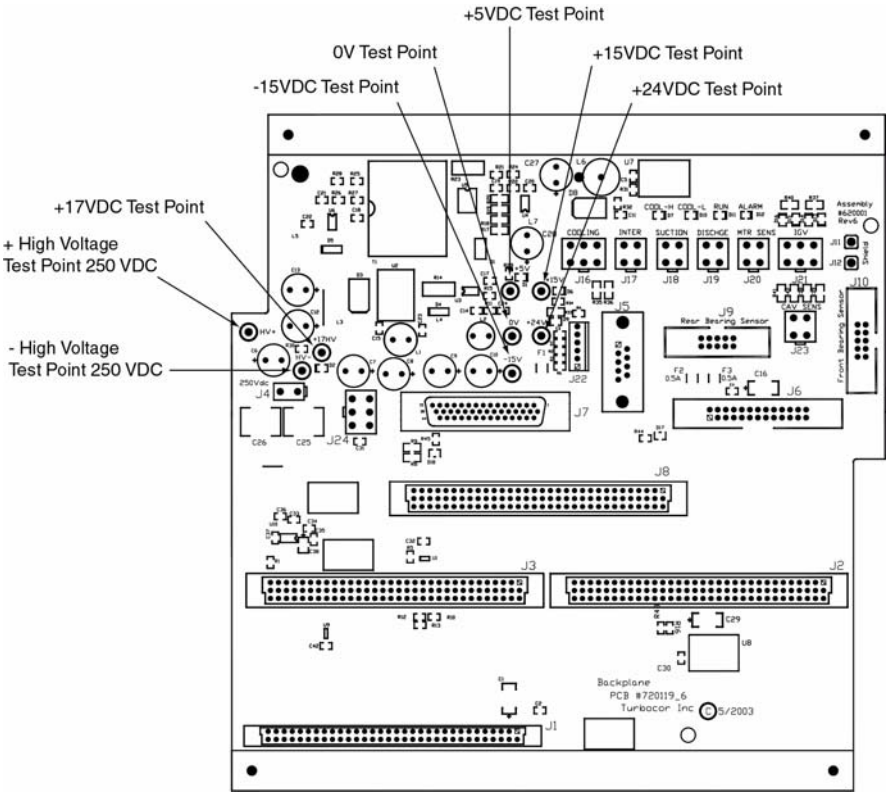


Figure 20 Backplane Test Points

Compressor Configuration

This section describes compressor configuration using the Monitor Program. Installation and operation of the Monitor Program are also covered.

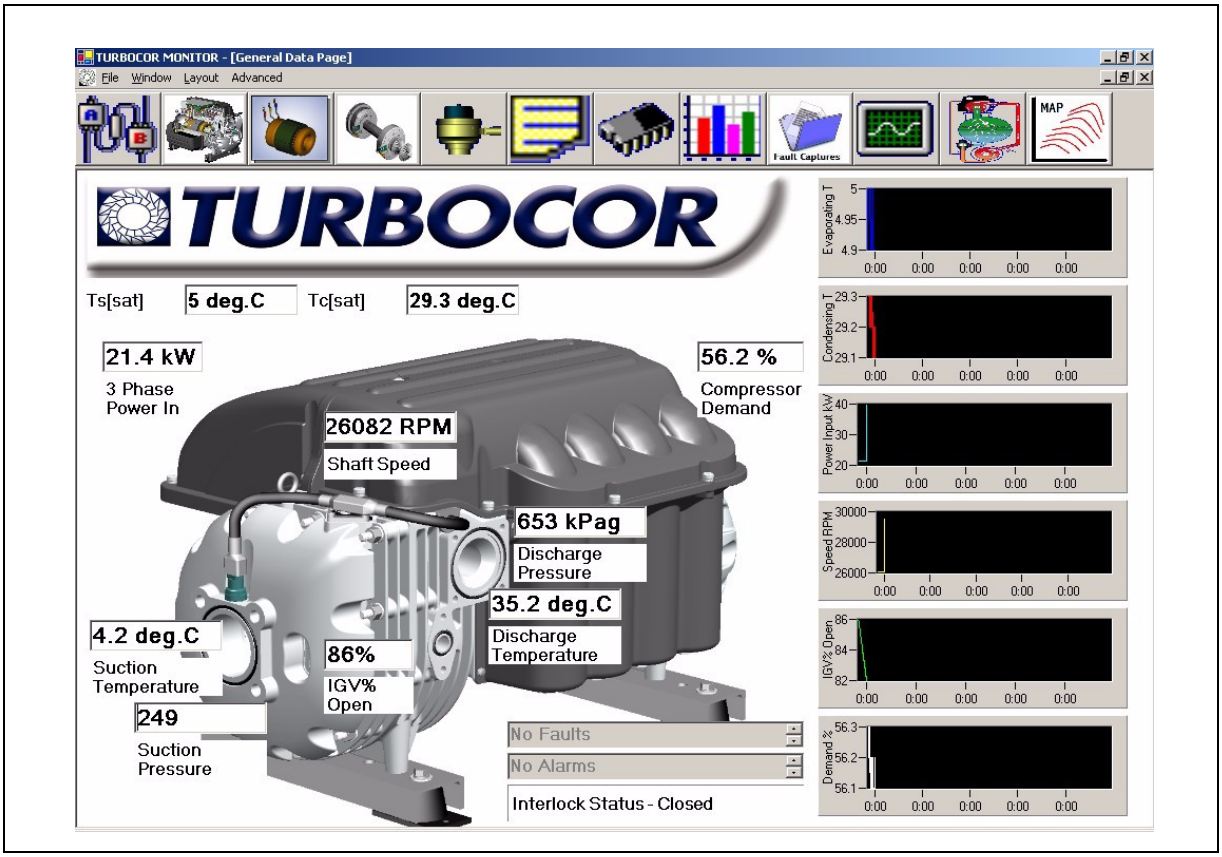


Figure 21 Compressor General Data Page (metric display)

System Requirements

The monitor program must be installed on a PC that meets the minimum requirements specified in Table 5. For optimum performance, a 533 MHz Pentium or higher CPU with 128 MB RAM running Windows 2000 (SP4) or XP is recommended.

The monitor program was developed for the .NET Framework and requires the .NET Framework to be installed on the PC where the program runs. Microsoft provides a redistributable installer, Dotnetfx.exe, that contains the common language runtime and .NET Framework components that are necessary to run the monitor program. Before installing the monitor program, the .net framework 1.1 redistributable must be installed. This can be downloaded from the Microsoft website.

The latest Windows service packs and security updates should also be installed on the PC.

Table 5: Minimum Requirements

Processor	133-MHz Intel Pentium-class processor
Operating System	The .NET Framework 1.1 Redistributable is supported on the following platforms: • Microsoft Windows® Server 2003 (.NET Framework 1.1 is installed as part of the operating system) • Windows XP Professional • Windows XP Home Edition • Windows 2000 • Windows Millennium Edition (Windows Me) • Windows 98 • Microsoft Windows NT® 4.0 Service Pack 6a The .NET Framework 1.1 Redistributable cannot be installed on 64-bit computers; Windows NT 4.0 Terminal Server is not supported
Memory	128 MB of RAM, 256 MB recommended
Hard Disk	110 MB of hard disk space required, 40 MB additional hard disk space required for installation (150 MB total)
Display	800 x 600 or higher-resolution display with 256 colors
Input Device	Microsoft mouse or compatible pointing device
Other	Install the latest Windows service packs and critical updates from the Windows Update site. Installation of the .NET Framework 1.1 is split into two parts: the core and language packs. The core contains everything you need to run .NET Framework applications; all dialog boxes and error messages will be in English. If you want dialog boxes and error messages in another language, you must also install the corresponding language pack. For more information, see the .NET Framework Downloads page.

Cable Connection

The monitoring program communicates with the compressor via the Modbus* protocol using either the RS232 or RS485 connection at the Compressor Interface module. RS485 communication requires an RS485/RS232 adapter (user-supplied). RS232 communication is recommended for cable lengths not exceeding 15 meters (50 feet) between the PC and compressor. For cable runs up to 100 meters (328 feet), use the RS485 communication line. Always use shielded, twisted-pair cable for data communications.

*The Modbus protocol was originally developed to exchange information between products on the factory floor. This protocol has become a de facto standard for exchanging data and control between PLC systems. Modbus is a registered trademark of Modicon Corp.

RS232 Connection

1. Connect one end of the RS232 cable (user-supplied) to the DB9 connector on the Compressor Interface module; see Figure 22.

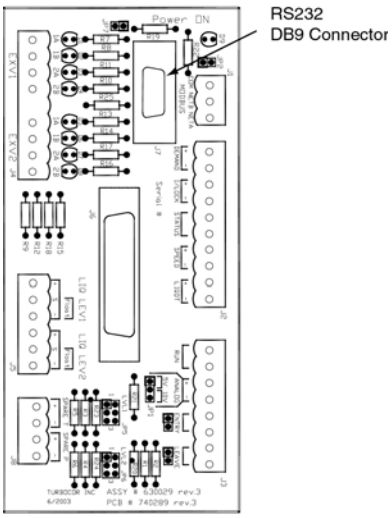


Figure 22 RS232 Connector - Compressor Interface Module

2. Connect the other end of the cable to an available COM port on the PC.

RS485 Connection

1. Connect the RS485/RS232 adapter directly onto the PC COM port
2. Connect the other side of the adapter to the Modbus. Figure 23 shows the PC and adapter connections to the Modbus for a single compressor application. Ensure that the termination jumper on the Compressor Interface module is installed.

   Figure 24 shows the PC and adapter connections to the Modbus for a multiple compressor application. In this case, set the termination jumper only on the Compressor Interface module that is connected at the end of the Modbus cable run.

Monitor Program Installation

The Monitor Program is installed on the PC and communicates with the compressor using the ModBus over a RS232 or RS485 serial link. Administrator privileges may be required to install and remove software on the PC.

NOTE:
If a previous version of the monitor program is already installed on the PC, it must be uninstalled before proceeding with the current installation. To uninstall the monitor program, from the Start menu, select Settings → Control Panel. Double-click Add/Remove Programs. From the list, select Danfoss Turbocor Service Monitoring Tool. Click the Remove button.

Installation Procedure:

1. Insert the Monitor Program CD-ROM into the drive.
2. In Windows Explorer, navigate to the Turbocor_Service_Tool_Setup.msi file. Double-click the file to launch the setup wizard.
3. Follow the instructions provided by the wizard to complete the installation.
4. Click the Close button to exit the setup wizard.

Starting the Monitor Program

To start the Monitor program: from the Start menu, select Programs →Danfoss Turbocor Monitoring Tool. The Serial Port Connection dialog box appears.

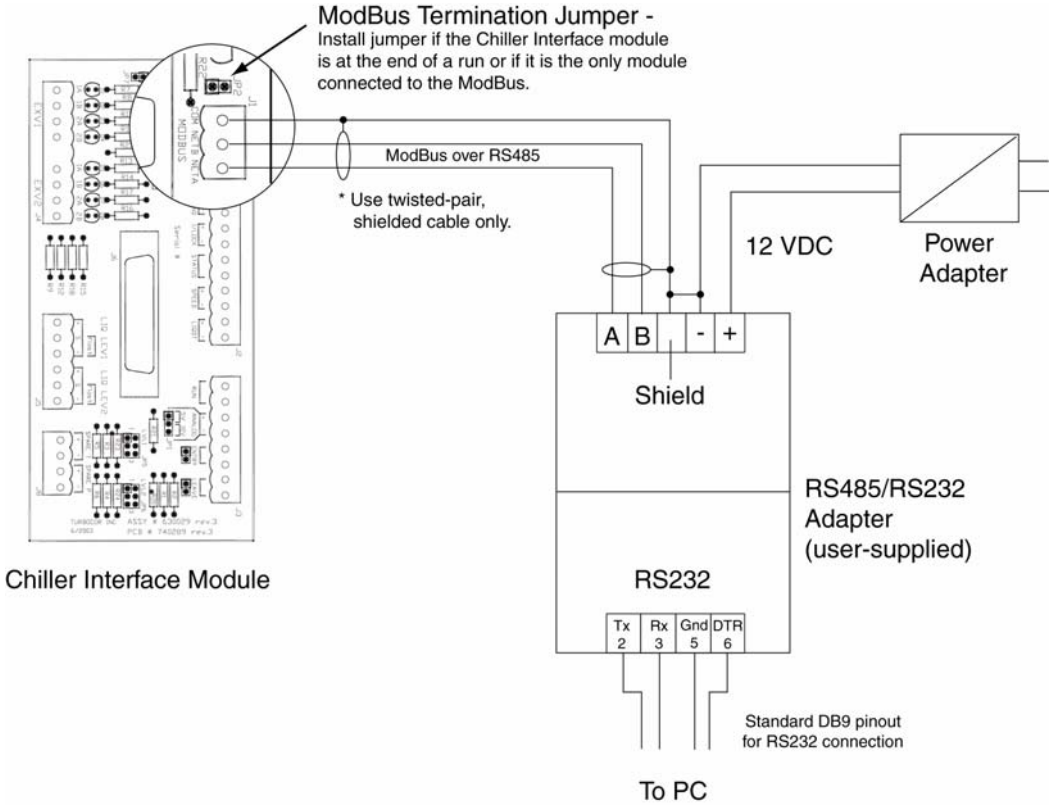


Figure 23 PC to Modbus Connection (single compressor with > 15 m (50 feet) cable length)

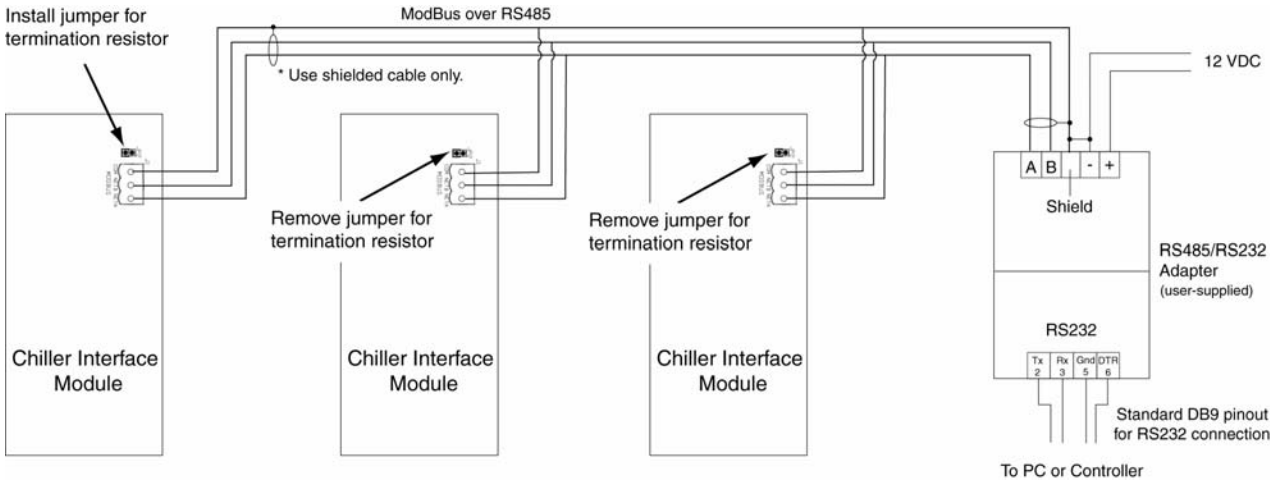


Figure 24 PC to Modbus Connection (multiple compressors with > 15 m (50 feet) cable length)

Serial Port Connection Setup

The Serial Port Connection dialog box contains fields that must be filled in order to enable communication between the monitor program and the compressor; refer to Figure 25. The following paragraphs describe the dialog box fields.

Comm Port - Serial communication port that the computer will use to connect to the compressor. Enter the COM port number such as COM1 or COM2, etc.

Baud Rate -19,200 or 38,400 baud (38,400: default)

Stop Bits - 1 or 2. (2: default)

Slave Address - 1-63. (1: default)

Access Code - The access code controls access to all settable parameters. Enter the code that corresponds to the access level you require. Refer to “Controlling User Access” on page 29 for further details.

Figure 25 Serial Port Connection Dialog Box

Once the serial port connection data has been set, click the Connect button. At this point, connection status, compressor details, and user access level appear in the right-hand pane of the dialog box. Click the “OK to start monitoring” button.

Entering User Input

When user input is required for the monitor program fields, perform the following sequence:

1. Double-click the variable field. (This activates the field for user input.)
2. Scroll or type in the new setting.
3. Press Enter. (This causes the user input to be validated.)

Compressor Configuration

The monitor program features a commissioning setup wizard to guide the user through the complete compressor configuration sequence.

To launch the commissioning setup wizard, select System Commissioning from the Advanced menu item. The introduction screen for the commissioning setup wizard appears; refer to Figure 26.

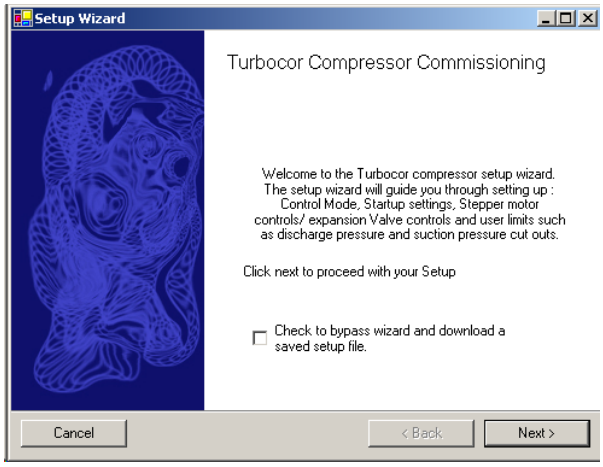


Figure 26 Commissioning Set-up Wizard

1. Click the Next button.
2. Select the appropriate units of measurement, i.e., metric or imperial. Refer to Figure 27.
3. Select the appropriate compressor control method. There are three modes available:
   - Analog Input
   - Modbus Network
   - Chiller Control

Refer to Control Modes for further details.

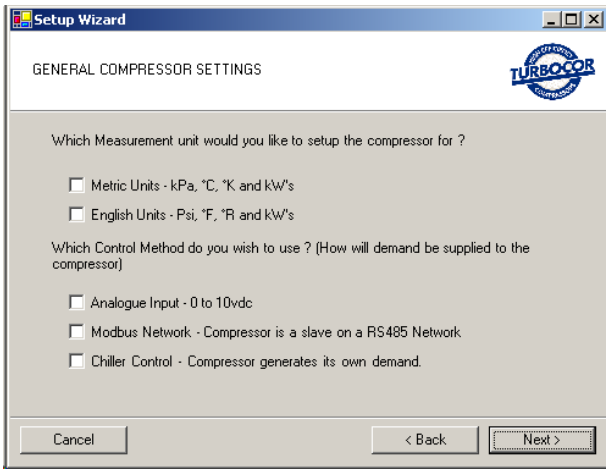


Figure 27 General Compressor Settings Form

NOTE:
If the compressor is linked to an external controller, changes made to the compressor demand via the Monitor Program can conflict with controller-issued commands. This situation can lead to unexpected results. Before testing the demand input, isolate the compressor from the controller.

4. Click the Next button.

   Steps 5 through 8 apply to the Chiller Control mode only.

5. Select the type of sensor that will control the chiller. If selecting Entering or Leaving Chiller Air/Water Temperature, connect an NTC temperature sensor (as specified in the compressor Application manual) to either the Entering- or Leaving Chilled Water temperature input on the Compressor Interface module.
6. Set the Chiller Control Set Point to the desired value.
7. Set the Proportional and Integral Gain values to obtain stable control.

NOTE:
The Integral part of the internal chiller controller is switched off until the compressor reaches a speed of 18,500 RPM. Stopping the compressor and restarting also resets the Integral part to 0.

8. Click in the Chiller Enable checkbox if you would like to have the compressor start automatically. It is advised, however, to open the interlock contact to prevent the compressor from starting before the commissioning sequence is complete.

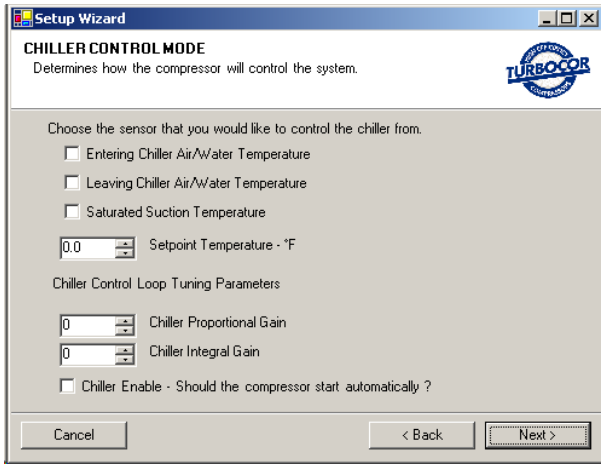


Figure 28 Chiller Control Commissioning Form

Startup Settings
(Refer to Figure 29)

1. Enter the Temporary Suction Pressure Alarm %. The alarm is set up as a % of the current suction pressure limit, e.g., if a suction pressure trip limit of 270 kPa was set and the temporary suction pressure alarm was set to 25%, the temporary suction pressure trip limit would be 67.5 kPa. This temporary alarm is only active while the suction pressure start fault delay is timing down.

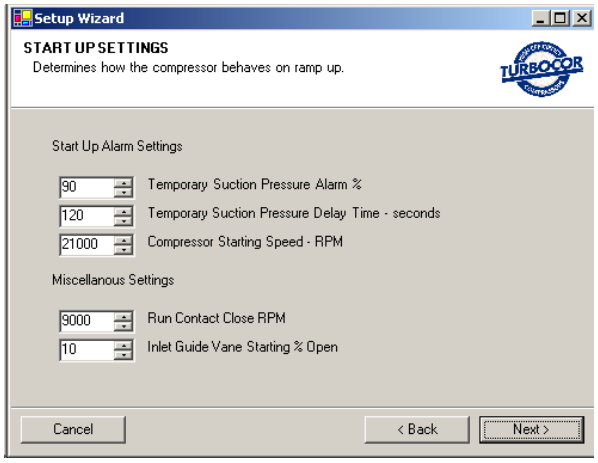


Figure 29 Startup Settings Form

2. Enter the Temporary Suction Pressure Delay Time. This parameter represents time in seconds that the temporary suction pressure alarm / fault limit should be enabled. The timer starts to count down once the shaft starts to rotate.
3. Enter the Compressor Starting Speed. If the estimated surge speed is greater than the starting speed setting, the compressor will ramp up to the surge speed. If the starting speed setting is greater than the estimated surge speed, the compressor will ramp up to the starting speed. In both cases, the compressor speed will increase at the full ramp rate.
4. Enter the Run Contact Close RPM. The compressor contains a NO relay contact that closes while the compressor is running. The speed at which the contact closes is the Run Contact Close RPM.
5. Enter the Inlet Guide Vane Starting % Open. Typically, the vanes will be set to the closed or almost closed position at startup.This is to minimize the possibilty of liquid floodback or to reduce the compressor's startup current draw.

Electronics Valve Control # 1

(Refer to Figure 30)

This section explains how to set up the expansion valves for various applications. Both valves can be operated independently or in parallel.

1. Enter the number of steps to drive the valve from fully closed to fully open. Expansion valves with different numbers of steps can be used.

⚠ WARNING

If the incorrect number of steps is selected, the valves may not have enough travel to allow the required amount of mass flow or the valve may not be able to throttle down to the required amount of mass flow. This situation could cause liquid floodback and damage to the compressor.

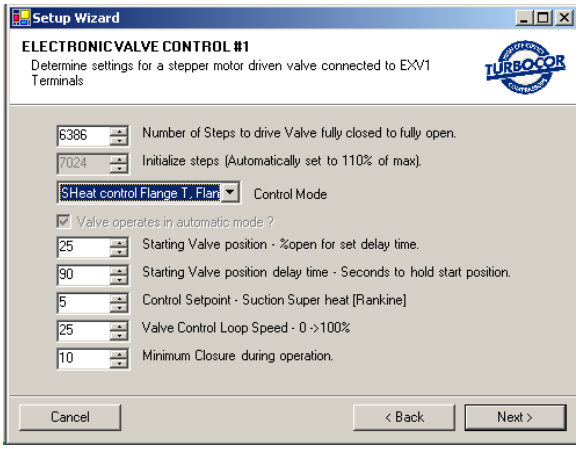


Figure 30 Electronics Valve Control Form

2. Select the control mode for the expansion valve. Available options are: superheat, liquid level, or load balance.

   The calculation of superheat can be based on the temperature and pressure measurements from one of the following sources:

- **SHeat Control Flange T, Flange P** - external suction temperature and pressure sensor (Factory-installed temp/pressure sensor should not be used for this purpose.)
- **SHeat Control, EWT, Flange P** - entering water temperature sensor (connected to the ENTRY input on the Compressor Interface module) and suction pressure sensor
- **SHeat Control LIQT, Flange P** - liquid temperature sensor (connected to the LIQD input on the Compressor Interface module) and suction pressure sensor

- **SHeat Control LIQT, Flange P** - spare temperature and pressure sensor (connected to the SPARE T and SPARE P inputs on the Compressor Interface module)

For liquid level sensing, two types of level sensors can be used:

- A level sensor with a supply of 15VDC and an output of 0-5VDC
- A resistive-type level sensor, 0-90 Ohm

Refer to vendor documentation for wiring these types of sensors to the Compressor Interface module.

The Load Balance control mode uses the compressor's own internal control algorithm to determine the best mix of speed control, inlet guide vane opening and load balance valve opening. Use this mode only if a load balancing valve is installed in the system. Since the load balancing valve is connected to the compressor's capacity control algorithm, selecting this mode without a valve installed will add a delay to the loading/ unloading process, i.e., the compressor will try to open and close the valve for 2 minutes rather than close the vane or change the speed.

3. Enter the Starting Valve Position. If desired, at compressor start-up, the valves can be set to open to a pre-start value for a given time. This value represents the percentage of maximum steps sent to the motor on start of the compressor. The stepper motor will hold at this position until the stepper start delay timer has expired.
4. Enter the Valve Starting Position Delay Time. The delay is the amount of time from compressor start-up to hold the number of steps sent to the motor as determined by the Starting Valve Position %. Value is in seconds and starts to count down when the drive is enabled.
5. Enter the Control Setpoint, i.e., suction superheat or liquid level.. (Not applicable to load balance control mode.)
6. Enter the Valve Control Loop Speed. This value represents the reaction time of the control loop to a process error and replaces the PID controller gains (proportional, integral, and derivative).
7. Enter the Minimum Closure During operation. This is the minimum close position for the valve while the compressor is spinning
8. Repeat steps 1 through 7 for electronic expansion valve # 2.

Analog Output Setup

The compressor features a universal analog output for load balancing valve, IGV position, discharge pressure, etc. The operating range can be set to 0-5V or 0-10V via jumpers on the Compressor Interface module.

Configure the analog output as follows (Refer to Figure 31):

1. Select the control mode for the analog output. The selection determines which control variable will be the source for the 0-10vdc output (at the ANALOGUE output terminals on the Compressor Interface module) . The options are:

- Load Balance
- HP
- IGV
- Auto
- Superheat - Flange TP
- Superheat - FlangeP, EWT
- Superheat - FlangeP, LIQT
- Suction Pressure.
- Leaving Temp
- Entering Temp
- Liquid Temp

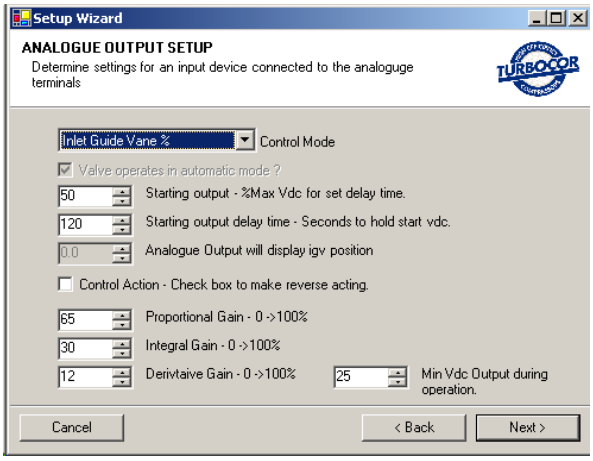


Figure 31 Analog Output Setup Form

2. Enter the Starting Output. This value equals the percentage of maximum voltage sent to the terminals of the Compressor Interface module on compressor

startup. The analog output will hold at this position until the start delay timer has expired.

3. Enter Starting Output Delay Time. This value is the amount of time from compressor start-up to hold the voltage at the startup %. Value is in seconds and starts to count down when the drive is enabled.
4. Enter the controlled variable setpoint.
5. Enter the Proportional, Integral, and Derivative gains to provide stable control.
6. Enter the minimum analog output (in DC volts) during operation, if required. This parameter can be used, for example, to maintain a minimum valve open position during operation.

Modbus Communications
(Refer to Figure 32)

Set up the RS485 and RS232 ports, as required, on the Compressor Interface module to enable communication with an external PLC, computer or building management system.

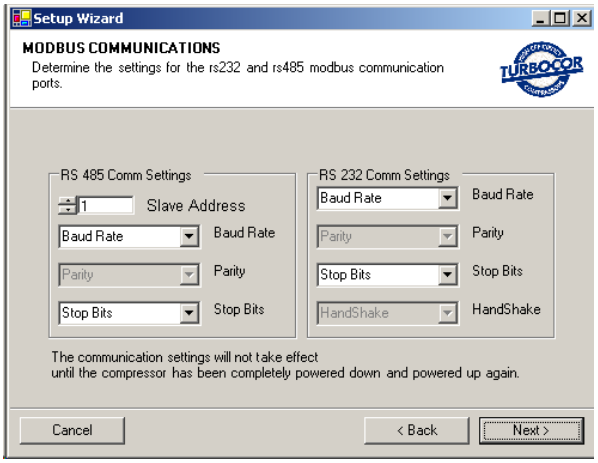


Figure 32 Modbus Communications Form

Downloading and Saving Configuration Data

At the end of the commissioning sequence, you have the choice of either downloading the configuration data to the compressor or saving it to a file for later use.

To save the data to a configuration file, click the Save to Configuration File button. In the Save As dialog box, name the file and save it in a designated location.

NOTE:
If modifications are made to the configuration data after the commissioning is complete, the new values must be recorded in a new commissioning session if the data is to be saved to a file.

⚠ WARNING

Never attempt a download while the compressor is running as it can lead to a loss of compressor control. Open interlock contacts before downloading configuration data.

For immediate downloading of the configuration data to the compressor, click the Download to Compressor button. To enable the new configuration data, perform the following steps:

1. Turn OFF power to the compressor. Wait at least 5 minutes, then check that the LEDs on the Backplane are OFF.
2. Turn ON power to the compressor.

NOTE:
Record the comm settings before you close the monitor program since they will be necessary to communicate with the compressor when you restart the monitor program.

3. Close and then restart the Monitor program.

Downloading a Configuration File

Follow the steps outlined here if you have bypassed the commissioning wizard in order to download a configuration file to the compressor.

⚠ WARNING

Never attempt a download while the compressor is running as it can lead to a loss of compressor control. Open interlock contacts before downloading configuration data.

1. Click the “Load configuration from file” button; refer to Figure 33.
2. In the Open File dialog box, browse to the location of the .ttc file.
3. Click Open.
4. On the Download Settings form, click “Download to compressor” button.
5. When the message “ Done. Cycle power before running the compressor” appears, turn OFF power to the compressor; refer to Figure 34. Wait at least 5 minutes, then check that the LEDs on the Backplane are OFF.

NOTE:
Record the comm settings before you close the monitor program since they will be necessary to communicate with the compressor when you restart the monitor program.

6. Close the Monitor program.
7. Turn ON power to the compressor.
8. Restart the Monitor program.
9. Once reconnected, the text in the right-hand pane of the Serial Port Connection dialog box appears in red. When the text turns black, it indicates that the new configuration file has been successfully downloaded to the compressor.

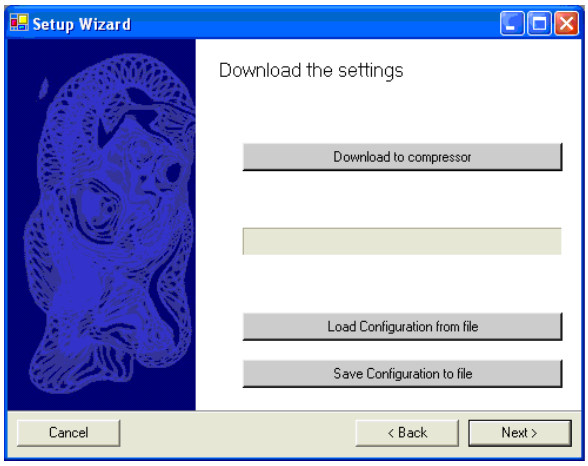


Figure 33 Download Settings Screen

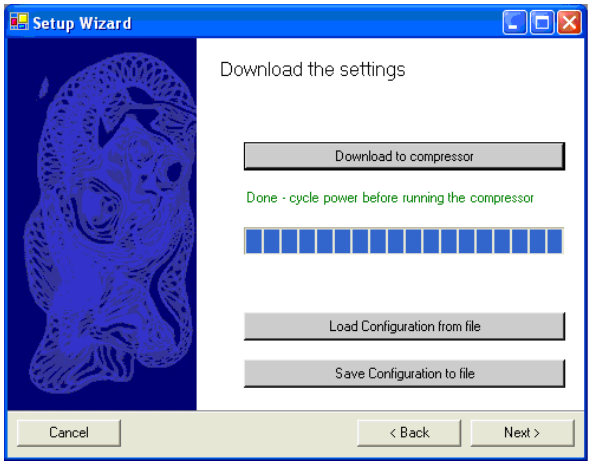


Figure 34 Download Settings Screen (After Download)

Running Checks

This section contains the running checks that should be performed following compresor configuration. Refer to Table 6.

Table 6 Running Checks

Step	Procedure
1.	Remove the mains input cover. Using a voltmeter, check the line voltages at the compressor terminals and verify that they match the display readings (under the heading of Soft Start Data on the VSPMM form of the Monitor Program). Replace the mains input cover.
2.	Clear alarms, if necessary, before running the compressor.
3.	Start compressor. Refer to “Compressor Control Modes” on page 27 for instructions on starting the compressor in various modes.
4.	Using a pressure gauge, check the suction and discharge pressures and verify that they match the display readings. If the compressor is equipped with the economizer option, also check the intermediate pressure.
5.	Using a temperature probe, check the suction and discharge temperatures and verify that they match the display readings.
6.	Check operational temperatures and pressures are as per application.
	Note: After the compressor has been operating for 100 hours at 80-100% load, remove the suction strainer.

Compressor Control Modes

Modbus Network

In Modbus Network mode, the compressor receives a demand from an external computer, PLC, or building management system using the Modbus protocol on a RS232 or RS485 communication line.

NOTE:
Interlock switches must be closed and no errors present for the compressor to start up and run.

How to Start the Compressor

On the Compressor Control Data form, click in the Loading Demand field and enter a value representing a percentage of maximum power available. (The maximum power available is dependent on the compressor model.) The compressor will levitate and spin up. Refer to Figure 35

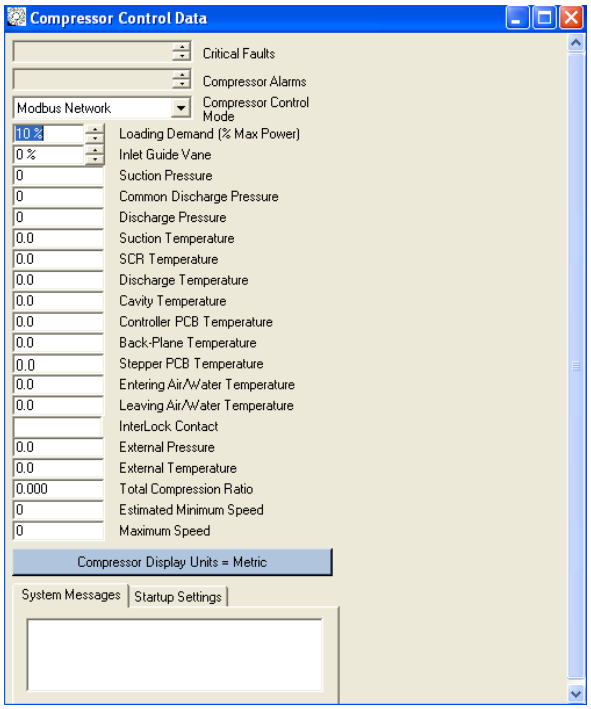


Figure 35 Compressor Control Data Form

How to Stop the Compressor

To stop the compressor, enter '0' in the Loading Demand field.

Analog Input

The Analog Input mode controls the compressor loading using an analog demand signal of 0-10 VDC from an external controller. The variable demand signal corresponds to the range of 0-100% maximum power available.

NOTE:
Interlock switches must be closed and no errors present for the compressor to start up and run.

How to Start the Compressor

1. Make sure the contact to the 'Interlock' input is closed.

⚠ WARNING

Ensure that power to the compressor is OFF before connecting wiring to the Compressor Interface module.

2. Connect a 0-10VDC demand signal to the Compressor Interface module.
3. Apply a signal between 2 and 10VDC to the 'Demand' input. (2VDC = min kW/min speed, 10VDC = max kW according to model capacity.)

How to Stop the Compressor

Decrease the demand signal to 0VDC **or** open the contact connected to the 'Interlock' input. The compressor will ramp down to 0 RPM and de-levitate.

Chiller Control

The Chiller Control mode is fully automatic and controls the chilled water temperature using a temperature sensor connected directly to the Compressor Interface module. This mode can also be used to control evaporating temperature which is derived from the suction pressure measurement

NOTE:
Interlock switches must be closed and no errors present for the compressor to start up and run.

How to Start the Compressor

On the Chiller Control form, click in the Chiller Enable Status box. The compressor will ramp up and adjust its speed to reach and maintain the setpoint. Refer to Figure 36.

How to Stop the Compressor

On the Chiller Control form, uncheck the Chiller Enable Status box. The compressor will ramp down to 0 RPM and de-levitate.

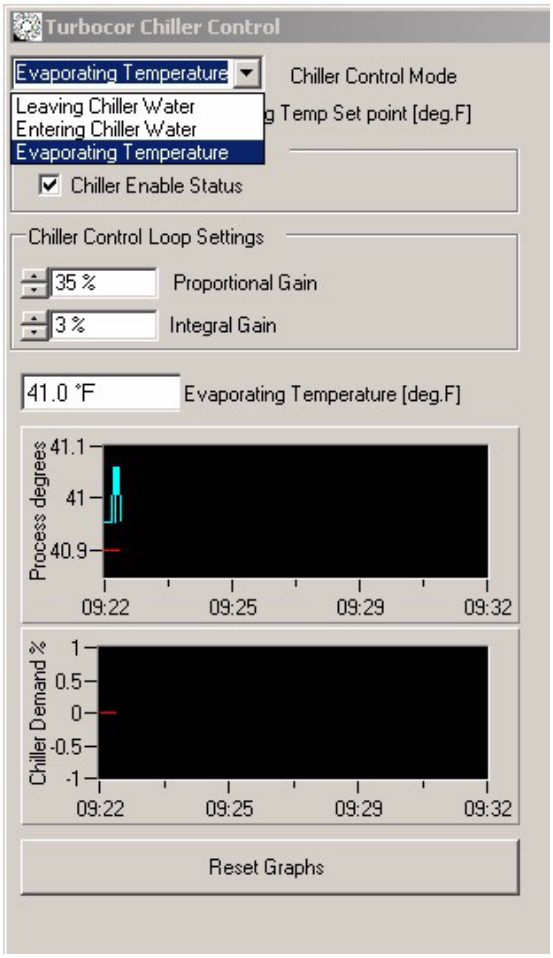


Figure 36 Chiller Control Form

Controlling User Access

The access code system allows OEM customers to set their own unique pass codes thereby restricting access to company authorized personnel.

These access codes control access to all settable parameters via the Modbus communications layer. The access levels are:

- Read only ~ User may only view values across the Modbus layer.
- Low Level ~ User may only alter basic settings such as leaving chilled water temp, display units, chiller enable/disable, etc.
- Mid Level ~ User may alter all settings that are required for commissioning a compressor in the field. Values alterable are things like control mode, valve control settings, run status contact energize RPM, reset load profile data, and retrieve and save fault data.
- High level ~ User may alter all settings. This level of access is reserved for users that configure motor/compressor and bearing control only.

Upon power-up of the compressor, the access codes are calculated and stored in RAM memory. The default user access level on power up is read only.

To change the access code, select Access Codes from the Advanced menu item; refer to Figure 37.

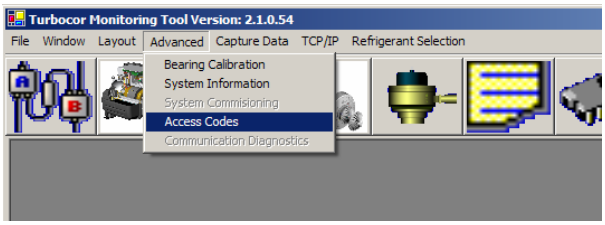


Figure 37 Navigating to the Access Code Change Form

The Access Code Change form appears. To change the access code for a specific user level:

1. Select the appropriate radio button.
2. Enter the current access code followed by the new access code for the selected user level (if you enter the incorrect access code nothing will be changed).
3. Re-enter the new access code in the Confirm Access Code field.
4. Click the Change Access Code button.

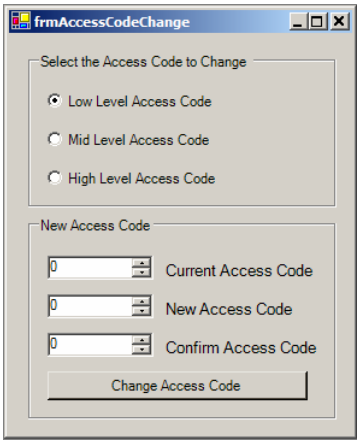


Figure 38 Access Code Change Form

Functional Description

Compressor Fundamentals

Compressor operation begins with a call for cooling from a system controller. The chiller controller, in turn, signals the compressor controller to begin compressor spin-up.

Main Fluid Path

(Refer to Figure 39 and Figure 40)

The following paragraphs describe the flow of refrigerant from the intake to the discharge port of the compressor.

The refrigerant enters the suction side of the compressor as a low-pressure, low-temperature, super-heated gas.

The refrigerant gas passes through a set of adjustable inlet guide vanes (IGV) that are used to control the compressor capacity at low load conditions. The first compression element that the gas encounters is the first-stage impeller. (The TT300 features an open impeller design, as opposed to the shrouded impeller design of the TT400.) The centrifugal force produced by the rotating impeller results in an increase in both gas velocity and pressure.

The high-velocity gas discharging from the impeller is directed to the second stage impeller through de-swirl vanes. The gas is further compressed by the second stage impeller and then discharged through a volute via a vaneless diffuser. (A volute is a curved funnel increasing in area to the discharge port. As the area of the cross-section increases, the volute reduces the speed of the gas and increases its pressure.) From there, the high-pressure/high-temperature gas exits the compressor at the discharge port.

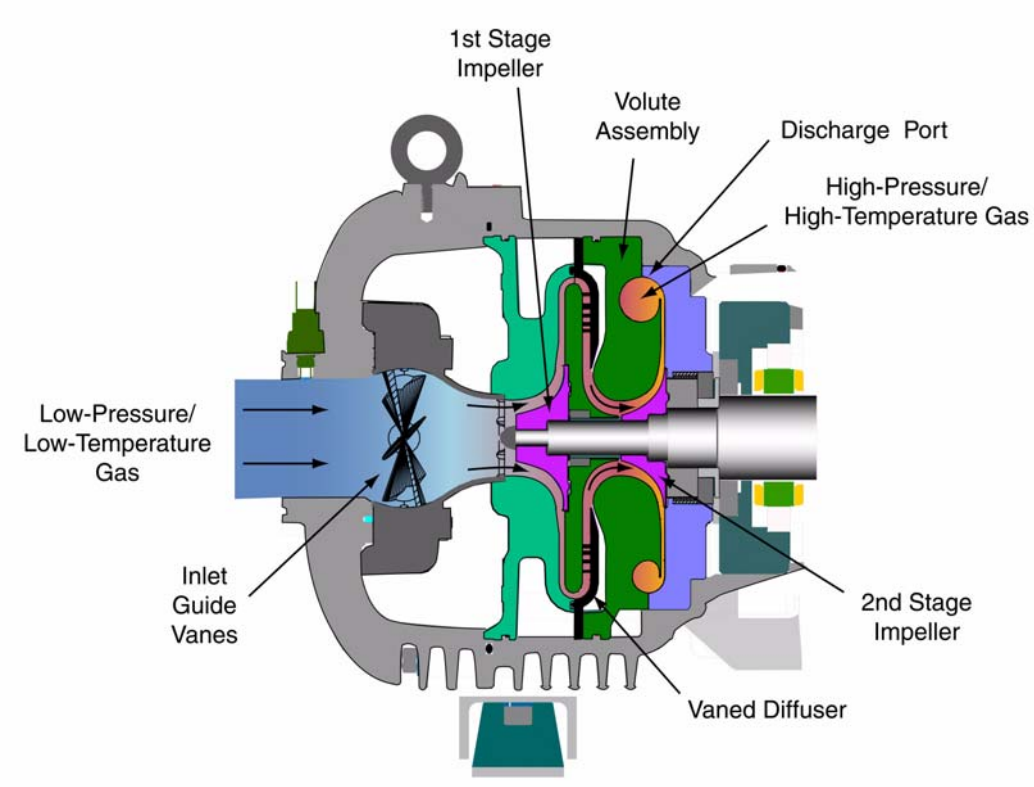


Figure 39 TT300 Compressor Fluid Path

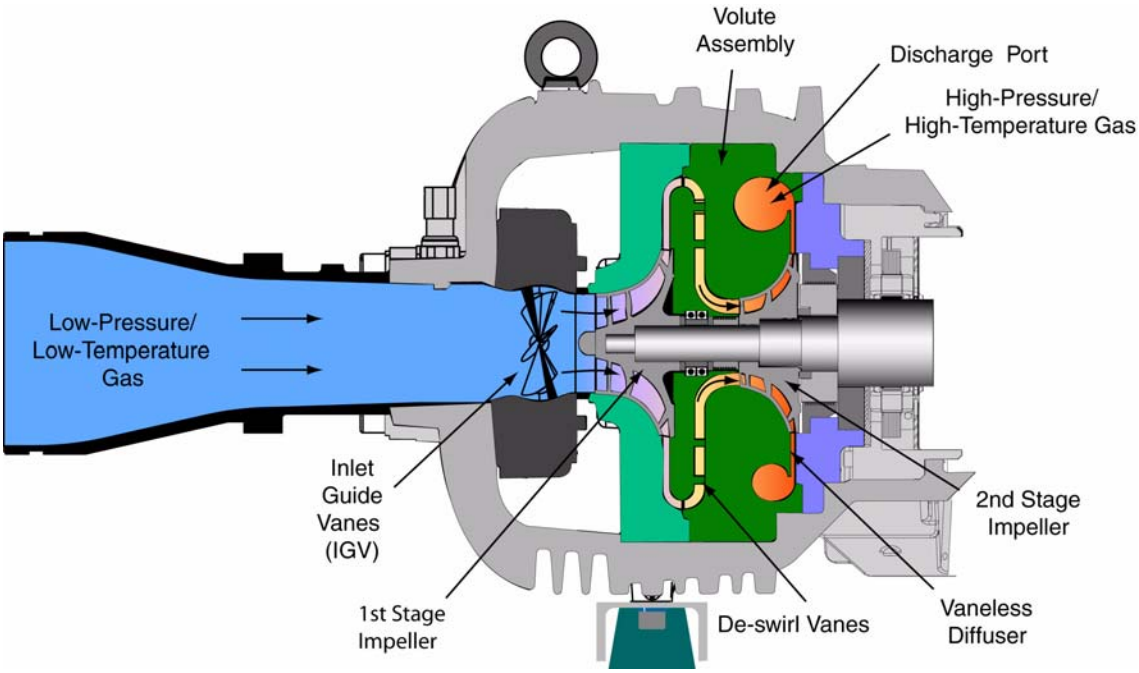


Figure 40 TT400 Compressor Fluid Path

Motor Cooling

Refrigerant is supplied to the compressor to cool the electronic, mechanical, and electromechanical components in order to maintain maximum efficiency and safe operating conditions. Refer to Figure 41 and Figure 42.

⚠ WARNING

A minimum operating pressure ratio of 1.5 is required to maintain adequate cooling of the compressor.

Liquid refrigerant is channelled, at full condenser pressure, from the main liquid line to the compressor. The sub-cooled refrigerant enters the compressor through two solenoid valves and associated fixed orifices located behind the service access cover. The orifices cause the refrigerant to expand, thereby lowering its temperature. Both valves operate relative to the temperature at the sensors that are located at the Insulated Gate Bipolar Transistor (IGBT) inverter and motor cavity. When the temperature at either sensor reaches a pre-determined threshold, one solenoid valve opens. If the temperature increases to the point where it equals a higher temperature threshold, the second solenoid valve opens.

In the TT300, the refrigerant flows from the outlet of the orifices to the heatsink plate of the IGBT inverter and then to the underside of the rectifier heatsink.

In the TT400, the refrigerant flows from the outlet of the orifices, in parallel, to the heatsink plate of the IGBT inverter and the underside of the rectifier heatsink.

The refrigerant then passes through grooves surrounding the motor stator. As the refrigerant flows through the grooves, it vapourizes into a gas. At the coil outlet, the refrigerant gas is channeled back to the suction inlet via the motor cavity, thereby cooling the rotor.

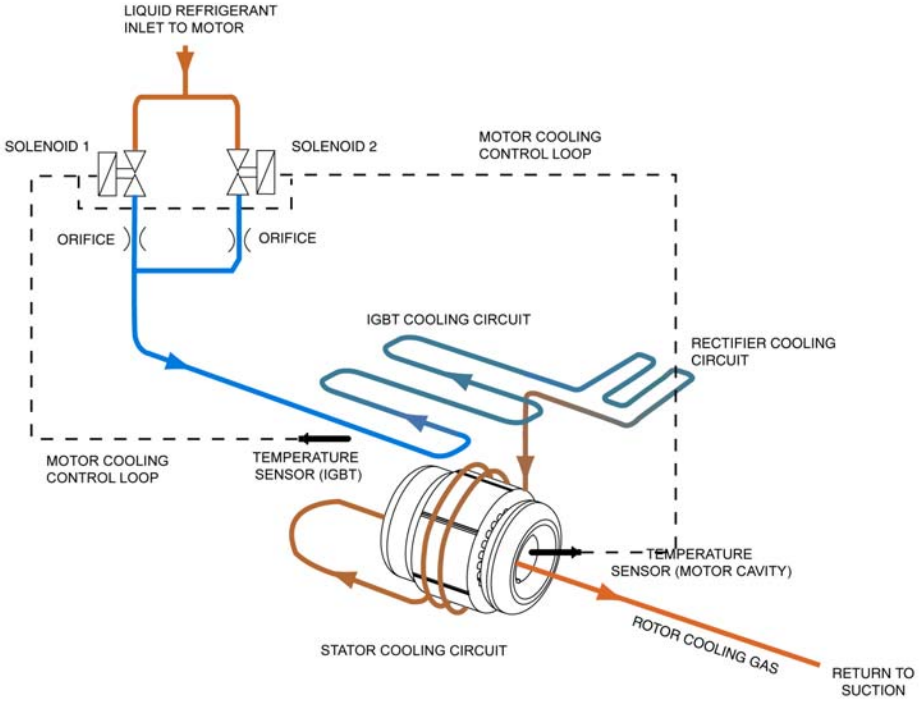


Figure 41 TT300 Compressor Cooling Circuit

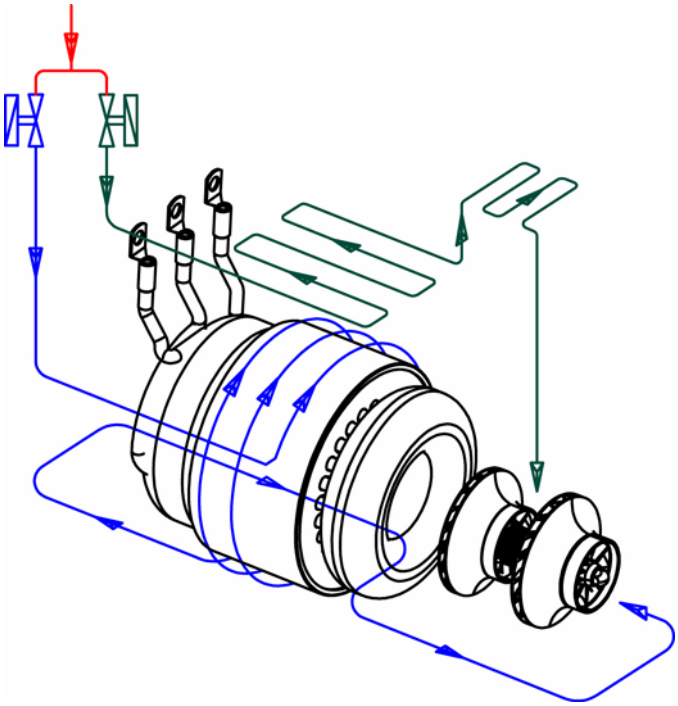


Figure 42 TT400 Compressor Cooling Circuit

Inlet Guide Vanes

The Inlet Guide Vanes (IGV) assembly is an adjustable guide that pre-rotates refrigerant flow at the compressor intake. The IGV assembly consists of movable vanes and a motor. The vane angle, and hence, the degree of pre-rotation to the refrigerant flow is determined by the compressor controller. The IGV position can vary between approximately 0% and 110% open. A visual indicator for the IGV position is mounted on the outside of the IGV housing.

Compressor Control Overview

Figure 43 shows a functional block diagram of the compressor control and monitoring system. Figure 44 highlights the component locations. The major components are:

- Motor drive
- Soft-start controller
- Bearing-motor-compressor controller (BMCC)
- Bearing PWM amplifier
- Backplane
- Serial driver
- DC-DC converters

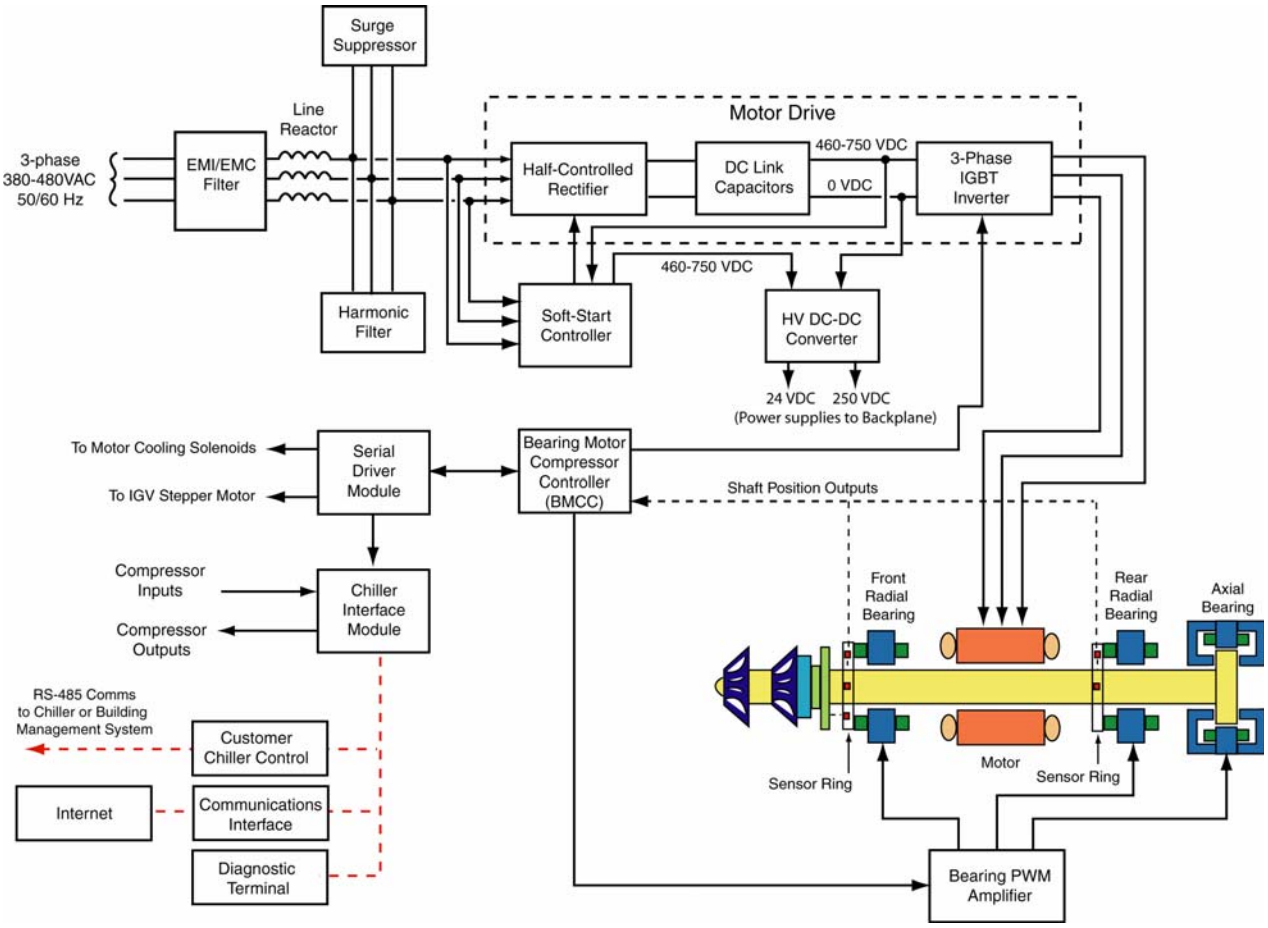


Figure 43 Compressor Control System, Functional Block Diagram

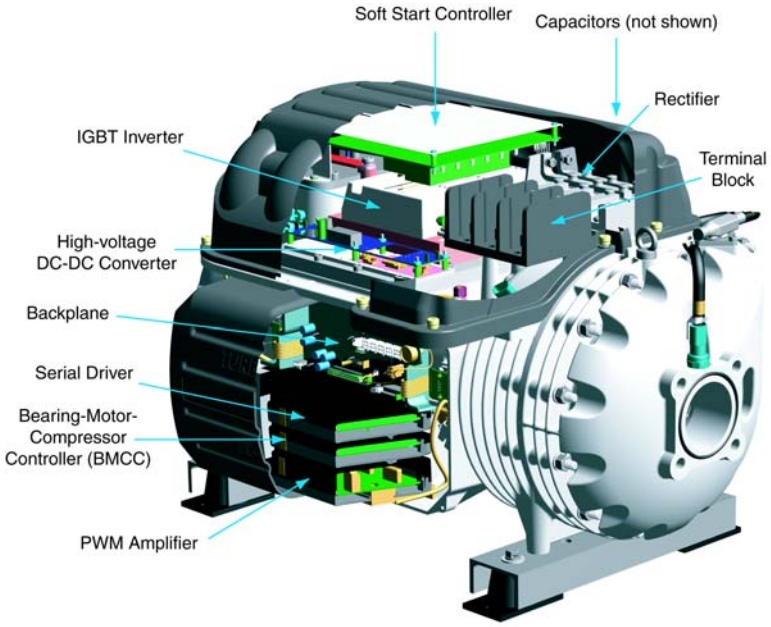


Figure 44 Component Locations

Motor Drive System

Normally, AC power to the compressor remains on, even when the compressor is in the off state. The compressor motor requires a variable-frequency three-phase source for variable speed operation. The AC line voltage is converted into a DC voltage by a half-controlled, full-wave rectifier. DC link capacitors at the rectifier output serve as energy storage and filter out the voltage ripple to provide a smooth DC voltage. The Insulated-Gate-Bipolar Transistor (IGBT) is an inverter that converts the DC link voltage into an adjustable three-phase AC voltage. Pulse-Width Modulation (PWM) signals from the Bearing-Motor-Compressor Controller control the inverter output frequency and voltage. By modulating the on and off times of the inverter power switches, three-phase variable sinusoidal waveforms are obtained.

If the power should fail while the compressor is running, the motor switches into generator mode thereby sustaining the capacitor charge. The rotor can then spin down safely in a controlled sequence preventing damage to components.

Soft-Start Controller

The soft-start controller limits inrush current by progressively increasing the conduction angle of the silicon-controlled rectifiers (SCRs). This technique is used at compressor start-up while the DC link capacitors are charging up.

The soft-start function and the variable-speed drive combined, limit the inrush current at start-up.

Bearing-Motor-Compressor Controller

The hardware and software for the compressor controller and the bearing/motor controller physically reside in the Bearing-Motor-Compressor Controller (BMCC) module. The BMCC is the central processor of the compressor.

Compressor Control

The compressor controller is continuously updated with critical data from external sensors that indicate the compressor's operating status. Under program control, the compressor controller can respond to changing conditions and requirements to ensure optimum system performance.

Figure 45 to Figure 48 provide flowcharts showing how the controller responds to chiller demands.

Capacity Control

One of the compressor controller's primary functions is to control the compressor's motor speed and IGV position in order to satisfy load requirements and to avoid surge and choke conditions. However, the majority of capacity control can be achieved via motor speed.

Expansion Valve Control

The on-board electronic expansion valve (EXV) controller uses a simplified loop gain to control the response characteristics of the valve. The valve opening is determined by either superheat or liquid level sensing.

Depending on the application, a load balancing (hot gas bypass) valve can be driven by the auxiliary EXV output. Load balancing allows the compressor to obtain lower capacities at higher pressure ratios. The valve opens to lower the overall pressure ratio and thereby reduces the lift, enabling the compressor to reduce speed/unload. Refer to Appendix A for details.

Motor/Bearing Control

The magnetic bearing system physically supports a rotating shaft while enabling non-contact between the shaft and surrounding stationary surfaces.

A digital bearing controller and motor controller provide the PWM command signals to the bearing amplifier and IGBT inverter, respectively.

The bearing controller also collects shaft position inputs from sensors and uses the feedback to calculate and maintain the desired shaft position.

Monitoring Functions

The compressor controller monitors over 60 parameters, including:

- Gas pressure and temperature monitoring
- Line voltage monitoring and phase failure detection
- Motor temperature
- Line currents
- External interlock

Abnormal Conditions

The compressor controller responds to abnormal conditions by monitoring:

- Surge RPM
- Choke RPM
- Power failure/phase unbalance
- Low/high ambient temperature
- High discharge pressure
- Low suction pressure
- Stop/start short cycle
- Motor cooling circuit failure (over temperature)
- Refrigerant loss
- Power supply
- Overcurrent

Bearing PWM Amplifier

The bearing pulse-width-modulation (PWM) amplifier supplies current to the radial and axial magnetic bearing actuators.

The bearing amplifier consists of high voltage switches that are turned on and off at a high frequency, as commanded by the PWM signal from the Bearing-Motor-Compressor Controller (BMCC).

Serial Driver

The serial driver module performs serial-to-parallel conversion on the stepper motor drive signals from the BMCC. The module also contains four normally-open relays under BMCC control. Two of the relays drive the motor cooling solenoids and the other two are used to indicate compressor fault status and running status. The status relays can be wired to external control circuits.

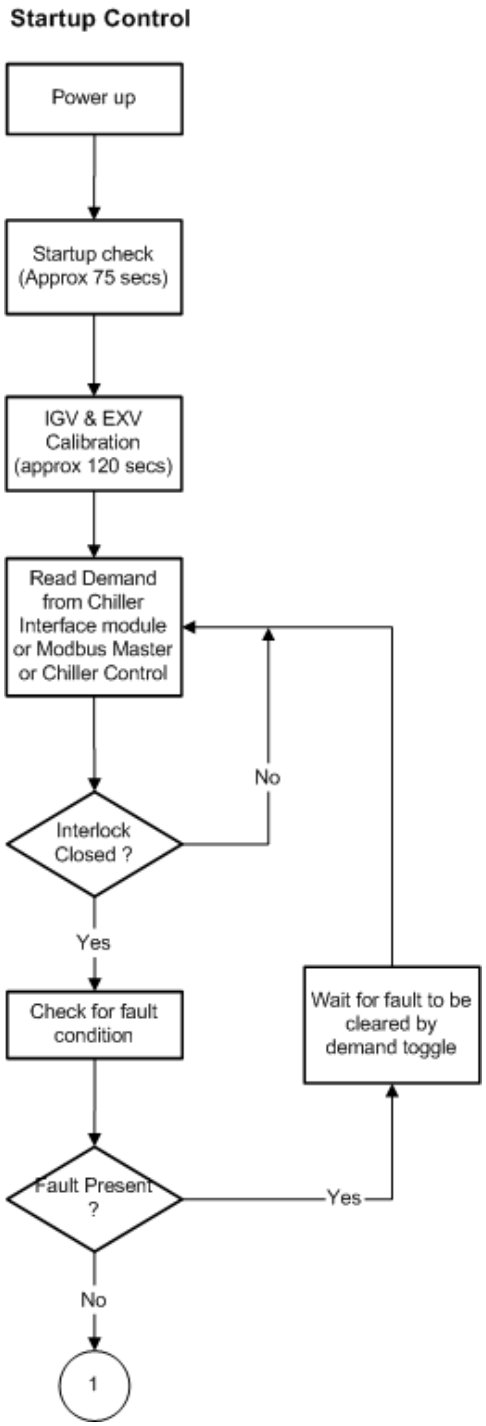


Figure 45 Compressor Controller Operational Flowchart (1 of 6)

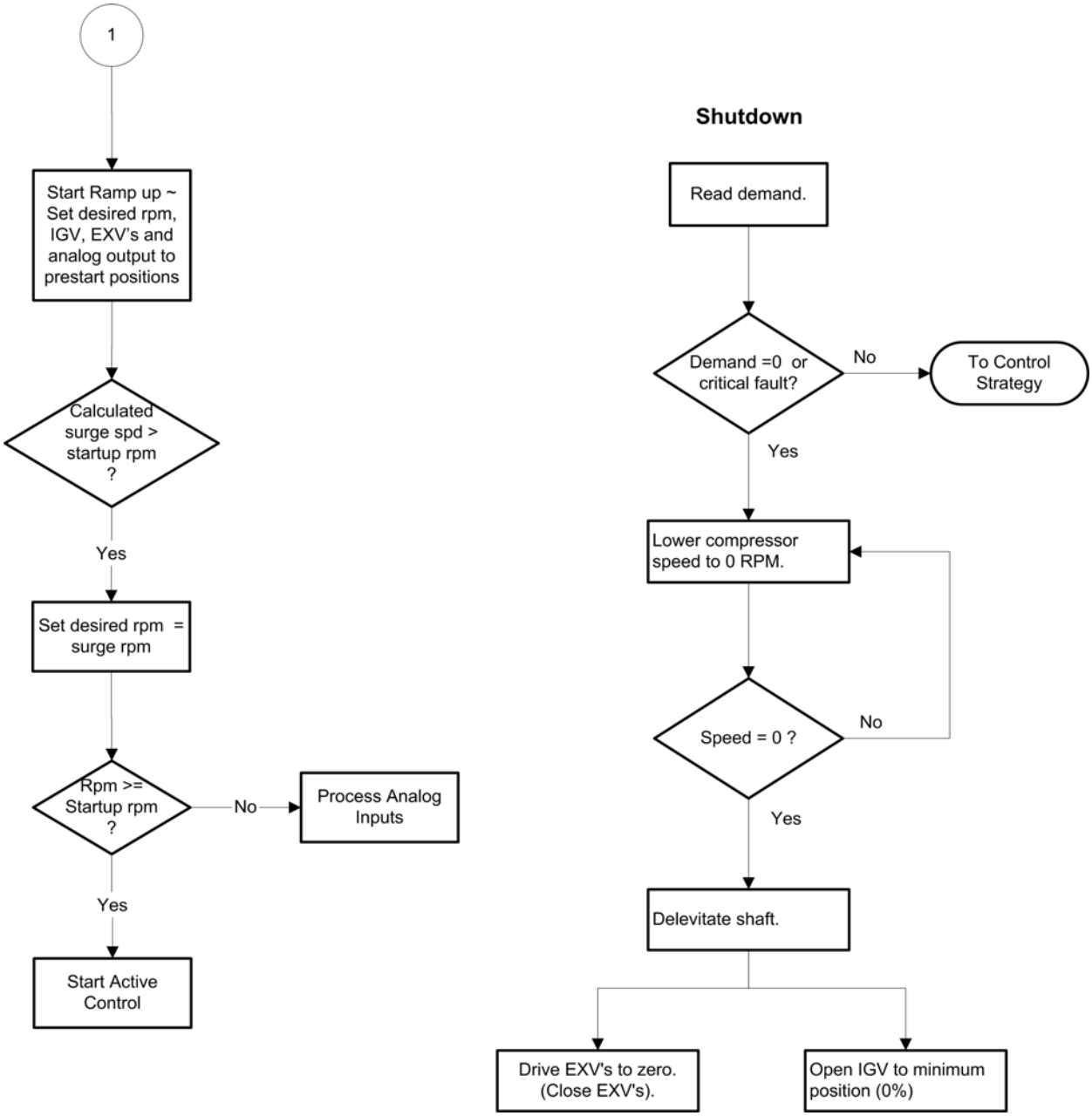


Figure 46 Compressor Controller Operational Flowchart (2 of 6)

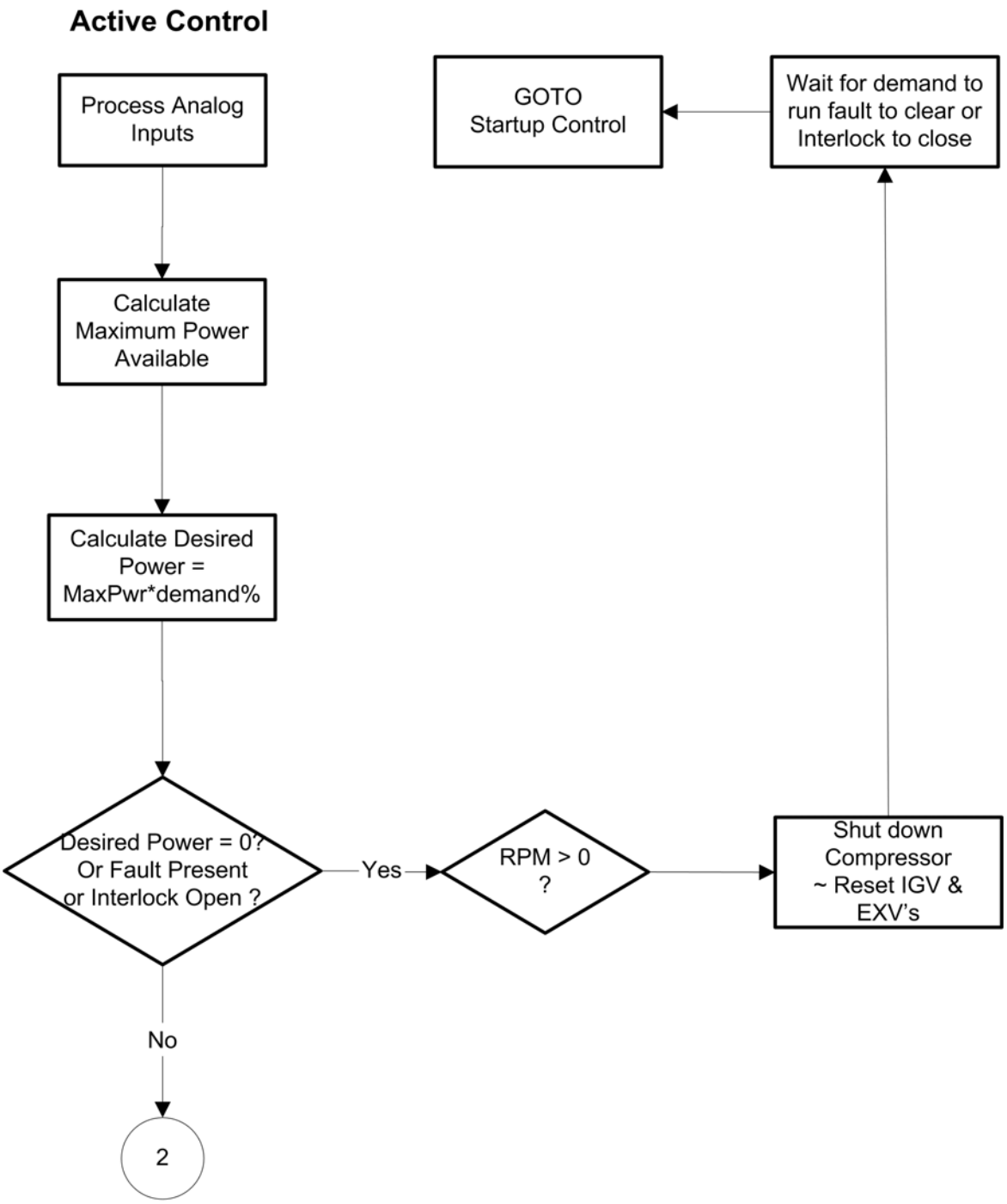


Figure 47 Compressor Controller Operational Flowchart (3 of 6)

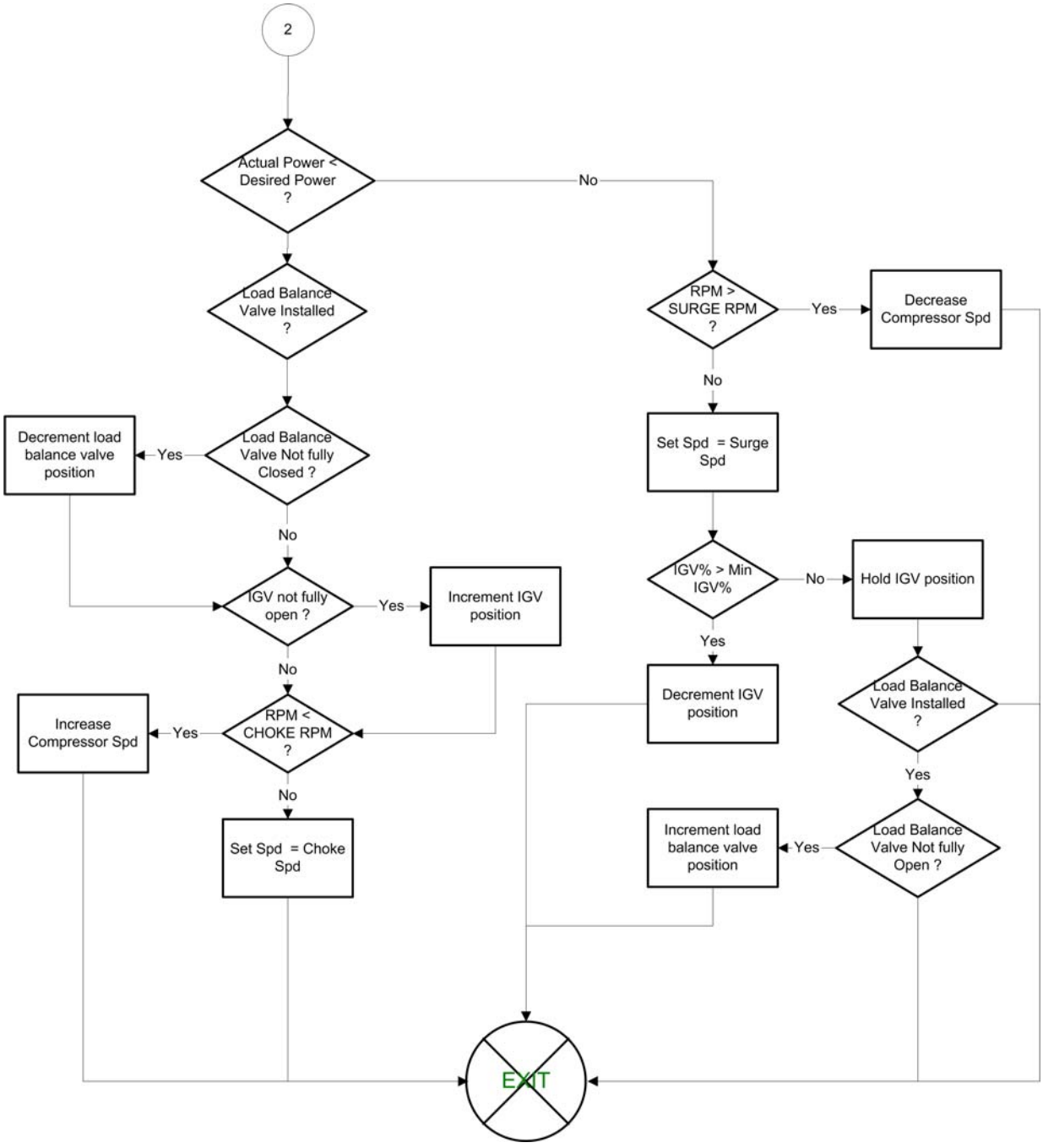


Figure 48 Compressor Controller Operational Flowchart (4 of 6)

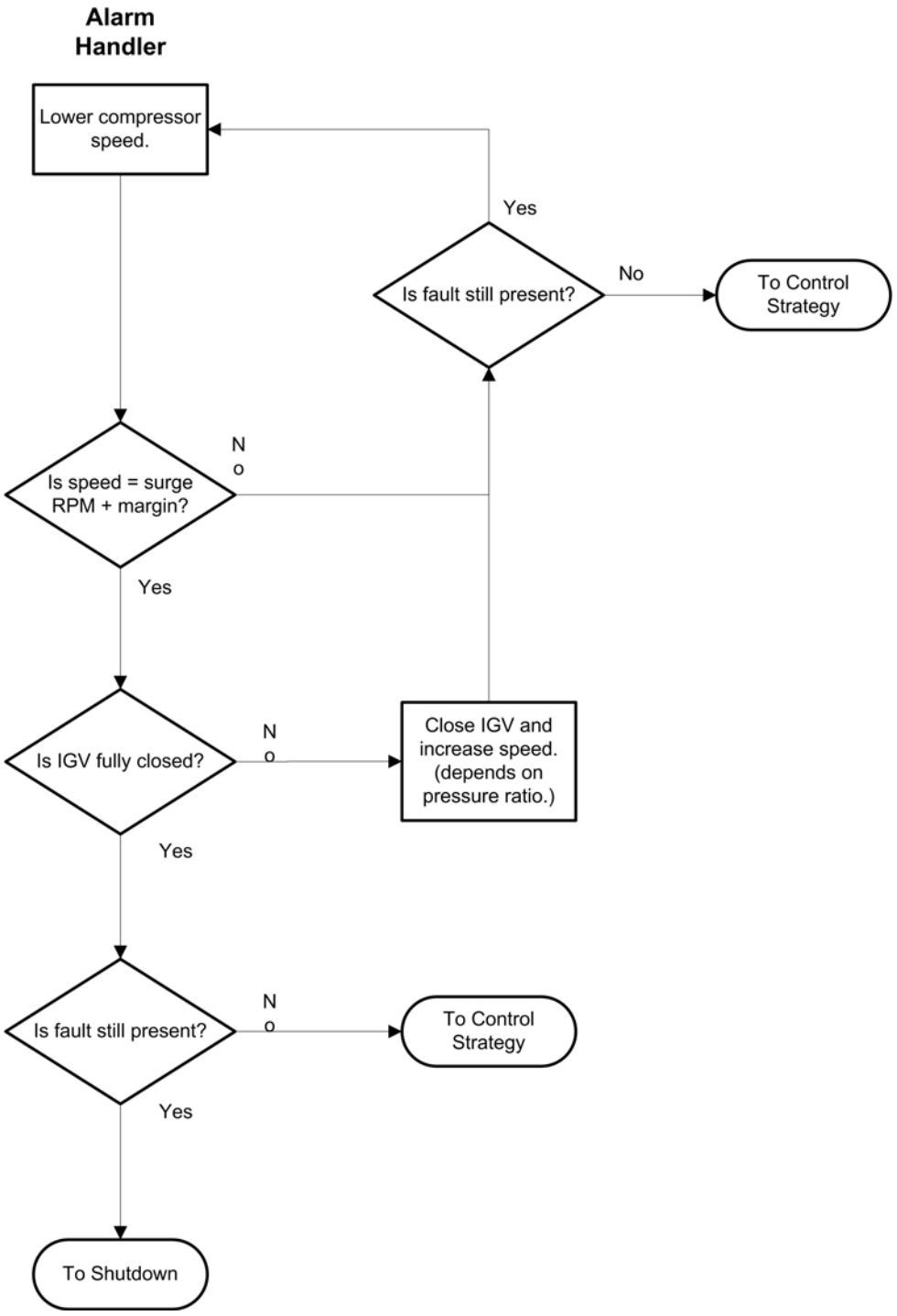
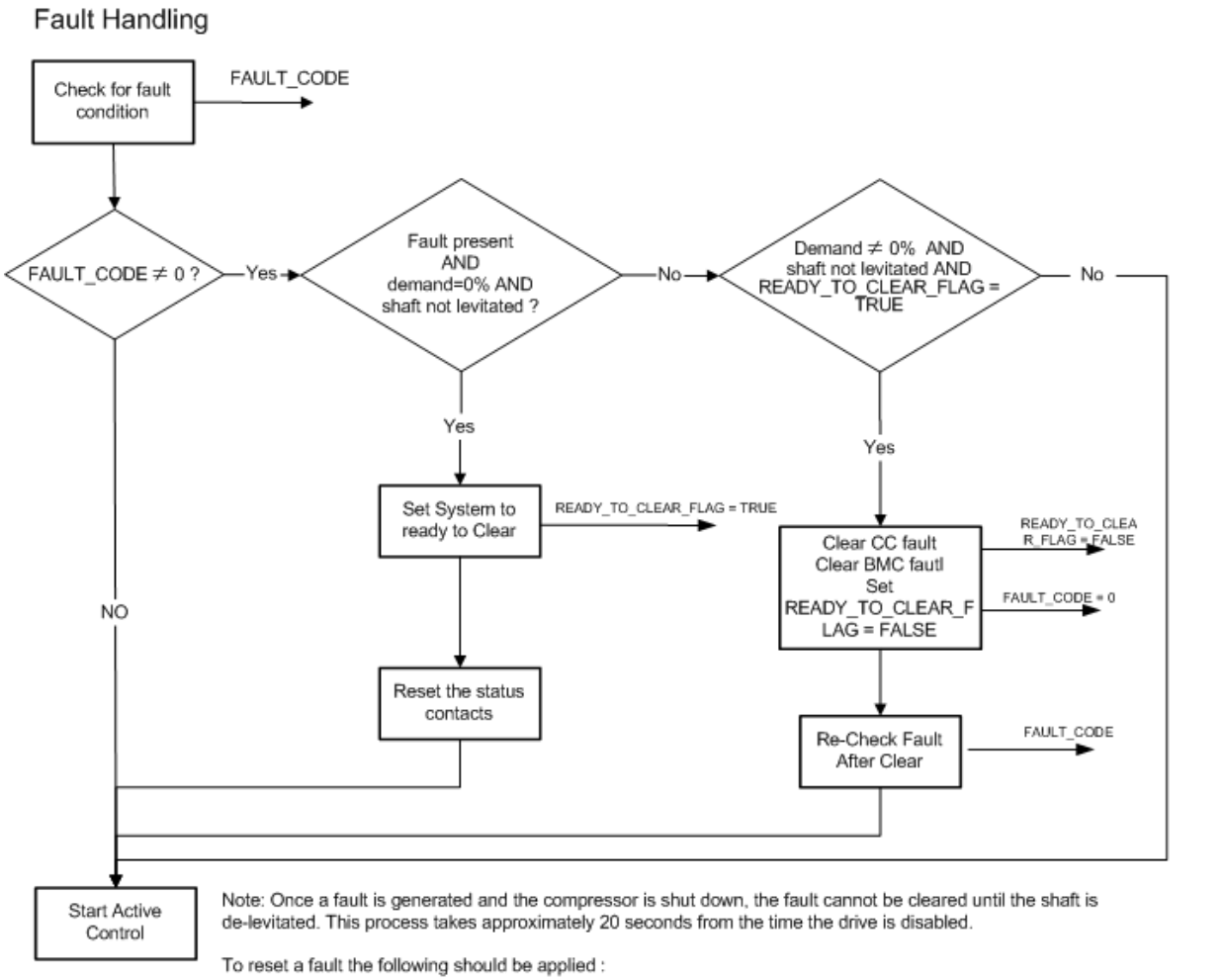


Figure 49 Compressor Controller Operational Flowchart (5 of 6)



Note: Once a fault is generated and the compressor is shut down, the fault cannot be cleared until the shaft is de-levitated. This process takes approximately 20 seconds from the time the drive is disabled.

To reset a fault the following should be applied :

1) Fault generated -> Fault Register Set -> Status Contact State Changed -> Compressor shutdown process starts.
2) Master Controller picks up change in Fault status contacts or reads the fault Register is not equal to zero.
3) Master Controller Sets the demand to 0%. (This puts the compressor into a waiting-to-clear fault state.)
4) Master Controller waits 30 secs. (Time to allow motor to stop spinning and for bearing to de-levitate).
5) Master Controller applys demand -> if fault is not present anymore it will be cleared.

An Alternative to steps 4 and 5 may be to continually toggle the demand from 0 to a non-zero value until the fault goes away.

If the fault generated is Discharge Pressure or Amperes, the fault will only be reset on a cycle of power.

Figure 50 Compressor Controller Operational Flowchart (6 of 6)

Backplane

The backplane physically interconnects the on-board plug-in modules with the power electronics, IGV stepper motor, motor cooling solenoids, rotor position sensors, and pressure/temperature sensors. The backplane also features on-board, low-voltage DC-DC converters for generating +15V, -15V, +5V, and +17V from an input of +24VDC. The backplane receives its +24VDC power input from the high-voltage DC-DC converter mounted on the topside of the compressor.

The backplane is also equipped with status-indicating LEDs. All LEDs are yellow except for the alarm LED which is green/red. Table 7 describes their functions.

Table 7 Backplane LEDs

LED	Function
+5V, +15V, +17HV, +24V	LEDs are ON when DC power is available.
Cool -H, Cool -L	LEDs are ON when their respective coil is energized.
Run	LED is ON when the shaft is spinning.
Alarm	LED is green when normal status, red when alarm status
D13, D14, D15, D16	LEDs indicate IGV status and flash when IGV is moving

High-voltage DC-DC Converter

DC-DC converters supply and electrically isolate the high and low DC voltages that are required by the control circuits. The high-voltage DC-DC converter delivers 24VDC and 250VDC from an input of 460-750 VDC. The 24VDC and 250VDC are used to power the backplane and magnetic bearing PWM amplifier, respectively.

Magnetic Bearing System

Overview

A rotating shaft, under changing load conditions, will experience forces in both radial and axial directions. In order to compensate for these forces, a five-axis bearing system is used, incorporating two radial bearings of two axes each, and one thrust (axial) bearing. See Figure 51.

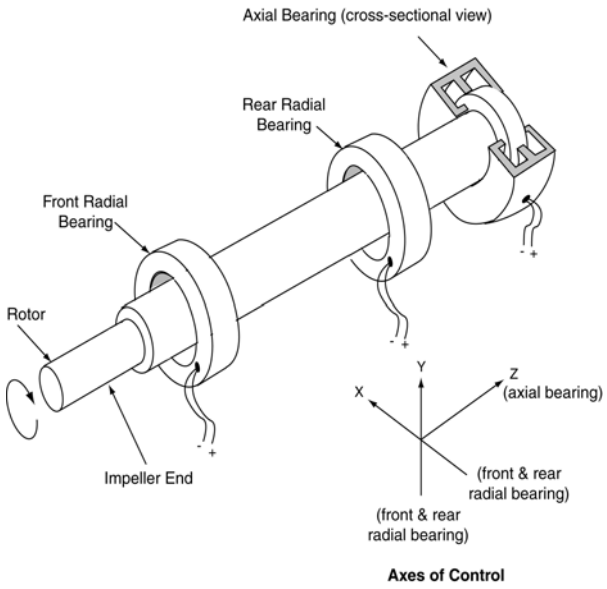


Figure 51 Magnetic Bearing Configuration

Bearing Control System

The bearing control system uses rotor position feedback to close the loop and maintain the rotor in the correct running position; refer to Figure 52. The bearing controller issues position commands to the bearing PWM amplifier. The position commands consist of five channels with each channel allocated to one of the five bearing actuator coils (one coil for each axis. The amplifier uses IGBT technology to convert the low-voltage position commands to the 250VDC PWM signals that are applied to each bearing actuator coil.

Rotor position sensors are located on rings attached to the front and rear radial bearing assemblies. The front sensor ring contains sensors that read the rotor position along the X, Y , and Z axes. The rotor position along the Z (or axial) axis is read by measuring the distance between the sensor and a target sleeve mounted on the rotor. The rear sensor ring contains sensors that read the position along the X and Y axes. Information from the position sensors is continuously fed back to the bearing controller.

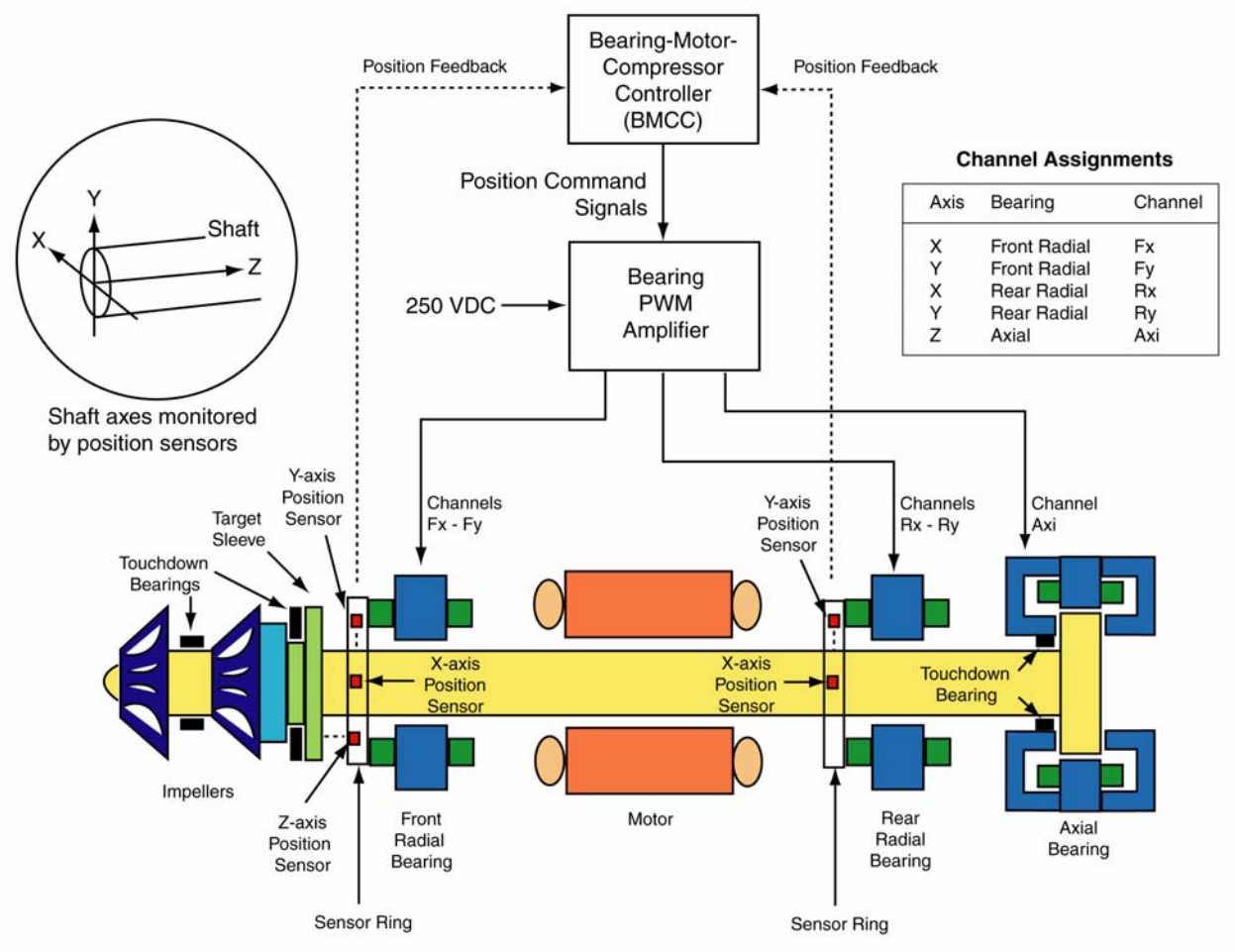


Figure 52 Magnetic Bearing Control System

Power Line Control and Filtering

Power Line Contactor

Consult local codes to determine if a power line contactor is necessary for your application.

NOTE:
It is not recommended to use the contactor to start/stop the compressor during normal operation. Compressor generator mode is used for emergency purposes only.

Power Line Filters and Line Reactor

The equipment described in this section may be available from Danfoss Turbocor as compressor accessories. For equipment specifications, refer to Appendix C of the Application Manual.

EMI Filter

The EMI filter minimizes harmonics in the higher frequency domain (typically above 1kHz). It should be located between the contactor and the line reactor. The European version of EMI filter is required for CE compliance.

Line Reactor

The line reactor acts like an input buffer between the motor drive power circuits and the AC line power. Line reactors provide additional circuit impedance that improves power factor, reduces line current harmonics and dampens the transient voltages on the power line.

Harmonic Filter

The harmonic filter operates in conjunction with the line reactor to minimize low-frequency harmonics on the power line emanating from the switching devices on the compressor. It should be located between the line reactor and the compressor.

Compressor Operating Modes

There are four modes for controlling compressor operation, ranging from fully automatic to manual, as follows:

- Analog mode
- Chiller mode
- Network mode
- Manual mode

The Network and Manual modes are used mainly for commissioning purposes. In addition, the Manual mode is reserved for authorized service personnel only; refer to the Service Manual (ECD-00007S) for further information.

Analog Mode

This control mode is used when an external controller controls the chiller/compressor. An analog control signal is applied to the compressor that represents the setpoint for the compressor loading.

The relationship is as follows: 2-10VDC = 0 – 100% of maximum power available for that given compressor model number, and operating condition. (See the following example.)
When a demand >2V is applied to the compressor, the shaft will levitate, and the compressor will automatically speed up to the minimum start-up speed. This takes approximately 90 seconds. When the compressor has reached this point, it will adjust its speed and the IGV position in order to obtain the desired kW setpoint. If the demand drops below 2V, the compressor will ramp down to 0 RPM and de-levitate the shaft. For proper operation, various control strategy rules are implemented in the compressor controller. They can mainly be divided into efficiency rules, unloading rules, and safety rules.

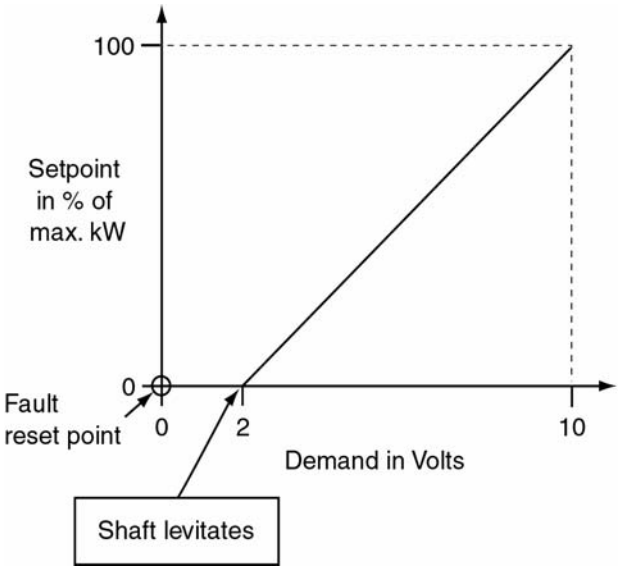


Figure 53 Demand - kW Relationship

Chiller Mode

When a chiller is equipped with a single compressor, there is no need to have a separate chiller controller, since the compressor can be set up to control either the leaving- or entering chilled water temperature, simply by connecting a NTC temperature sensor to the Compressor Interface module; refer to Application Manual ECD-00007A for sensor characteristics. A start/stop command (dry contact, for instance, from a chilled water pump) will start/stop the compressor. The chilled water setpoint can be set through the monitor program.

Modbus Network Mode

The demand to the compressor motor kW can be either directly set using the monitor program or can be provided by the chiller controller via the Modbus over RS485 link. The compressor will adjust its speed in order to obtain the desired setpoint. The compressor controller will keep monitoring all critical parameters and ensure safe operation.

Expansion Valve Control

The compressor has the optional functionality to control two electronic expansion valves. These valves should be of the stepper motor design. Refer to the Danfoss Turbocor Application Data in the compressor Application manual for details on which valves can be used.

The first expansion valve (or Main Expansion Valve) can be set up to control liquid level, superheat, or load balancing (hot gas by-pass valve). When controlling liquid level, it will normally control the level in the evaporator or condenser. The second valve (or Auxiliary Expansion Valve) can also be set up to control liquid level, superheat, or load balancing. When controlling liquid level, it will normally be for economizer level control.

Operational Maintenance Checks

Maintenance Inspections

Owner's responsibilities

- Report any compressor damage.
- Report any faults that occur with the compressor.
- Turn off the compressor if fault condition persists.
- Maintain a safe working environment in the plant room, free from obstructions and debris.
- Maintain adequate lighting.
- Ensure plant room ventilation is adequate and as per government regulations.

Frequency of Maintenance Inspections

Danfoss Turbocor recommends that on-site operational checks be carried out as per Table 8. The operational checks evaluate the system performance, fault history and system trends.

Table 8 Preventive Maintenance Tasks

Item	Task	Frequency		
		6 Mths	12 Mths	60 Mths
General Inspections	Check for visible mechanical damage to compressor.	√		
	Check for excessive vibration from other rotating equipment.	√		
Electrical Inspections	Check main power supply voltages. “Checking the Main Supply Voltage” on page 47.	√		
	Check electrical terminals are tight.		√	
	Check for signs of hot spots/discolouration on power cables.	√		
	Check amperages are as per design.	√		
	Check DC bus voltage.	√		
	Replace capacitor set.			√

Table 8 Preventive Maintenance Tasks (Continued)

Item	Task	Frequency		
		6 Mths	12 Mths	60 Mths
	Check operation of all system safety devices and interlocks.		√	
Electronic Inspections	Check all communication cables are secure and tight.	√		
	Check all electronic modules are secure.	√		
	Check physical condition of all exposed printed circuit boards (PCBs).	√		
	Check all exposed PCBs for dust build-up and clean, if necessary.		√	
	Check calibration of temperature/pressure sensors.		√	
Refrigeration	Check operation of IGV assembly.		√	
	Check system refrigeration charge.	√		
	Check superheat/level control, if applicable.		√	
	Check system and motor cooling liquid line to ensure sufficient subcooling.	√		
	Check operating conditions external to the compressor.	√		
	Inspect/clean motor-cooling strainer. (If service has taken place.)	As required		

Checking the Main Supply Voltage

⚠ DANGER

Removing the mains input cover will expose you to a high voltage (380-460 VAC) hazard. Exercise care when working around energized circuits.

Service Tools/Test Equipment:

- T25 Torx bit and driver
- voltmeter

1. Release the four captive screws that secure the mains input cover to the compressor. Lift away cover.
2. With a voltmeter, measure the voltage between each phase and a grounding point such as the main input bracket.
3. Verify that the voltage is as per design value ±10%.
4. Replace and secure the mains input cover.

Appendix A Mounting Kit Instructions

The compressor mounting kit (part no. 100066) includes:

- four rubber mounts
- four sets of attaching hardware including 3/8” screws, spring washers, and flat washers

Mounting Instructions

1. Following the footprint dimensions given in Figure 1-1, drill two 9mm (11/32") holes in the base frame for each rubber mount.
2. Align the rubber mounts over the holes and secure them with attaching hardware (customer supplied).
3. Place one flat washer on each rubber mount.
4. Position the compressor over the rubber mounts and align the four holes in the compressor mounting rails with the rubber mounts.
5. Assemble the four 3/8” screws with the spring washers. Insert the screws into the rubber mounts and tighten them.
6. Check that the compressor mounting rails are level ±5mm (3/16”) in the lateral and longitudinal planes.

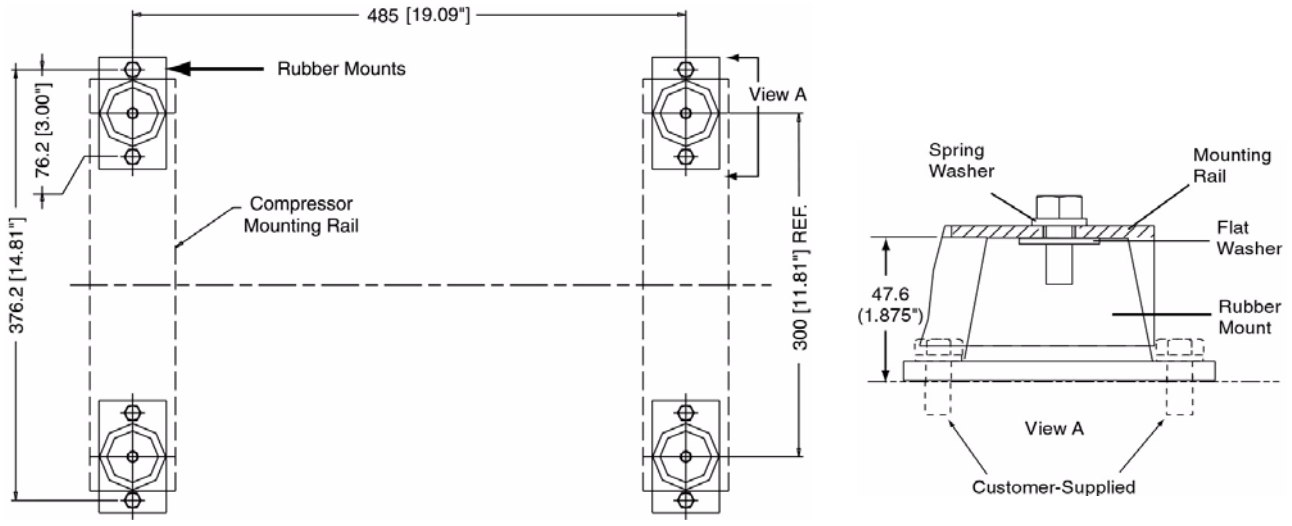


Figure 1-1 Compressor Mounting Details

Appendix B Valve/Flange Kit Installation Instructions

The instructions provided in this section apply to the following Turbocor valve/flange kits:

- suction service valve kit (100412)
- discharge service/non-return valve kit (100413)
- economizer service valve kit (100014)
- 3-1/8" flange kit (100402)
- discharge non-return valve kit (100479)
- 7/8" flange kit (100400)

Each individual valve kit includes o-ring, lubrication, and attaching hardware.

⚠ WARNING

Brazing without the use of dry nitrogen will result in debris being deposited in the pipework, potentially causing blockage and/or damage.

The heat generated from brazing can damage valve components. Always wrap a wet rag around the valve body to reduce valve temperature.

Mounting Instructions

1. Assemble the four sets of M16 x 45 hex-head screws and spring washers.
2. Align the suction valve/flange with the compressor suction port and insert the four hex-head screws. Using a 24mm combination wrench, tighten the screws to 75 Nm (55 ft-lbs).
3. Assemble the six sets of M10 x 35 hex-head screws and spring washers.
4. Align the discharge valve/flange with the compressor discharge port and insert the four hex-head screws. Using a 17mm socket, tighten the screws to 22 Nm (195 in-lbs).
5. If applicable, align the economizer valve/flange with the compressor economizer port and insert the two hex-head screws. Using a 17mm socket, tighten the screws to 22 Nm (195 in-lbs).

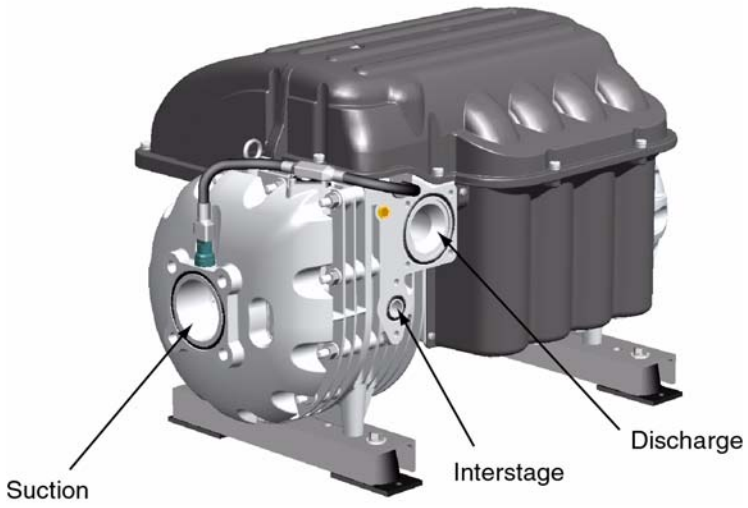


Figure 1-1 Compressor Ports

Appendix C Power Line Accessories Installation

Line Reactor Installation Instructions

These instructions apply to the installation of the line reactor kit in a main supply panel. Refer to the Application manual for product specifications.

AC Line Cable Connection (from external disconnect)

NOTE:
The customer is responsible for supplying the mounting hardware for the line reactor.

Figure 1-1 shows a schematic of the main input circuit and connections to the line reactor. Use this schematic as a guide for choosing the location of the line reactor.

1. Feed the AC line cable through the opening in the side of the main supply panel.
2. Attach the AC line wires to the line reactor terminals as shown in Figure 1-2.
3. Attach the ground cable to the mounting block on the panel wall. Ensure that there is good electrical/mechanical contact between the ground cable and the panel wall.
4. Secure the AC line cable to the box connector.

AC Line Cable Connection (to compressor terminal)

1. Feed the AC line cable through the opening in the side of the main supply panel.
2. Attach the AC line wires to the line reactor output terminals as shown in Figure 1-2. If a harmonic filter is being installed, attach its AC line wires to the line reactor output terminals. Refer to the harmonic filter installation instructions for further information.
3. Attach the ground wire to the mounting block on the panel wall. Ensure that there is good electrical/mechanical contact between the ground wire and the panel wall.
4. Refer to “Power Wiring” on page 10 for instructions on completing the AC input connection to the compressor.

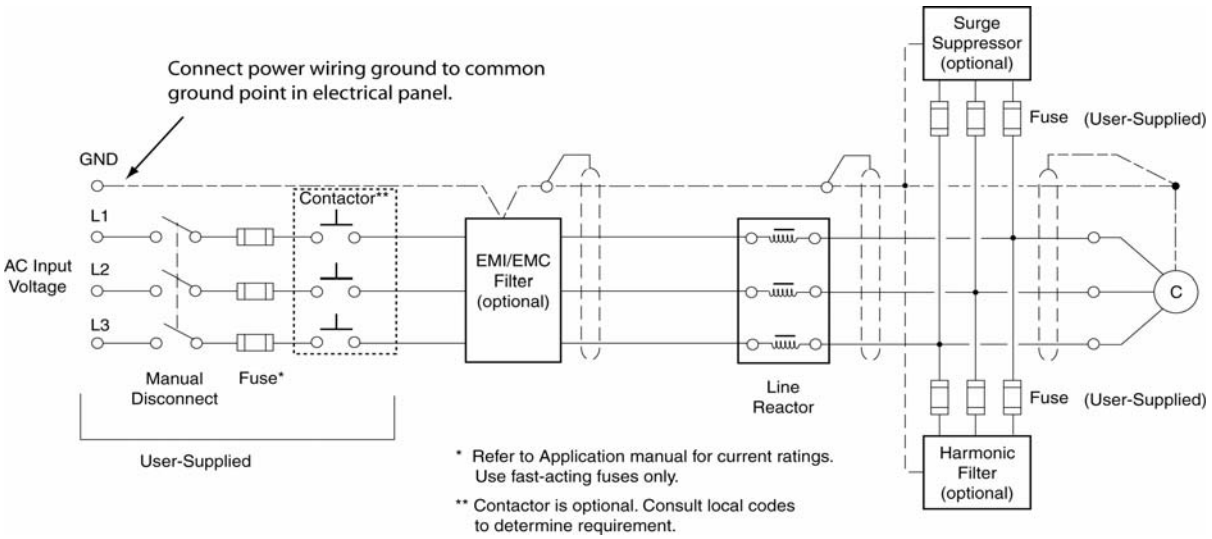


Figure 1-1 Main Input Schematic

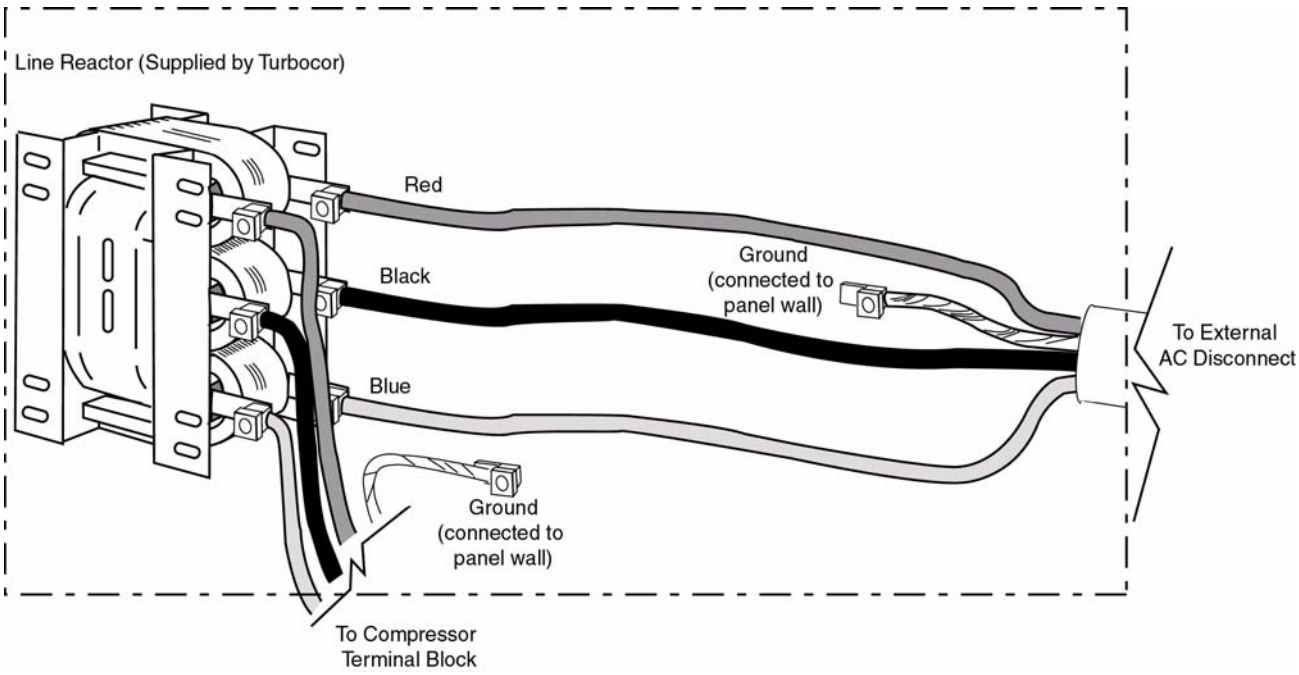


Figure 1-2 Line Reactor Connections

Harmonic Filter Kit Installation Instructions

These instructions apply to the installation of the harmonic filter kit. Figure 1-1 shows a schematic of the main input circuit and connections to the harmonic filter. Use this schematic as a guide for choosing the location of the harmonic filter.

AC Line Cable Connection (to harmonic filter)

1. Feed the AC line cable through the cable gland in the side of the harmonic filter enclosure.
2. Attach the AC line wires to the circuit breaker terminals as shown in Figure 1-3.
3. Attach the ground wire to the mounting block on the enclosure wall. Ensure that there is good electrical/mechanical contact between the ground wire and the enclosure wall.
4. Tighten the gland nut to secure the cable to the harmonic filter enclosure.

AC Line Cable Connection (at line reactor)

1. Feed the AC line cable through the opening in the side of the main supply panel.
2. Attach the AC line wires to the line reactor terminals.
3. Attach the ground wire to the mounting block on the panel wall. Ensure that there is good electrical/mechanical contact between the ground wire and the panel wall.

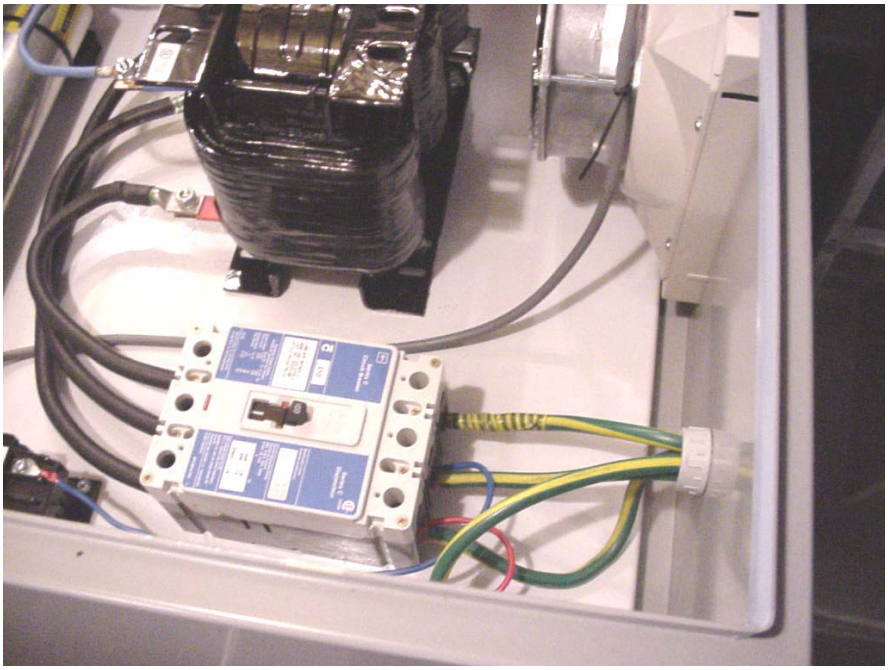


Figure 1-3 AC Input Connection at the Harmonic Filter

EMI/EMC Filter Installation Instructions

1. Mount the filter on the floor or on a wall in a vertical position.
2. Ensure that there is a minimum of 60 mm (2-3/8") of space for the cooling slots.

Line Side Connection

Input and output filter leads should be separated by a maximum practical distance within the enclosure and should be routed separately in interconnecting conduits when used; refer to Figure 1-4.

1. Insert the line wires into the terminals labelled L1, L2, and L3 on the 'Line' side of the filter. Tighten the terminal screws.
2. Attach the ground lug to the main ground bus and tighten the nut; refer to Figure 1-5.

NOTE:
A short, heavy, stranded conductor from the filter chassis to the main ground bus is recommended for top performance. A battery braid, litz wire, or flexible welding cable with many fine strands is recommended for best grounding performance.

Load Side Connection

1. Insert the load wires (from the line reactor) into the terminals labelled L1', L2', and L3'on the 'Load' side of the filter. Tighten the terminal screws.
2. Attach the ground lug to the main ground bus and tighten the nut.

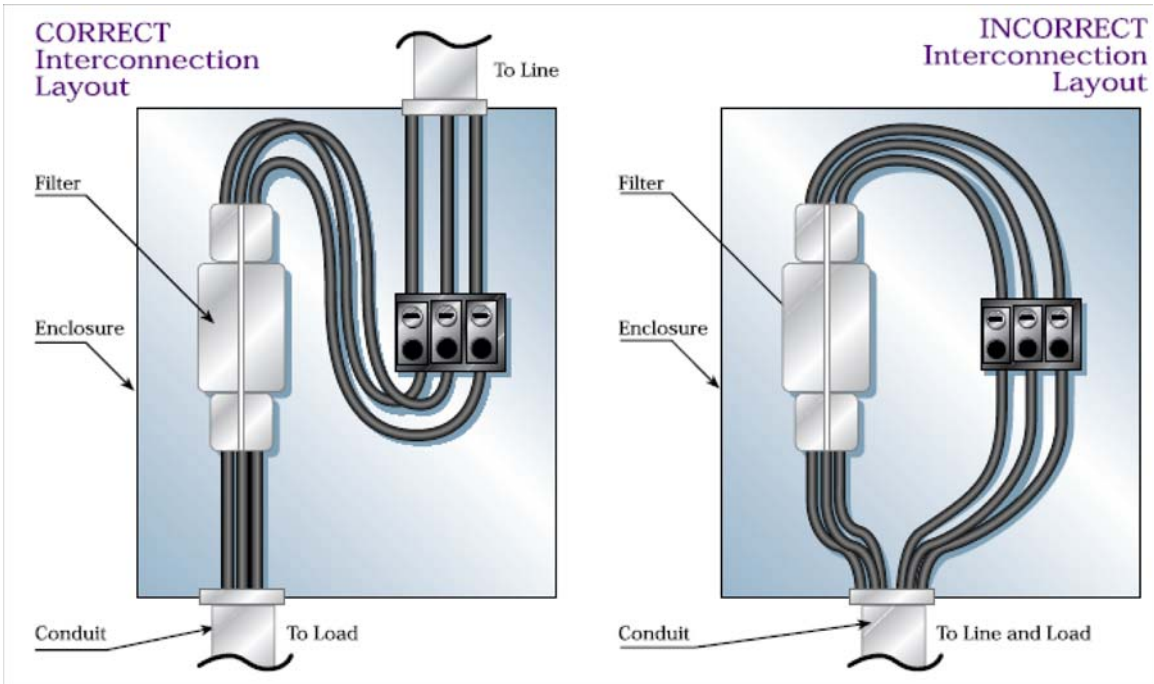


Figure 1-4 Interconnection Layout

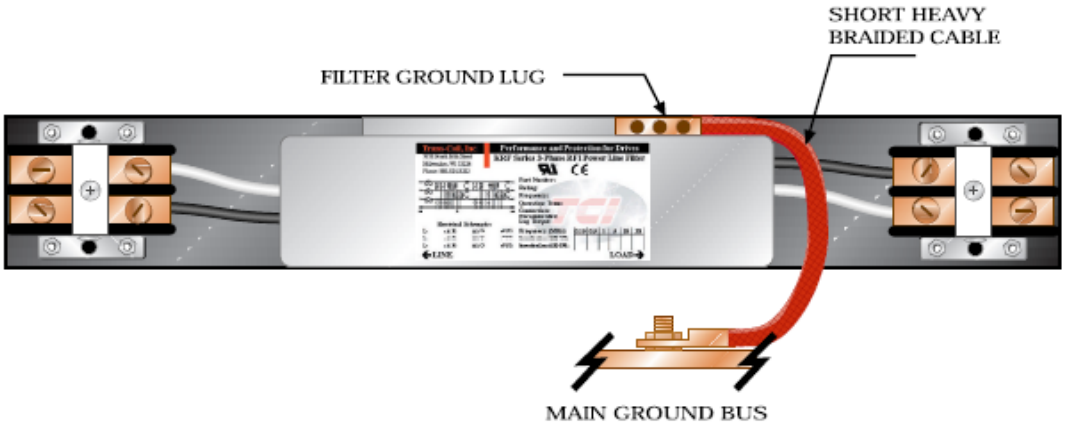


Figure 1-5 Grounding Diagram

Appendix D Commissioning Log

Job Details

Job Name: _____

Customer:
(equipment manufacturer) _____

Compressor Serial No.:_____

Equipment Serial No.: _____

Contractor: _____

Contact: _____

Tel. #: _____

Application:

- ☐ Air-cooled chiller (DX)
- ☐ Air-cooled chiller (flooded)
- ☐ Water-cooled chiller (DX)
- ☐ Water-cooled chiller (flooded)
- ☐ Air-cooled (rooftop)
- ☐ Evaporatively-cooled chiller (DX)
- ☐ Evaporatively-cooled chiller (flooded)
- ☐ Evaporatively-cooled (rooftop)
- ☐ Retrofit
- ☐ Other (specify) _____

Step	Procedure	Display Value	Measured Value
1.	Confirm that the line voltage is as per rated input +/-10%.	N/A	
2.	Remove the mains input cover. Using a voltmeter, check the line voltages at the compressor terminals and verify that they match the display readings (under the heading of Soft Start Data on the VSPMM form of the Monitor Program). Replace the mains input cover.		
3.	Check that all DC voltages on the backplane are within the specified range, as follows: **P/S:** **Range:** +5V 4.9 - 5.1V +15V 14.7 - 15.6V +17V 16.6 - 17.5V +24V 23.7 - 24.5V +250V 250 - 270V -15V -14.6 - 15.7V	N/A	+5V ____ +15V ____ +17V ____ +24V ____ +250V____ -15V ____

Step	Procedure	Display Value	Measured Value
4.	Complete the commissioning sequence using the Monitor Program.		
5.	Using a pressure gauge, check the suction, intermediate, and discharge pressures and verify that they match the display readings.		
6.	Using a temperature probe, check the suction, intermediate, and discharge temperatures and verify that they match the display readings.		
7.	Check operational temperatures and pressures are as per application.		

Attach a screen capture of the monitor display to this log sheet.

Commissioning Notes:

Technician Name: _____

Company: _____

Date: _____

Telephone No. _____

Note:This commissioning report must be duly completed and returned to Turbocor for warranty purposes.

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