TWIN-TURBINE CENTRIFUGAL COMPRESSOR

MODEL TT-300

SERVICE MANUAL

Danfoss Turbocor Compressors Inc.

ECD-00007S Rev. 2

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Proprietary Notice

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Contents

The purpose of this manual is to inform qualified service technicians on service requirements and troubleshooting techniques for the Turbocor twin-turbine centrifugal compressor.

The manual also covers "good practice techniques" and standard service procedures as prescribed by the operational maintenance schedule, or in response to system failure.

1 Safety Considerations

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 information is located throughout the manual to alert service personnel of potential hazards. The safety information is identified by the following special notice headings: DANGER, WARNING, and CAUTION. DANGER signifies the most serious hazards which will result in severe or fatal injury to personnel. CAUTION signifies hazards which could result in minor injury to personnel. WARNING identifies actions that could lead to possible damage to equipment or potential problems in the outcome of the procedure being performed.

This section consolidates the special notices that appear in this manual.

⚠ 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.

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

Removing the top cover will expose you to a high voltage (600-800 VDC) hazard. Exercise care when working around energized circuits.

⚠ DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

Make sure that electrical power is isolated from the AC mains cables before handling them.

⚠ 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.

Isolation and recovery of the refrigerant must be performed by a qualified service technician.

Always wear proper safety equipment when handling refrigerants

⚠ WARNING

It is extremely important that the manifold set is free of moisture and dust.

It is also important that the gauge set is calibrated and not contaminated with other refrigerants or oil.

When performing any service procedure that requires the addition of refrigerant, do not use reclaimed refrigerant unless it is of guaranteed quality and oil-free.

WARNING

During the soldering process, be sure that any component that may be affected by the addition of heat to the area be cooled by means of a wet rag wrapped around the component.

For chiller applications, make sure that the circulating pumps are on and that you have flow. Failure to do so can result in significant tube damage to the chiller.

WARNING

Make sure that there is no secondary power source connected to the Compressor Interface module before disconnecting the I/O cable.

Install new gaskets only when reattaching the ball valves to the compressor.

Recover refrigerant from the compressor before removing the diode and Inverter mounting screws. Removal of the mounting screws can break the seal under the heatsinks and release refrigerant.

2 Service Tools

This section lists the service tools that are required to perform the procedures in this manual.

Table 2-1 List of Service Tools

Tools	Spec.
Allen key set	2.5, 4, 5, 8, 14 mm 7/64"
Torx screwdriver	#25
Phillips screwdriver	#2, #3
Assorted sockets and driver	14, 16, 17 mm 18 mm deep socket 15/16", 1’1/8"
Combination wrench set	5/16", 7/16", 5/8" 10, 24 mm
Adjustable 14" wrench	
Manifold set	
Multimeter (with clamp-type ammeter and diode setting)	1000V AC-DC
Torque wrench	55 ft-lbs (75 Nm)
Putty knife	1”
Safety glasses	approved, impact-resistant
Grounding wrist strap	

3 Understanding the Compressor

The purpose of this section is to help those troubleshooting the compressor to identify and understand the use of all the input/output ports of the compressor components; and also to provide fundamental knowledge of the role each compressor component plays in the main fluid path, motor cooling system, and energy and signal flow.

3.1 Component Identification

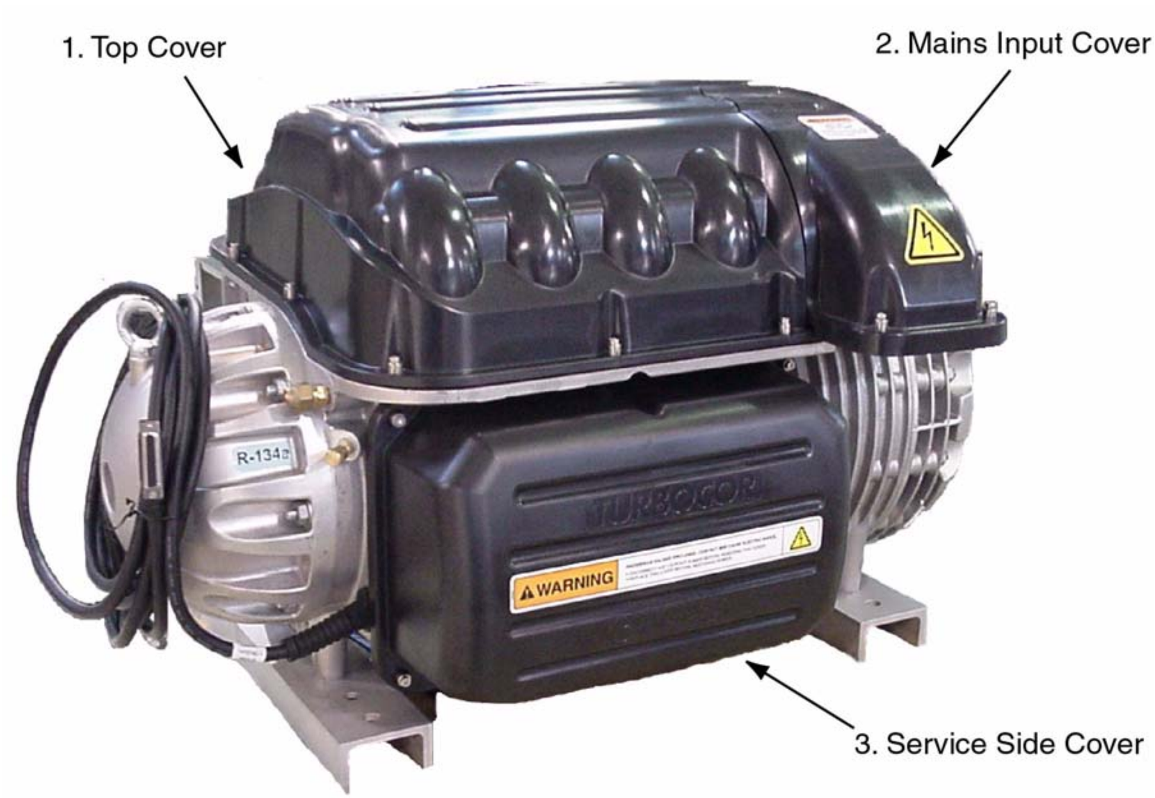

Figure 3-1 Compressor Access Covers

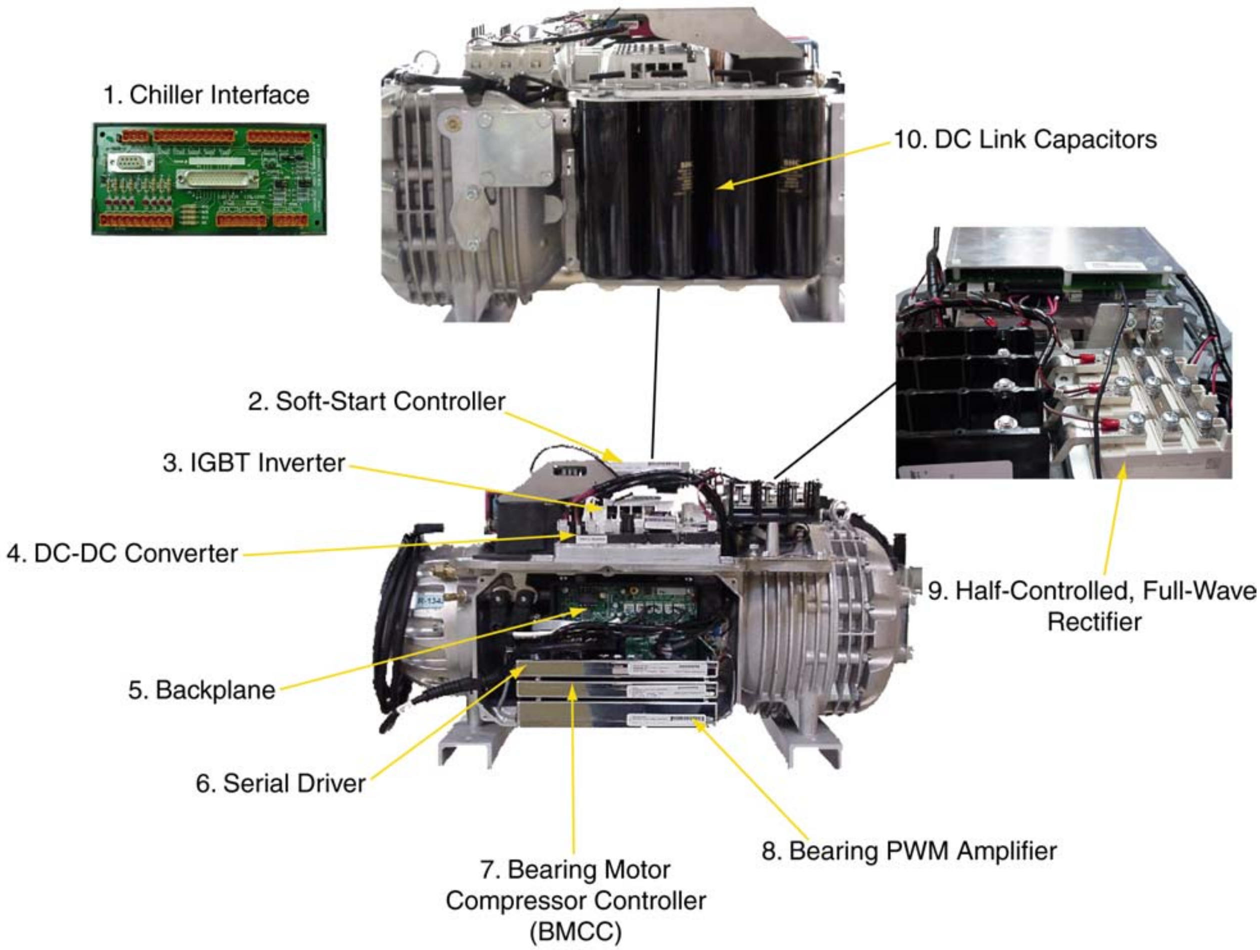

Figure 3-2 Compressor Electronic Circuit Components

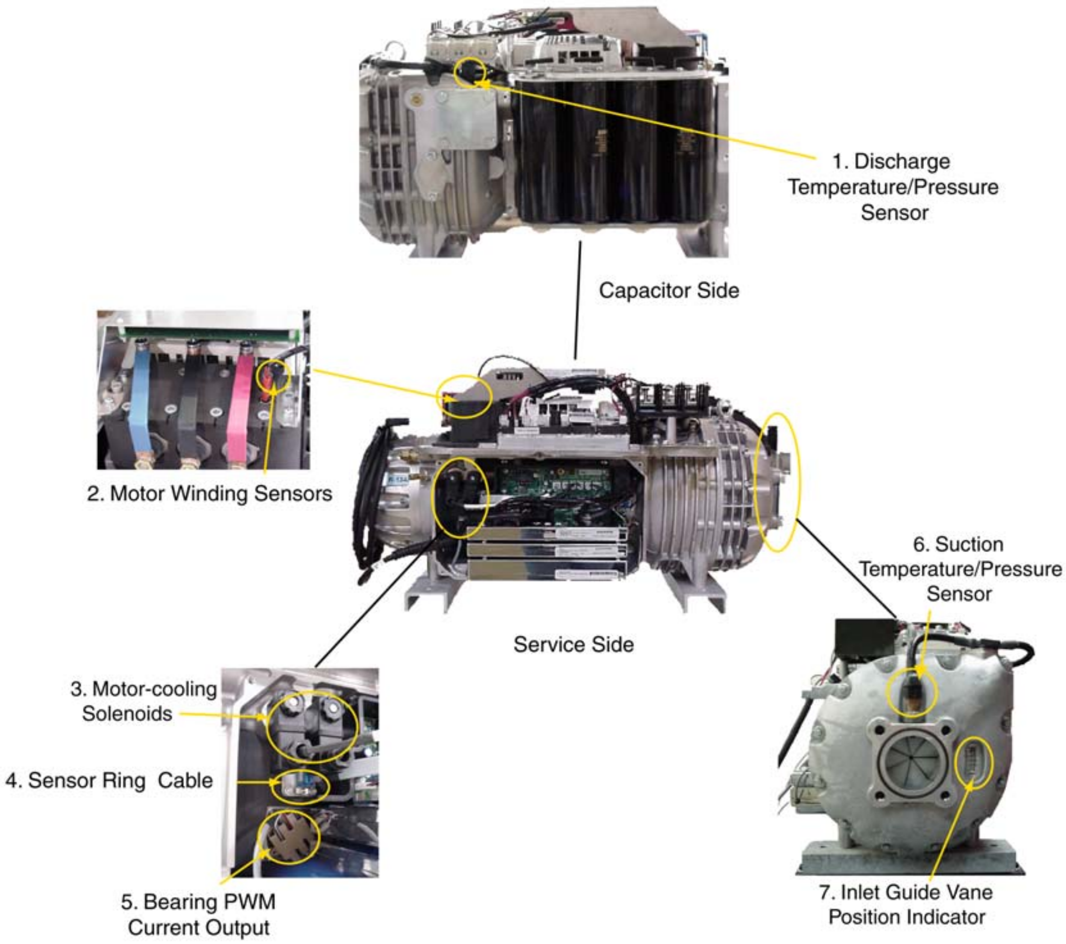

Figure 3-3 Compressor Sensors, Cables, and Indicators

3.2 Compressor Interconnections

This section details the inputs and outputs of the major compressor components.

3.2.1 Soft-Start Controller I/O

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 Controller takes as input a 3-phase voltage source at 50/60Hz from the input terminal, and a DC voltage signal from the Rectifier output. In turn, it outputs pulses to the Rectifier and provides power to the High-voltage (HV) DC-DC Converter.

Two versions of the Soft-Start Controller have been produced: P/N 220039 and P/N 200135. The module versions have identical I/O ports as shown in Figure 3-4 and Figure 3-5 and described in Table 3-1. Soft-Start Controller (P/N 200135) is equipped with status-indicating LEDs; refer to Table 3-2.

NOTE:
All voltages from the Soft-Start Controller are with respect to the positive DC bus and not the compressor ground.

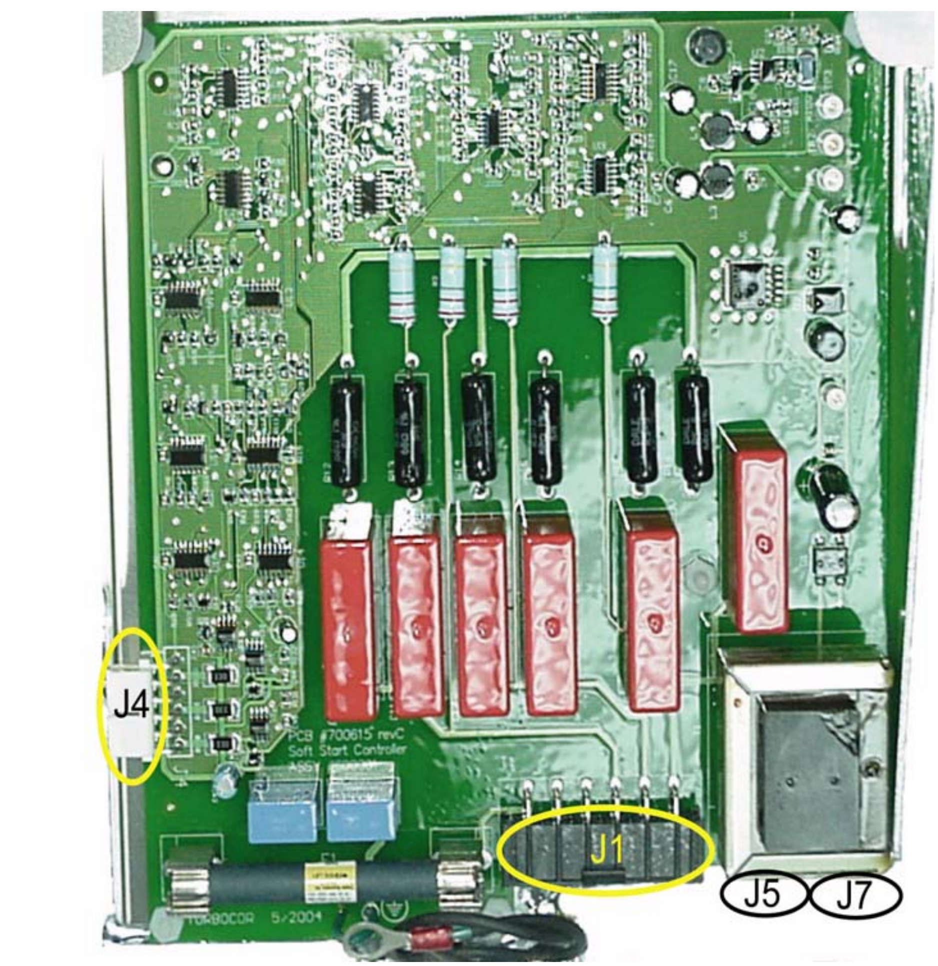

Figure 3-4 Soft-Start Controller (P/N 220039) Input/Output

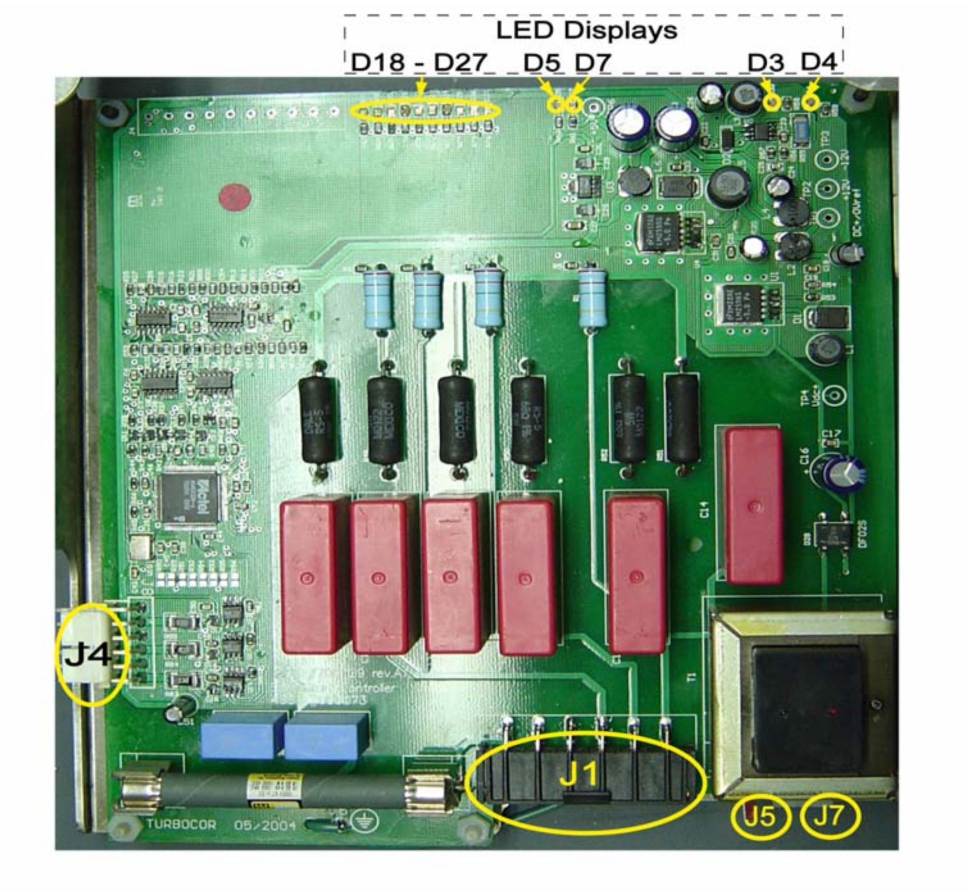

Figure 3-5 Soft-Start Controller (P/N 200135) Input/Output

Table 3-1 Soft-Start Controller Input/Output Port Description

Port	Type	Description
J1	IN/OUT	•**AC input:** From the AC input terminal block, a 3-phase voltage varying from 380-480VAC at 50/60Hz. •**DC input:** 460-720VDC input voltage from the Rectifier DC bus output. •**DC output:** 460-720VDC output to the HV DC-DC Converter. The DC input voltage is not only used by the DC voltage detector on the Soft-Start module, but is also routed through the fuse located next to input/output port J1 and then outputted to the HV DC-DC Converter. The fuse will break if the HV DC-DC Converter is overloaded, i.e., the HV DC-DC Converter is shorted
J4	OUT	•**DC output pulses:** Using the AC and DC voltage inputs from port J1, the Soft-Start Controller limits the inrush current by outputting pulses of 0-12VDC (with respect to the positive DC bus) to the Rectifier
J7	OUT	•**AC output:** Outputs 15VAC to the DC-DC Converter.

Table 3-2 Soft-Start Controller (P/N 200135) LED Designations

Designation	Type	Description
D3	LED (yellow)	ON: +12VDC obtained
D4	LED (yellow)	ON: - 12VDC obtained
D5	LED (yellow)	ON: + 2.5VDC obtained
D7	LED (yellow)	ON: + 5.0VDC obtained
D18	LED (green)	ON: 3-phase input signal detected
D19	LED (green)	ON: maximum peak voltage determined
D20	LED (green)	ON: capacitor charging period expiration
D21	LED (yellow)	ON: phase-loss detected
D22	LED (red)	ON: AC voltage exceeded 850V_p 3 times within 10 minutes
D23	LED (yellow)	ON: AC signal exceeds 850V
D24	LED (yellow)	ON: DC signal exceeds 850V
D25-D27	LED (red)	Soft Start error codes (see Table 3-3)

Table 3-3 Soft-Start Controller (P/N 200135) LED Display Error Codes

Failure Mode [D27:D25]	Description
000	Normal - No error
001	Peak voltage searching exceeds 6 seconds during start-up
010	Capacitor charging time-out
011	DC voltage exceeds high voltage level 3 times within 10 minutes
100	Phase loss detected while charging up
101	Phase loss detected while DC voltage is lower than the charge voltage
110	Reserved for future development
111	Reserved for future development

3.2.2 High-voltage DC-DC Converter I/O

DC-DC converters supply and electrically isolate the high and low DC voltages that are required by the control circuits. When the compressor is switched on, the high-voltage (HV) DC-DC Converter receives its initial power from the 15VAC supply from the Soft-Start Controller. Once the DC bus voltage has risen to a pretermined level, the HV DC-DC Converter's onboard circuits are powered by the DC bus (480-720VDC).

The HV DC-DC Converter delivers +24VDC (with respect to 0V) to the Backplane, and HV+ (+250VDC with respect to HV-) to the magnetic bearing PWM Amplifier via the Backplane.

Figure 3-6 shows the locations of the HV DC-DC Converter input/output ports, and Table 3-4 provides a description for each port.

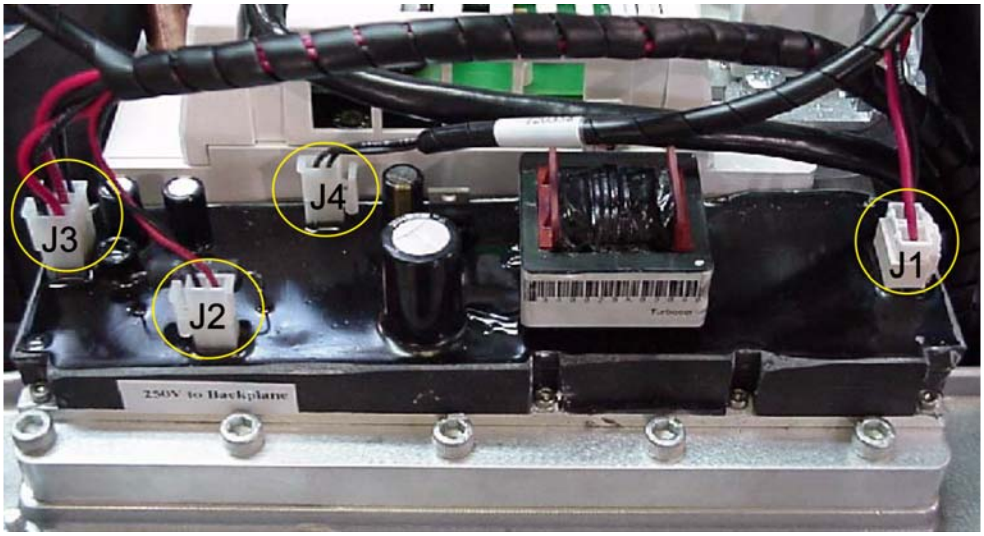

Figure 3-6 DC-DC Converter Input/Output

Table 3-4 HV DC-DC Converter Input/Output Port Description

Port	Type	Description
J1	IN	**DC input:** 480-720VDC input from the DC bus via the Soft-Start Controller fuse. Note that if the HV DC-DC Converter is overloaded, this fuse (located next to port J1 on the Soft-Start Controller - see Figure 3-5) will blow.
J2	OUT	**DC output:** HV+ (+250VDC with respect to HV-) output to the Backplane, in order to power the magnetic bearing PWM Amplifier.
J3	OUT	**DC output:** +24VDC output to power the Backplane
J4	IN	**AC input:** 15VAC power input from the Soft-Start Controller

3.2.3 Backplane I/O

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. It is a means to transfer control, sensor, and error information between the BMCC and other compressor components. The Backplane also serves as the source of power to the parts connected to it. It features on-board, low-voltage DC-DC converters for generating +15V, -15V, +5V, and +17V from its input of +24VDC. Note, however, that the +15V, -15V, and +5V are with respect to 0VDC, but the +17V is with respect to HV-.

The Backplane is also equipped with status-indicating LEDs. All LEDs are yellow except for the alarm LED which is green/red.

Figure 3-7 shows the locations of the Backplane input/output ports, and Table 3-5 provides a description of each port.

For connection ports J16-J21 and J23, Table 3-6 provides details about each connector pin input/output direction, signal level, and signal source. Refer to Figure 3-8 and Figure 3-9 for the pin numbering on the connectors.

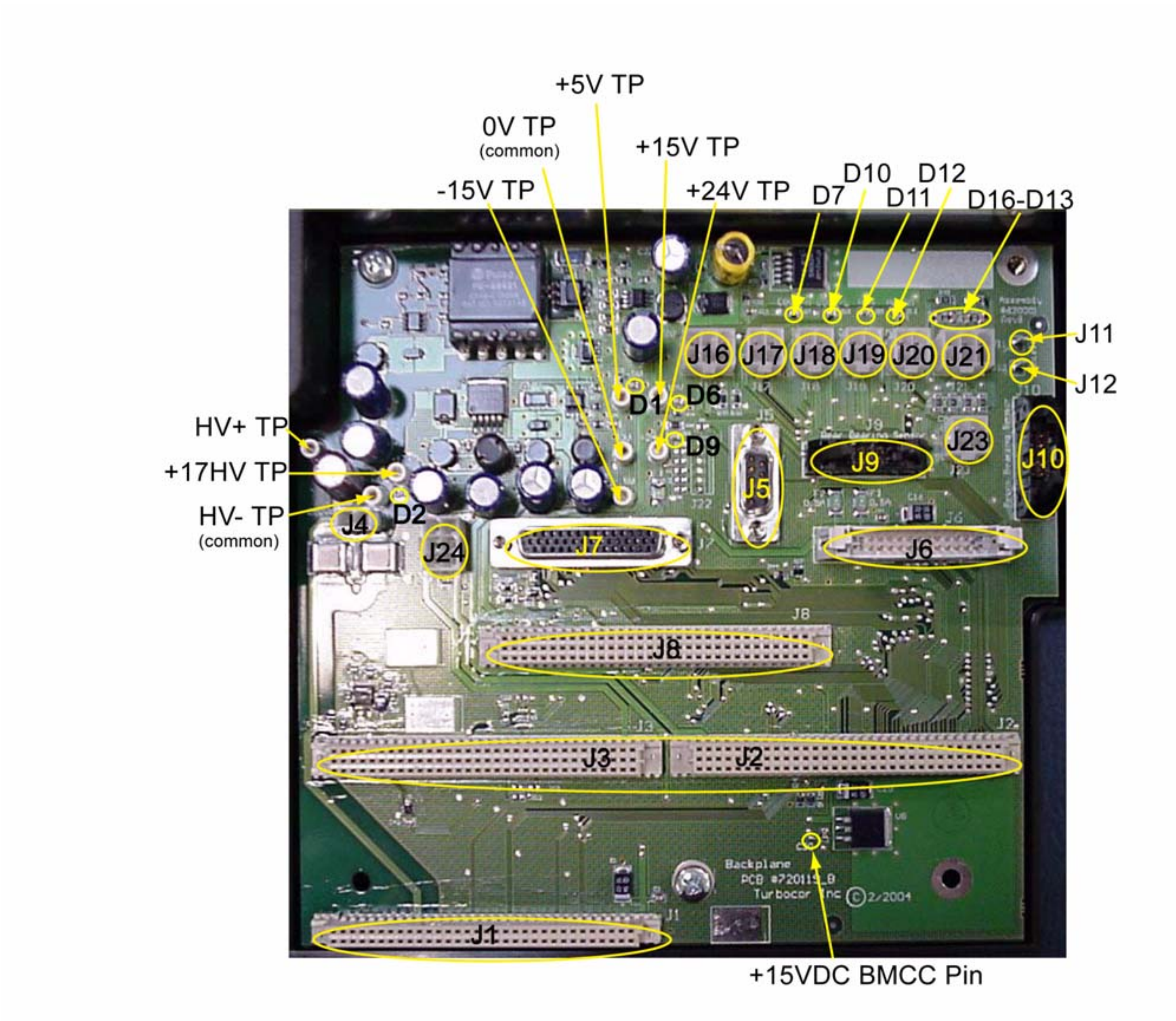

Figure 3-7 Backplane Input/Output

Table 3-5 Backplane Input/Output Port Description

Port	Type	Description
J1	IN/OUT	*Bearing Pulse-Width-Modulation (PWM) Amplifier connection port* •**Input:** PWM Amplifier passes feedback from a current sensor for the bearing coils, and a spare temperature sensor reading for the heat sink. The Backplane in turn reroutes the feedback information to the Bearing Motor Compressor Controller (BMCC). •**Output:** To power the bearing PWM Amplifier, the Backplane outputs +5VDC (with respect to 0VDC), +17VDC (with respect to HV-), and HV+ (+250VDC with respect to HV-). It also outputs pulses to control the PWM Amplifier.
J2 & J3	IN/OUT/COM	*Bearing Motor Compressor Controller (BMCC) connection port* •**Input:** The BMCC sends control signals to the Backplane to reroute to the appropriate compressor modules. •**Output:** The Backplane powers the BMCC by providing it with +15VDC and -15VDC (both with respect to 0VDC). •Communication: RS485/RS232, MODBUS
J4	IN	**DC input:** HV+ (+250VDC with respect to HV-) input from the DC-DC Converter
J5	COM	RS232 communication port (for initial program loading use only)
J6	IN/OUT	*IGBT connection port* •**Input:** The IGBT inputs current, temperature, error, and DC bus voltage information for the Backplane to reroute to the BMCC. •**Output:** The Backplane outputs +24VDC (with respect to 0VDC) and gating signals to the IGBT for it to control the motor.
J7	COM	RS232 communication bus with the Compressor Interface
J8	OUT/COM	*Serial Driver connection port* •**DC Output:** The Backplane sends +15VDC and +24VDC, both with respect to 0VDC, to power the Serial Driver. •**Communication:** I^2C
J9	IN	**Sensor Input:** Inputs shaft position from rear bearing sensor
J10	IN	**Sensor Input:** Inputs shaft position from front bearing sensor
J11	OUT	Connects metallic covering of the rear bearing sensor cable to ground
J12	OUT	Connects metallic covering of the front bearing sensor cable to ground
J16	OUT	**Control Output:** Output to control motor-cooling solenoids
J17	IN	**Sensor Input:** Intermediate temperature/pressure sensor input (not used)
J18	IN	**Sensor Input:** Suction temperature/pressure sensor input
J19	IN	**Sensor Input:** Discharge temperature/pressure sensor input
J20	IN	**Sensor Input:** Motor winding sensor input
J21	OUT	**Control Output:** Output to control the IGV motor
J23	IN	**Sensor Input:** Input from the cavity sensor (motor temperature probe)
J24	IN	**DC Input:** +24VDC input from the DC-DC Converter

Table 3-5 Backplane Input/Output Port Description (Continued)

Port	Type	Description
HV+TP	OUT	+ High voltage test point HV+ (+250VDC with respect to HV-)
+17HV	OUT	+ 17VDC test point with respect to HV-
HV- TP	OUT	- High voltage test point (HV-)
+24V TP	OUT	+24VDC test point with respect to 0VDC
+15V TP	OUT	+15VDC test point with respect to 0VDC
+5V TP	OUT	+5VDC test point with respect to 0VDC
0V TP	OUT	0VDC ground test point
-15V TP	OUT	-15VDC test point with respect to 0VDC
+15V BMCC	OUT	+15VDC test point with respect to 0VDC (+15VDC BMCC source)
D1	LED	ON: voltage present, must measure +5V TP to confirm +5VDC obtained
D2	LED	ON: voltage present, must measure +17V TP to confirm+17VDC obtained
D6	LED	ON: voltage present, must measure +15V TP to confirm+15VDC obtained
D7 (COOL-H)	LED	ON: 24V power provided from Backplane to solenoid
D9	LED	ON: voltage present, must measure +24V TP to confirm+24VDC obtained
D10 (COOL-L)	LED	ON: 24V power provided from Backplane to solenoid
D11 (RUN)	LED	ON: 'RUN' relay contact on Serial Driver is closed, i.e., shaft is running. This indication is extended to the Compressor Interface module.
D12 (ALARM)	LED	• GREEN: indicates normal mode, compressor is idle, waiting for command; 'STATUS' relay contact on Serial Driver is closed This indication is extended to the Compressor Interface module. • RED: indicates compressor reset or alarm; 'STATUS' relay contact on Serial Driver is open. This indication is extended to the Compressor Interface module.
D13-D16	LED	IGV motor indicator; LEDs flicker when driving the motor

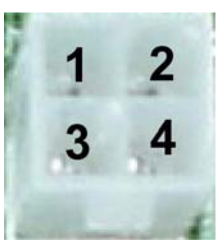

Figure 3-8 Connector Layout - 4 Pin

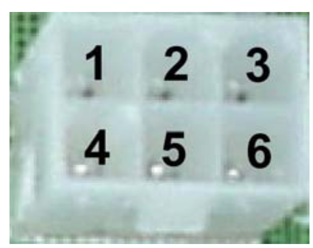

Figure 3-9 Connector Layout - 6 Pin

Table 3-6 Backplane Pin Details

Connector	Pin	Direction	Description	Signal Level	Source/Destination
J16	1	OUT	Cooling HI	+24V	from relay contact on the Serial Driver through the Backplane via fuse 2 (F2)
	2	OUT	Supply	0V	Backplane
	3	OUT	Supply	0V	Backplane
	4	OUT	Cooling LO	+24V	from relay contact on the Serial Driver through the Backplane via fuse 3 (F3)
J17 J18 J19	1	OUT	Supply	0V	Backplane
	2	IN	Temp. sensor 10K@25ºC	5V max	BMCC pull-up
	3	IN	Pressure sensor	0-5V	BMCC
	4	OUT	Supply	0V	via 10Ω from BMCC
J20	1	IN	Temp. sensor 10K@25ºC	5V max	BMCC pull-up
	2	IN	Temp. sensor switch 155ºC	2.5V max	BMCC pull-up
	3	OUT	Supply	0V	via 10Ω from BMCC
	4	OUT	Supply	0V	via 10Ω from BMCC
J21	1	OUT	Pulsed motor drive	15V	from IC on Serial Driver
	3	OUT	Pulsed motor drive	15V	from IC on Serial Driver
	4	OUT	Pulsed motor drive	15V	from IC on Serial Driver
	5	OUT	Pulsed motor drive	15V	from IC on Serial Driver
J23	1	Connected to J20, pin 1			
	3	Connected to J20, pin 3			

3.2.4 Compressor Interface I/O

The Compressor Interface module allows the user to interact with the compressor. It allows the user to control the compressor, and for the compressor to return status and sensor information to the user.

Figure 3-10 shows the locations of the Compressor Interface input/output ports, and Table 3-7 provides a description for each port.

Figure 3-11 and Figure 3-12 identify the jumpers on the Compressor Interface module, and Table 3-8 explains each jumper functionality and setting.

Figure 3-13 shows the pin layout on the Compressor Interface module, and Table 3-9 provides details about the pin input/output direction, signal level, and signal source.

Figure 3-10 Compressor Interface Input/ Output

Table 3-7 Compressor Interface Input/Output Port Description

Port	Type	Name	Description
J1	COM	MODBUS (RS485)	RS485 communication bus with the chiller controller or monitor program
J2	IN	DEMAND	Analog demand input to drive compressor (0-10V)
	IN	I/LOCK	*Switch to start compressor* •ON: (+) and (-) ports shorted •OFF: (+) and (-) ports open
	OUT	STATUS	Compressor error status
	OUT	SPEED	Compressor motor speed (0-5V where 10,000 RPM/volt)
	IN	LIQDT	Liquid temperature input
J3	OUT	RUN	Compressor running indicator
	OUT	ANALOG	Analog output control signal (0-5V or 0-10V)
	IN	ENTRY	Entering water temperature sensor
	IN	LEAVE	Leaving water temperature sensor
J4	OUT	EXV1	External expansion valve 1
	OUT	EXV2	External expansion valve 2
J5	IN	LIQ LEV1	Liquid level sensor driving the external expansion valve1 (EXV1)
	IN	LIQ LEV2	Liquid level sensor driving the external expansion valve2 (EXV2)
J6	COM	RS232	RS232 communication bus with the Backplane
J7	COM	MODBUS (RS232)	RS232 communication bus with the chiller controller or monitor program
J8	IN	SPARE T	Spare temperature sensor
	IN	SPARE P	Spare pressure sensor
D1-D4	LED	--	External Expansion Valve 1 (EXV1) motor indicator, LEDs flicker when driving EXV1 (refer to Table 4-14 for fault diagnosis)
D5-D8	LED	--	External Expansion Valve 2 (EXV2) motor indicator, LEDs flicker when driving EXV2 (refer to Table 4-14 for fault diagnosis)
D9	LED	--	ON: compressor is on (i.e Compressor Interface module and BMCC properly connected to the Backplane)

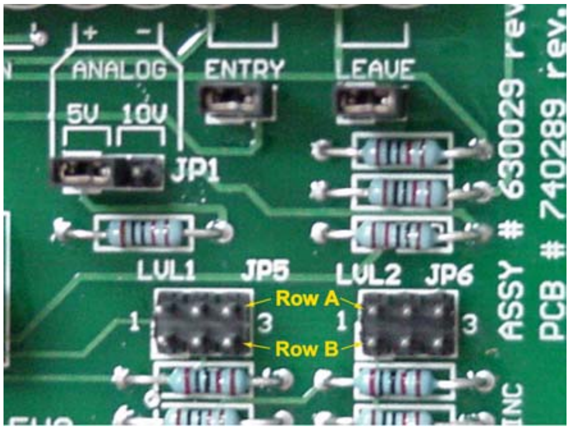

Figure 3-11 Compressor Interface Jumper Locations (1 of 2)

Figure 3-12 Compressor Interface Jumper Locations (2 of 2)

Table 3-8 Compressor Interface Jumper Detail

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 Compressor 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 Compressor 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	Jumper reserved for future development. Leave jumper off in current configuration.

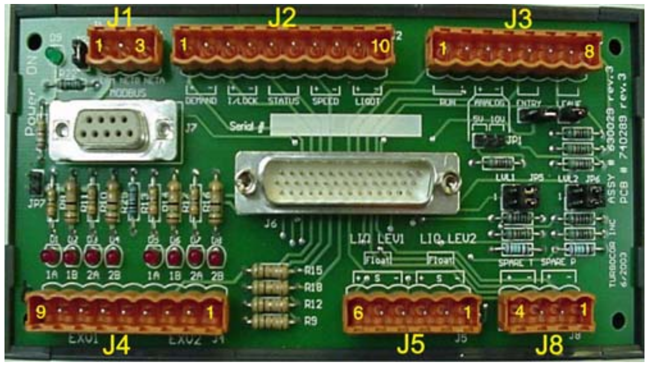

Figure 3-13 Compressor Interface Pin Layout

Table 3-9 Compressor Interface Pin Details

Connector	Pin	Direction	Description	Signal Level	Source/Destination
J1	1	OUT	Isolated ground	0V	BMCC
	2	IN/OUT	RS485	5V max	BMCC
	3	IN/OUT	RS485	5V max	BMCC
J2	1	IN	Demand (+)	0-10V	BMCC
	2	IN	Demand (-)	0V	via 10Ω from BMCC
	3	IN	Interlock	5V max	BMCC pull-up
	4	IN	Interlock	0V	via 10Ω from BMCC
	5	OUT	Status	-	common relay on Serial Driver
	6	OUT	Status	-	normal operation relay on Serial Driver
	7	OUT	Speed (+)	0-10V	BMCC
	8	OUT	Speed (-)	0V	via 10Ω from BMCC
	9	IN	Temp. sensor 10K@25ºC	5V max	BMCC pull-up
	10	IN	Supply	0V	via 10Ω from BMCC
J3	1	OUT	Run	-	common relay on Serial Driver
	2	OUT	Run	-	compressor running relay on Serial Driver
	3	OUT	Analog	0-5V 0-10V	JP1 on Compressor Interface set to 5V JP1 on Compressor Interface set to 10V signal source: BMCC
	4	OUT	Supply	0V	via 10Ω from BMCC
	5	IN	Temp. sensor 10K@25ºC	5V max	BMCC pull-up
	6	IN	Supply	0V	via 10Ω from BMCC
	7	IN	Temp. sensor 10K@25ºC	5V max	BMCC pull-up
	8	IN	Supply	0V	via 10Ω from BMCC

Table 3-9 Compressor Interface Pin Details (Continued)

Connector	Pin	Direction	Description	Signal Level	Source/Destination
J4	1	OUT	Pulsed motor drive	15V	IC on Serial Driver
	2	OUT	Pulsed motor drive	15V	IC on Serial Driver
	3	OUT	Pulsed motor drive	15V	IC on Serial Driver
	4	OUT	Pulsed motor drive	15V	IC on Serial Driver
	5	-	-	-	-
	6	OUT	Pulsed motor drive	15V	IC on Serial Driver
	7	OUT	Pulsed motor drive	15V	IC on Serial Driver
	8	OUT	Pulsed motor drive	15V	IC on Serial Driver
	9	OUT	Pulsed motor drive	15V	IC on Serial Driver
J5	1	OUT	Liquid level 2 (-)	0V	via 10Ω from BMCC
	2	IN	Liquid level 2 signal	15V max	jumper JP5 set to 2a/3a and 2b/3b source: BMCC
	3	OUT	Liquid level 2 (+)	15V	via 100Ω from Backplane
	4	OUT	Liquid level 1 (-)	0V	via 10Ω from BMCC
	5	IN	Liquid level 1 signal	15V max	jumper JP6 set to 2a/3a and 2b/3b source: BMCC
	6	OUT	Liquid level 1 (+)	15V	via 100Ω from Backplane
J8	1	IN	Pressure sensor	0-5V	BMCC
	2	OUT	Supply	5V	via 10Ω from BMCC
	3	OUT	Supply	0V	via 10Ω from BMCC
	4	IN	Temp. sensor 10K@25ºC	5V max	pull-up from BMCC

3.3 Compressor Fundamentals

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

3.3.1 Main Fluid Path

(Refer to Figure 3-14)

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

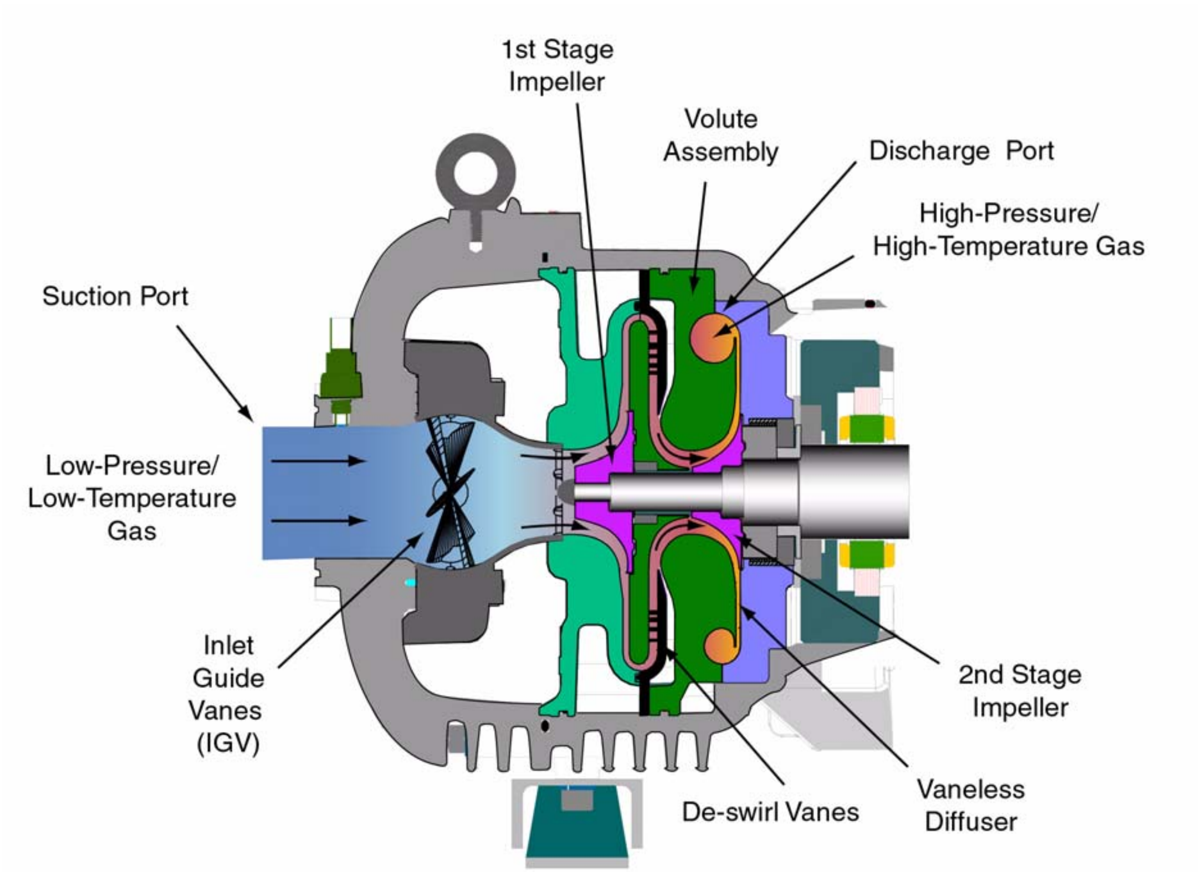

Figure 3-14 Compressor Fluid Path

3.3.2 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 3-15.

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.

From the outlet of the orifices, the refrigerant is directed to the heatsink plate of the IGBT Inverter and then to the underside of the Rectifier heatsink. From there, the refrigerant 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.

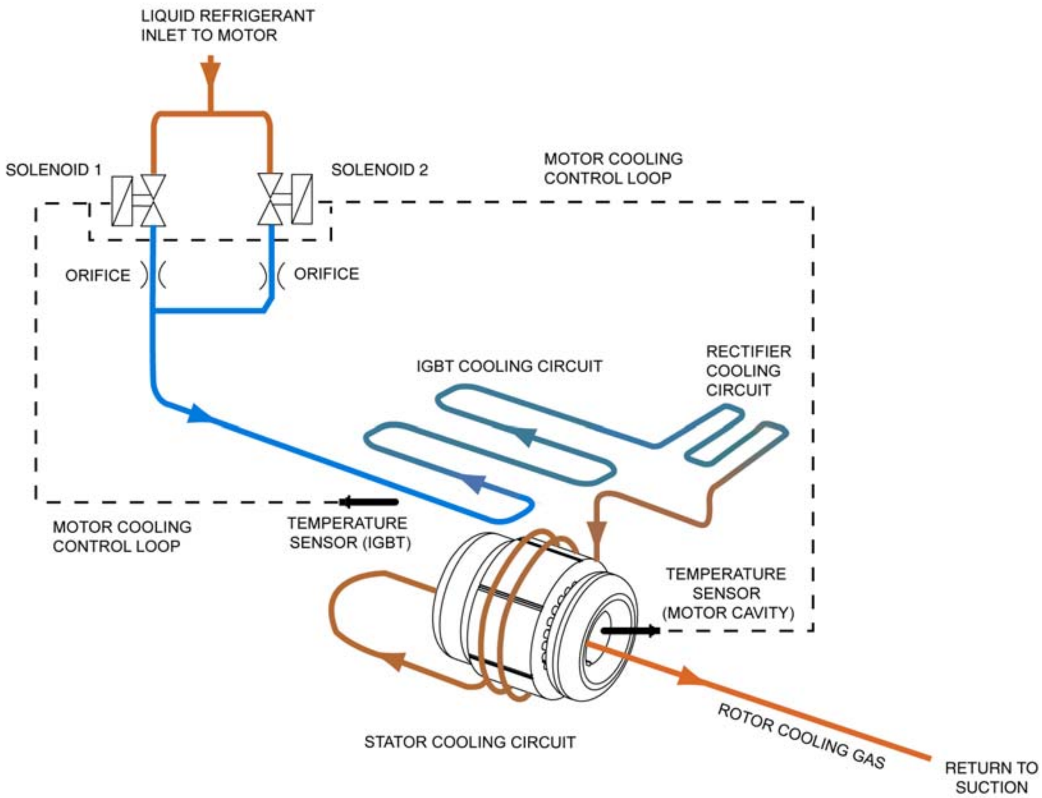

Figure 3-15 Compressor Cooling

3.3.3 Inlet Guide Vanes

The Inlet Guide Vanes (IGV) assembly is a variable-angle guiding device 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.

3.3.4 Energy and Signal Flow

This sections describes how energy and voltage signals are propagated through the compressor.

Normally, AC power to the compressor remains on, even when the compressor is in the stand-by state. 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 the components.

The compressor motor requires a 3-phase voltage source at 50/60Hz for variable speed operation. Entering through the compressor voltage input, energy flows through the following major components:

- Soft-Start Controller
- Half-Controlled, Full-Wave Rectifier
- DC Link Capacitors
- IGBT Inverter
- DC-DC Converter
- Backplane
- Bearing Motor Compressor Controller (BMCC)
- Serial Driver Module

- Compressor Interface Module
- Bearing PWM Amplifier

Refer to Figure 3-2 to identify the major components on the compressor.

Use Figure 3-16 to locate the connections on the compressor through which energy and voltage signals are transferred. The connections for the Soft-Start Controller, DC-DC Converter, Backplane, and Compressor Interface are shown and described later in the chapter. Refer to Figure 3-17 for a block-diagram summary of the energy and voltage signal flow through the compressor

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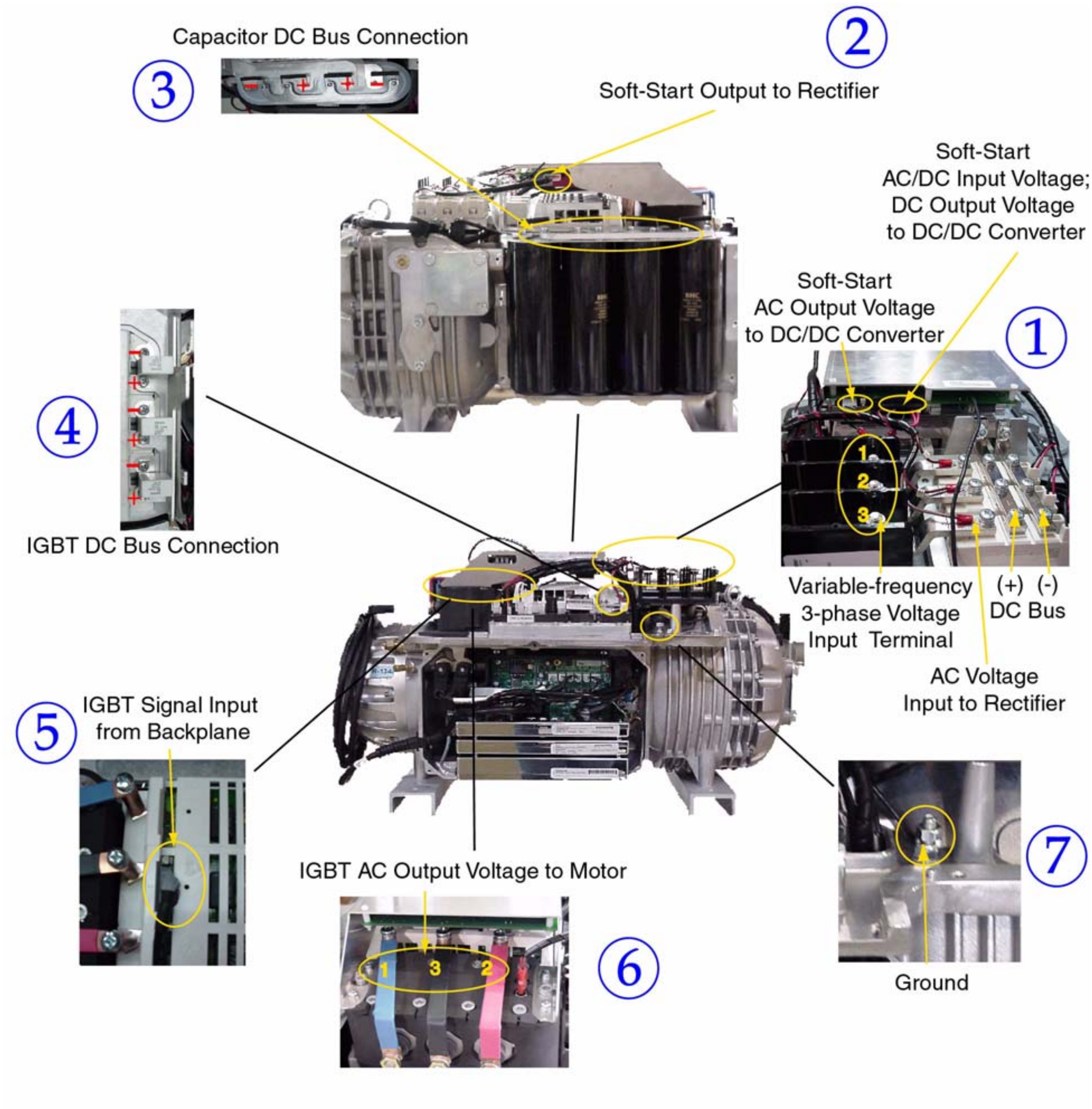


Figure 3-16 Compressor Energy and Signal Flow Connections

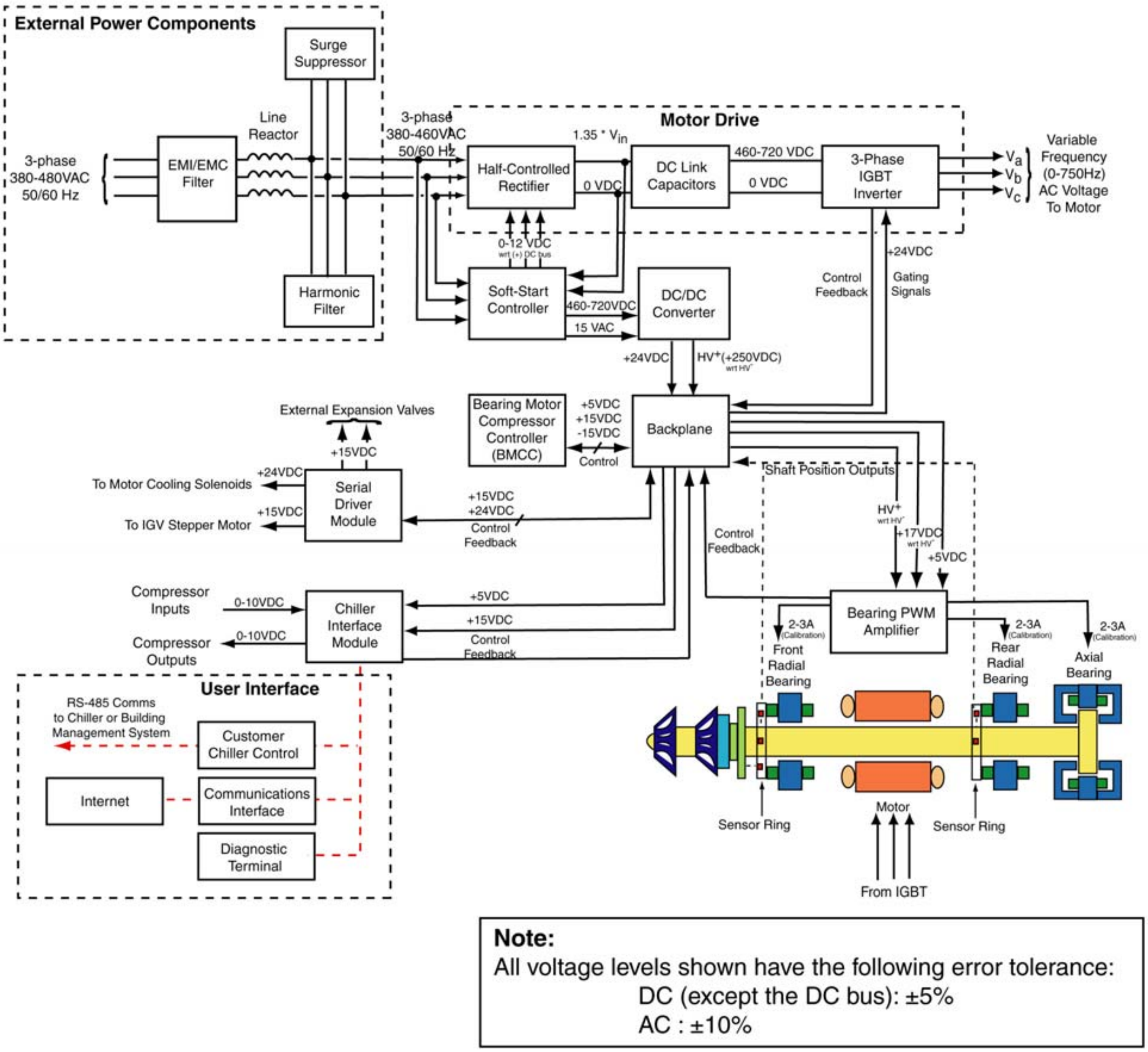


Figure 3-17 Compressor Energy and Control Flow Block Diagram

3.3.4.1 AC Voltage Input to Soft-Start Controller

A 3-phase voltage source is provided to the compressor through the voltage input terminal. The input voltage varies between 380-480VAC, at a frequency of 50/60Hz. The Soft Start Controller limits the inrush current at power-up. Refer to Figure 3-16, point (1) to locate the AC voltage input terminal and the Soft-Start AC input port.

3.3.4.2 AC Voltage Input to Rectifier

The AC line power is routed to the half-controlled, full-wave Rectifier to convert the AC voltage into DC voltage. The DC bus voltage output from the Rectifier is approximately 1.35 times that of the input signal, i.e., with an error tolerance of ±10%, the DC bus has a voltage of 460-720VDC depending on the value of the AC input voltage. The DC voltage output from the Rectifier is then fed into the Soft-Start Controller for voltage monitoring.

See Figure 3-16, point (1) to locate the AC voltage input port to the Rectifier, the Rectifier DC bus output, and the DC input to the Soft-Start Controller.

3.3.4.3 Soft-Start Controller to Rectifier

Using both the AC input voltage source and the DC voltage output from the Rectifier, the Soft-Start Controller generates the inrush current control signal and outputs pulses of 0-12VDC (with respect to the positive DC bus) to the Rectifier. The output of the Soft-Start Controller is identified in point (2) of Figure 3-16.

3.3.4.4 Soft-Start Controller to DC-DC Converter

The Soft-Start Controller not only uses the DC voltage to generate the inrush current control signal, but it also reroutes the DC voltage through a fuse and sends out the same DC voltage to the DC-DC Converter. In addition, the Soft-Start Controller also powers the DC-DC Converter with 15VAC. The Soft-Start AC and DC output ports to the DC-DC Converter are shown in point (1) of Figure 3-16.

3.3.4.5 Rectifier to DC Link Capacitors

DC Link Capacitors at the Rectifier output serve as energy storage and filter out the voltage ripple to provide a smooth DC voltage. Figure 3-16, point (3), shows the capacitor connections with the DC bus.

3.3.4.6 DC Link Capacitors to IGBT Inverter

The DC Link Capacitors provide the Insulated-Gate-Bipolar Transistor (IGBT) Inverter with 460-720VDC. The IGBT DC bus connections are shown in point (4) of Figure 3-16. The IGBT Inverter converts the DC link voltage into an adjustable frequency and adjustable amplitude, 3-phase simulated AC voltage.

3.3.4.7 DC-DC Converter to Backplane

The Backplane is powered by +24VDC (with respect to 0V) from the high-voltage (HV) DC-DC Converter. The HV DC-DC Converter also provides the Backplane with HV+ (+250VDC with respect to HV-) for the PWM Amplifier. The Backplane physically interconnects the on-board plug-in modules with the power electronics, inlet guide vanes (IGV) stepper motor, motor cooling solenoids, rotor position sensors, and pressure/temperature sensors. It is a means to transfer control, sensor, and error information between the BMCC and other compressor components.

3.3.4.8 Backplane Power Distribution

The Backplane also serves as the source of power to the parts connected to it. It features on-board, low-voltage DC-DC converters for generating +5V, +15V, -15V, and +17V from its input of +24VDC. Note, however, that the +5V, +15V, and -15V are with respect to 0VDC, but the +17V is with respect to HV-.

3.3.4.9 Backplane to Serial Driver

The Backplane provides +15VDC and +24VDC to the Serial Driver. The Serial Driver, in turn, uses +15VDC to control the external expansion valve stepping motors and the IGV stepper motor. The +24VDC is used by the Serial Driver to control the motor cooling solenoids.

3.3.4.10 Backplane to BMCC

In addition, the Backplane powers the BMCC with +5VDC, +15VDC and -15VDC. The BMCC uses the power source to process current, sensor and error information.

3.3.4.11 Backplane to PWM Amplifier

The Backplane also provides the bearing PWM Amplifier with +5VDC, along with +17VDC and HV+ (both with respect to HV^-). The bearing PWM Amplifier uses the energy to supply current to the radial and axial magnetic bearing actuators, as commanded by the BMCC. In return, the PWM Amplifier passes feedback from the current sensor for the bearing coils, and a spare temperature sensor for the heat sink.

3.3.4.12 Backplane to IGBT Inverter

The Backplane sends +24VDC and gating signals to the IGBT. In return, the IGBT Inverter sends current, temperature, error, and DC bus voltage information to the BMCC via the Backplane. Point (5) of Figure 3-16 shows the location where the gating signals enter the IGBT Inverter, and where the feedback control is output from the IGBT Inverter. With the input gating signals, the IGBT Inverter controls the motor at a variable frequency of 0-750Hz. Point (6) of Figure 3-16 shows the location on the compressor where the IGBT Inverter outputs control to the motor.

3.3.4.13 Compressor Ground

Finally, note the location of the compressor ground from Figure 3-16 at point (7).

4 Troubleshooting

DANGER

This equipment contains hazardous voltages that can cause injury or death. When a procedure requires that the power be turned off, wait ten minutes for the DC bus capacitors to de-energize before working on the equipment.

4.1 Fault Indications

Compressor faults are categorized according to the degree that the monitored parameter exceeds its set limit.

Alarms indicate a condition at the limit of the normal operating envelope. Compressor alarms will still allow the compressor to run, but speed is reduced to bring the fault condition under the set point.

Critical faults indicate an intolerable or unsafe condition that will result in equipment failure. Critical faults will cause the compressor controller to reduce speed and shut down the system within 60 seconds. At that time, the chiller controller drops the demand signal to the compressor. This type of fault requires a manual or auto reset from the chiller controller, as configured by the OEM.

Table 4-1 Alarm/Limit Trip Points (OEM Model-specific)

Compressor Model	Input Current A		Discharge Pressure* kPa (psi)		Discharge Temp. °C (°F)	
	Alarm	Limit	Alarm	Limit	Alarm	Limit
TT300-A2-1-ST-N-O-NC	85	94	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A3-1-ST-N-O-NC	106	117	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A4-1-ST-N-O-NC	113	124	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A5-1-ST-N-O-NC	122	134	1537 (223)	1600 (232)	95 (203)	100 (212)
TT300-A6-1-ST-N-O-NC	135	145	1537 (223)	1600 (232)	95 (203)	100 (212)
TT300-A2-1-ST-P-O-NC	85	94	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A3-1-ST-P-O-NC	106	117	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A4-1-ST-P-O-NC	113	124	1191 (173)	1240 (180)	85 (185)	90 (194)
TT300-A5-1-ST-P-O-NC	122	134	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-A6-1-ST-P-O-NC	135	145	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-A6-2-ST-P-O-NC	135	145	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-A6-1-MT-P-O-NC	135	145	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-B6-1-ST-N-O-NC	135	145	1537 (223)	1600 (232)	95 (203)	100 (212)

Table 4-1 Alarm/Limit Trip Points (OEM Model-specific)

Compressor Model	Input Current A		Discharge Pressure* kPa (psi)		Discharge Temp. °C (°F)	
	Alarm	Limit	Alarm	Limit	Alarm	Limit
TT300-B6-1-ST-N-O-CE	135	145	1537 (223)	1600 (232)	95 (203)	100 (212)
TT300-B6-1-ST-P-O-NC	134	140	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-B6-1-ST-P-O-CE	134	140	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-B6-1-MT-P-O-NC	134	140	1730 (250)	1800 (260)	95 (203)	100 (212)
TT300-B6-1-MT-P-O-CE	134	140	1730 (250)	1800 (260)	95 (203)	100 (212)

* **Gauge value**

Table 4-2 Alarm/Limit Trip Points (non Model-specific)

Description	Alarm		Limit	
	Metric	Imperial	Metric	Imperial
Cavity temperature	80°	176°	85°	185°
Inverter temperature	70°	158°	75°	167°
SCR temperature	70°	158°	75°	167°

4.2 Fault Symptoms

This section provides fault symptoms as an aid to identifying the most common faults.

Table 4-3 Troubleshooting Chart - System

Symptoms	Possible Cause	Action Required
Low suction pressure	Low water/air flow	Check water flow as per design.
	Chilled water temperature too low	Check set points.
	Faulty pressure sensor	Check pressure sensor.
	Low refrigerant charge	Check liquid level in cooler.
		Check subcooling.
		Check discharge temperature.
	Restriction in refrigeration pipework	Check electronic expansion valve operation.
		Check filter driers and suction strainer.
	Suction valve closed	Check valve position.
	IGV stuck open	Check position and operation. Refer to 4.4.4 "IGV Fault".
High discharge pressure	Condenser water temperature too high	Check cooling tower set point.
	Low condenser water flow	Check water flow as per design.
	Fouled water tubes	Clean tubes.
	Blocked condenser water strainer	Clean strainer
	Faulty pressure sensor	Check pressure sensor.
	Non-condensable in system	Dehydrate system.
	System overcharged	Adjust refrigerant charge.
	Discharge valve closed	Check valve position.
	Restriction in pipe work	Check pipework for excessive pressure drops.
High evaporator pressure	Chilled water temperature too high	Check temperature sensor.
		Check for excessive water flow.
	Faulty pressure sensor	Check pressure transducers.
	IGV failure (closed)	Check position and operation. Refer to 4.4.4 "IGV Fault".
Low refrigerant temperature cut-out	Insufficient refrigerant charge	Check refrigerant charge.
	Faulty sensor	Check sensor.
	Water temperatures too low	Check set points.

Table 4-4 Troubleshooting Chart - Compressor

Symptoms	Possible Cause	Action Required
Compressor does not power up	No/Low DC bus voltage - Capacitor failure	Refer to 4.3.1 "No (Low) DC Bus Voltage" and 4.5.2 "DC Bus Verification".
	Phase failure	Check phases of line power supply.
	No 250V DC Bus - HV DC-DC Converter fault	Refer to 4.5.7 "High-Voltage DC-DC Converter Verification".
	No 250V DC Bus - Bearing PWM Amplifier fault	Refer to 4.5.11 "PWM Amplifier Verification".
	No 250V DC Bus - Low-voltage DC-DC Converter fault	Refer to 4.5.8 "Backplane Verification".
	DC bus midpoint imbalance - Faulty capacitor	Replace capacitor.
	DC bus midpoint imbalance - Faulty bleed resistor	Replace bleed resistor.
	DC bus midpoint imbalance - Faulty HV DC-DC Converter	Replace HV DC-DC Converter
No motor drive	IGBT Inverter fault	Refer to 4.5.6 "IGBT Inverter Verification".
	IGBT Inverter interface cable fault	Check/replace cable.
	Bearing/Motor Controller fault	Refer to 4.5.10 "BMCC Verification".
	Faulty stator	Contact Turbocor Technical Support.
	Demagnetized shaft	Contact Turbocor Technical Support.
	Shaft position sensor fault	Check/replace sensor.
	Start RPM too low.	Check Start RPM. Must be > 18,500.
Bearing will not calibrate or levitate	Faulty bearing wiring	Check/repair wiring.
	Faulty Bearing PWM Amplifier	Refer to 4.5.11 "PWM Amplifier Verification".
	Faulty Bearing/Motor Controller	Refer to 4.5.10 "BMCC Verification"
No communications to Compressor Controller	Faulty Compressor Controller	Refer to 4.5.10 "BMCC Verification"
	External wiring fault	Check/repair wiring.
	Sensor Faults - Faulty wiring/ connector	
	Sensor Fault - Sensor Failure	

Table 4-4 Troubleshooting Chart - Compressor (Continued)

Symptoms	Possible Cause	Action Required
Drive temperature too high	No motor cooling	Check motor cooling solenoid valve. Refer to 4.5.14 "Motor-Cooling Solenoid Verification".
	Insufficient subcooling	Check refrigerant charge.
	Faulty temperature sensor	Check sensor.
Winding temperature too high	No motor cooling	Check motor cooling solenoid valve. Refer to 4.5.14 "Motor-Cooling Solenoid Verification".
	Faulty temperature sensor	Check thermistor resistance.
Compressor does not start	No cooling demand signal	Check temperature set points.
	Faulty chilled-water temperature sensors	Check temperature sensors.
	Faulty pressure sensors	Check pressure sensors.
	No mains power	Refer to 4.5.1 "3-phase AC Input Verification"

NOTE:
The following procedures assume that the mains input and top covers have already been removed. Refer to Figure 3-1 for compressor access cover locations.

4.3 Power Supply Troubleshooting

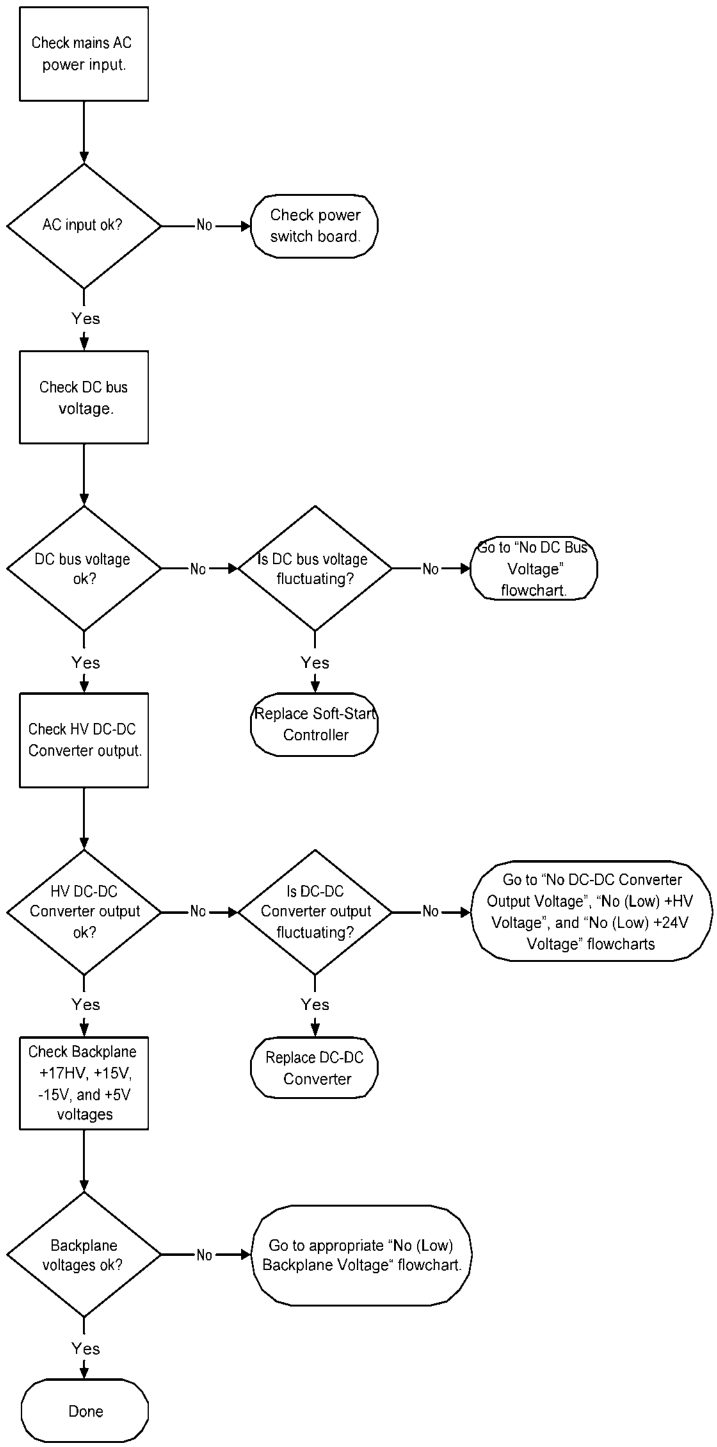


Figure 4-1 Power Supply Troubleshooting Flowchart

4.3.1 No (Low) DC Bus Voltage

Measure the DC bus voltage. Refer to “DC Bus Verification” on page 61. If the DC bus voltage is less than 15VDC, then continue to troubleshoot with the steps outlined in Figure 4-2 and Figure 4-3 to determine the source of the problem.

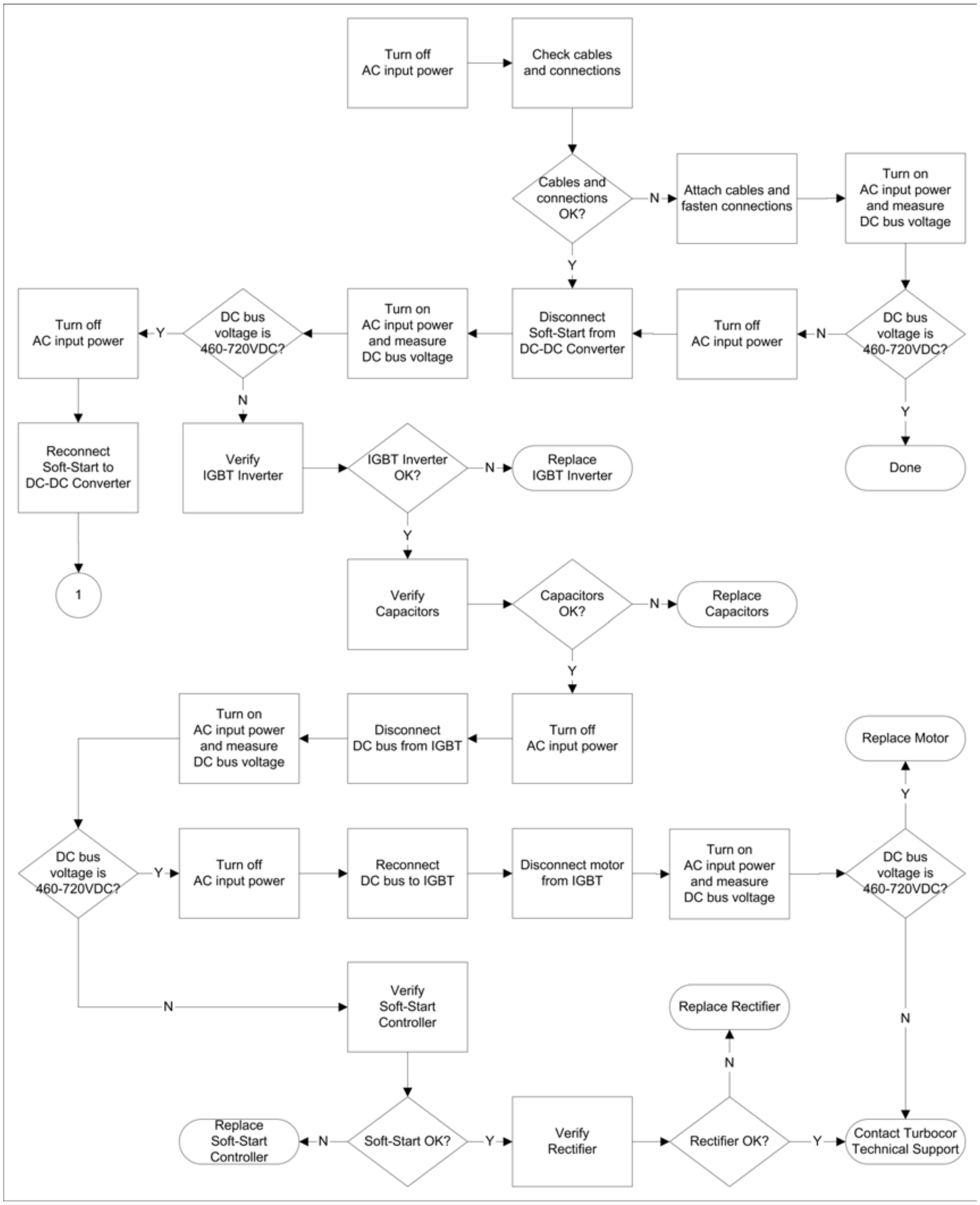


Figure 4-2 No DC Bus Voltage Troubleshooting Flowchart (1 of 2)

1. Turn OFF the AC input power to the compressor.
2. Verify that all cables are properly attached, and that all connections are tight. If all cables are properly attached and all connections are tight, skip to step 5.
3. Properly attach all cables and tightly fasten all connections.
4. Turn ON the AC input power and measure the DC bus voltage as described in section “DC Bus Verification” on page 61. If there is still no DC bus voltage of 460-720VDC, turn OFF the AC input power and proceed to the next step.
5. Disconnect the Soft-Start Controller from the DC-DC Converter (refer to “Disconnecting Soft-Start Controller from the DC-DC Converter” on page 92).
6. Turn ON the AC input power and measure the DC bus voltage (refer to the procedure outlined in section “DC Bus Verification” on page 61).

   If the DC bus voltage measures 460-720VDC, the problem is due to the DC-DC Converter, IGBT Inverter, Backplane, Serial Driver, BMCC, PWM Amplifier, or Compressor Interface. (refer to “Compressor Energy and Control Flow Block Diagram” on page 21), In such a case, reconnect the Soft-Start Controller to the DC-DC Converter and continue with part 2 of 2 of the troubleshooting steps outlined in Figure 4-3.

   If there is still no DC bus voltage after disconnecting from the DC-DC Converter, it can be concluded the problem is with the Soft-Start Controller, Rectifier, Capacitors, or the IGBT Inverter. Continue with the next step.
7. Verify the IGBT Inverter (refer to the procedure outlined in section “IGBT Inverter Verification” on page 67). If the IGBT Inverter does not pass the verification procedure, then it is faulty and needs to be replaced; otherwise, continue with the next step.
8. Verify the Capacitors (refer to the procedure outlined in section “DC-Link Capacitor Verification” on page 65).

   If the Capacitors do not pass the verification procedure, then they are faulty and need to be replaced; otherwise, proceed with the next step.
9. Turn OFF the AC input power to the compressor.
10. Disconnect the DC bus from the IGBT by following the procedure outlined in section “Disconnecting the DC Bus from the IGBT Inverter” on page 92.
11. Turn ON the AC input power to the compressor.
12. Measure the DC bus voltage as outlined in section “DC Bus Verification” on page 61. If a DC voltage of 460-720VDC is measured, continue with step 13; if not, go to step 18.
13. Turn OFF the AC input power to the compressor.
14. Reconnect the DC bus to the IGBT Inverter by reversing the procedure outlined in “Disconnecting the DC Bus from the IGBT Inverter” on page 92.
15. Disconnect the motor from the IGBT Inverter (see section “Disconnecting the Motor from the IGBT Inverter” on page 93).
16. Turn ON the AC input power to the compressor.
17. Measure the DC bus voltage (refer to the procedure outlined in section “DC Bus Verification” on page 61). If a DC bus voltage of 460-750VDC is measured, then the motor is faulty and needs to be replaced. If there is still no DC bus voltage, contact Turbocor technical support.
18. Verify the Soft-Start Controller following the procedure outlined in “Soft-Start Controller Verification” on page 61. If the Soft-Start Controller does not pass the verification procedure, then it is faulty and needs to be replaced; otherwise, proceed with the next step.
19. Verify the Rectifier (refer to the procedure outlined in section “Silicon-controlled Rectifier (SCR) Verification” on page 64). If the Rectifier does not pass the verification procedure, then it is faulty and needs to be replaced. If the Rectifier is not faulty, contact Turbocor technical support.

Figure 4-3 No DC Bus Voltage Troubleshooting Flowchart (2 of 2)

1. Turn OFF the AC input power to the compressor.
2. Measure the DC-DC Converter load resistance. Refer to section 4.5.7 "High-Voltage DC-DC Converter Verification" - "Minimum Load Resistance Measurement". If the load resistance does not satisfy the minimum load resistance requirements, the DC-DC Converter is faulty and needs to be replaced; if it satisfies the requirements, proceed to the next step.
3. Determine if the PWM Amplifier is draining all the energy by following the procedure outlined in “PWM Amplifier Draining Energy” on page 83; if it is not, proceed with the next step.
4. Measure the resistance at the +24V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is greater than 9Ω, replace the DC-DC Converter; otherwise, proceed with the next step.
5. Determine if the Serial Driver is draining all the energy by following the procedure outlined in “Serial Driver Draining Energy” on page 81; if it is not, proceed with the next step.
6. Determine if the IGBT Inverter is draining all the energy by following the procedure outlined in “IGBT Inverter Draining Energy” on page 86; if it is not, proceed with the next step.
7. Measure the resistance at the +15V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 20Ω, then continue with step 9; otherwise, proceed with the next step.
8. Determine if the Compressor Interface is draining all the energy by following the procedure outlined in “Compressor Interface Module Draining Energy” on page 85; if it is not, proceed with the next step.
9. Measure the resistance at the -15V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 150Ω, continue with step 11; otherwise, proceed with the next step.
10. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82; if it is not, proceed with the next step.
11. Measure the resistance at the +5V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 8Ω, continue with step 15; otherwise, proceed with the next step.
12. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, proceed with then next step.
13. Determine if the PWM Amplifier is draining all the energy by following the procedure outlined in “PWM Amplifier Draining Energy” on page 83. If it is not, proceed with then next step.
14. Determine if the Compressor Interface is draining all the energy by following the procedure outlined in “Compressor Interface Module Draining Energy” on page 85. If it is not, proceed with then next step.
15. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, replace the DC-DC Converter.

4.3.2 No HV DC-DC Converter Output Voltage

Measure the HV+ and +24V test points on the Backplane. Refer to 4.5.7 "High-Voltage DC-DC Converter Verification" - "Output Voltage Measurement" on page 71.

If there is no DC voltage output from the DC-DC Converter, then follow the troubleshooting steps outlined in Figure 4-4 to determine the source of the problem.

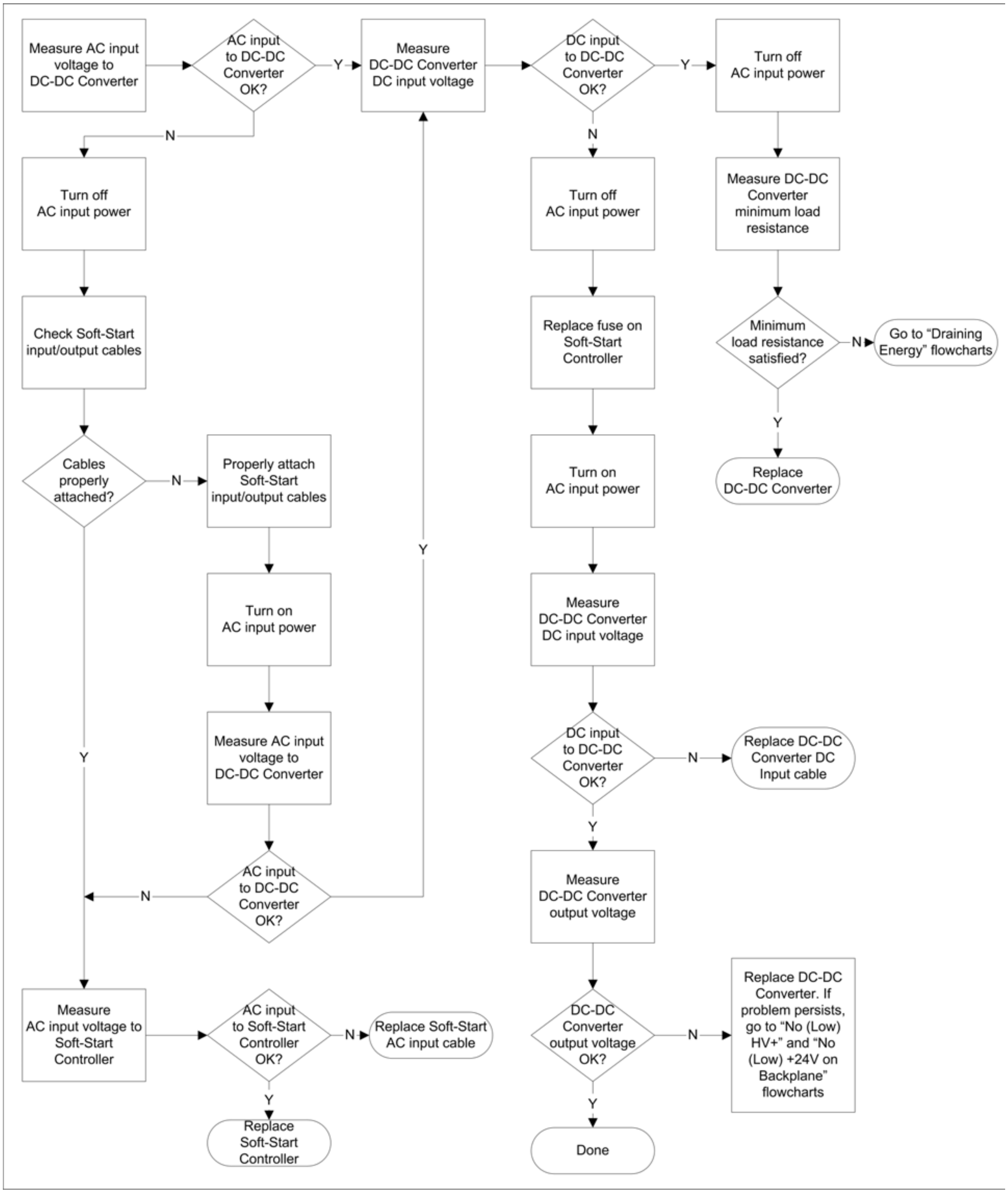


Figure 4-4 No DC-DC Converter Output Voltage Troubleshooting Flowchart

1. Measure the AC voltage at the DC-DC Converter AC input cable. Refer to 4.5.7 "High-Voltage DC-DC Converter Verification" - "Input Voltage Measurement". If the AC voltage is 15VAC±10%, then skip to step 8; otherwise proceed with the next step.
2. Turn OFF the AC input power to the compressor.
3. Check that the Soft-Start Controller input/output cables are all properly attached. Refer to 3.2.1 "Soft-Start Controller I/O" on page 6 for the input/output port locations. If the cables are already properly attached, skip to step 7; otherwise, proceed with the next step.
4. Properly attach all Soft-Start input/output cables.
5. Turn ON the AC input power to the compressor.
6. Measure the AC voltage at the DC-DC Converter AC input cable. Refer to 4.5.7 "High-Voltage DC-DC Converter Verification" - "Input Voltage Measurement". If the AC voltage is 15VAC±10%, continue with step 8; otherwise proceed with the next step.
7. Verify the AC input voltage to the Soft-Start Controller. Refer to 4.5.3 "Soft-Start Controller Verification" - "Input Voltage Measurement" on page 62. If the measured AC input is within the expected AC voltage range as specified in Table 4-8 on page 62, the Soft-Start Controller is faulty and needs to be replaced; otherwise, the AC input cable to the Soft-Start Controller is faulty and needs to be replaced.
8. Measure the DC voltage at the DC-DC Converter DC input cable. Refer to 4.5.7 "High-Voltage DC-DC Converter Verification" - “Input Voltage Measurement” on page 70. If the DC voltage is in accordance with the values specified in Table 4-11, “Expected DC Voltage Range,” on page 71, continue with the next step; otherwise, proceed with step 11.
9. Turn OFF the AC input power to the compressor.
10. Measure the DC-DC Converter minimum load resistance; refer to 4.5.7.2 "Minimum Load Resistance Measurement" on page 69. If the minimum load resistance is in accordance with the value specified, replace the DC-DC Converter; otherwise, refer to 4.6 "Compressor Module Draining Energy" on page 81.
11. Turn OFF the AC input power to the compressor.
12. Replace the fuse on the Soft-Start Controller. Refer to the procedure outlined in “DC-DC Converter Fuse - Removal” on page 107.
13. Turn ON the AC input power to the compressor.
14. Measure the DC voltage from the DC input cable. Refer to 4.5.7 "High-Voltage DC-DC Converter Verification" - "Input Voltage Measurement" on page 70. If the DC voltage is in accordance with the values specified in Table 4-11, “Expected DC Voltage Range,” on page 71, proceed with the next step; otherwise contact rplace/repair the DC input cable to the DC-DC Converter.
15. Measure the DC-DC Converter output voltage by following the procedure outlined in 4.5.7 "High-Voltage DC-DC Converter Verification" - "Output Voltage Measurement". If the output voltage is not as expected, replace the DC-DC Converter.

4.3.3 DC Voltage Fluctuating “In and Out” of Bounds

Open the “Compressor Event Log” window. Select “Window”→ “Event Log” from the menu bar, or click on the “Event Log” icon located below the menu bar. If either of the following errors:

- “Soft Start Error detected. Udc= XXX. Generator limit UdcMin= XXX”
- “24V out of bounds. Udc24=XXX. Exceeded boundary =XXX”

are repeated in the event log within 2 minutes (verify the timestamp in the event log), then follow the troubleshooting steps outlined in Figure 4-1 to determine the source of the problem.

NOTE:
During compressor start-up, there is always a “Soft Start Error detected”. Do not consider the “Soft Start Error detected” during compressor start-up in determining whether the DC voltage is fluctuating in and out of bounds.

4.3.4 No (Low) Backplane Voltage

4.3.4.1 No (Low) HV+ Voltage

Measure the voltage at the HV+ test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. The HV+ test point is expected to output a voltage of +250VDC±5% with respect to HV-. If there is no (low) voltage outputted from the HV+

test point, follow the troubleshooting steps outlined in Figure 4-5 to determine the source of the problem.

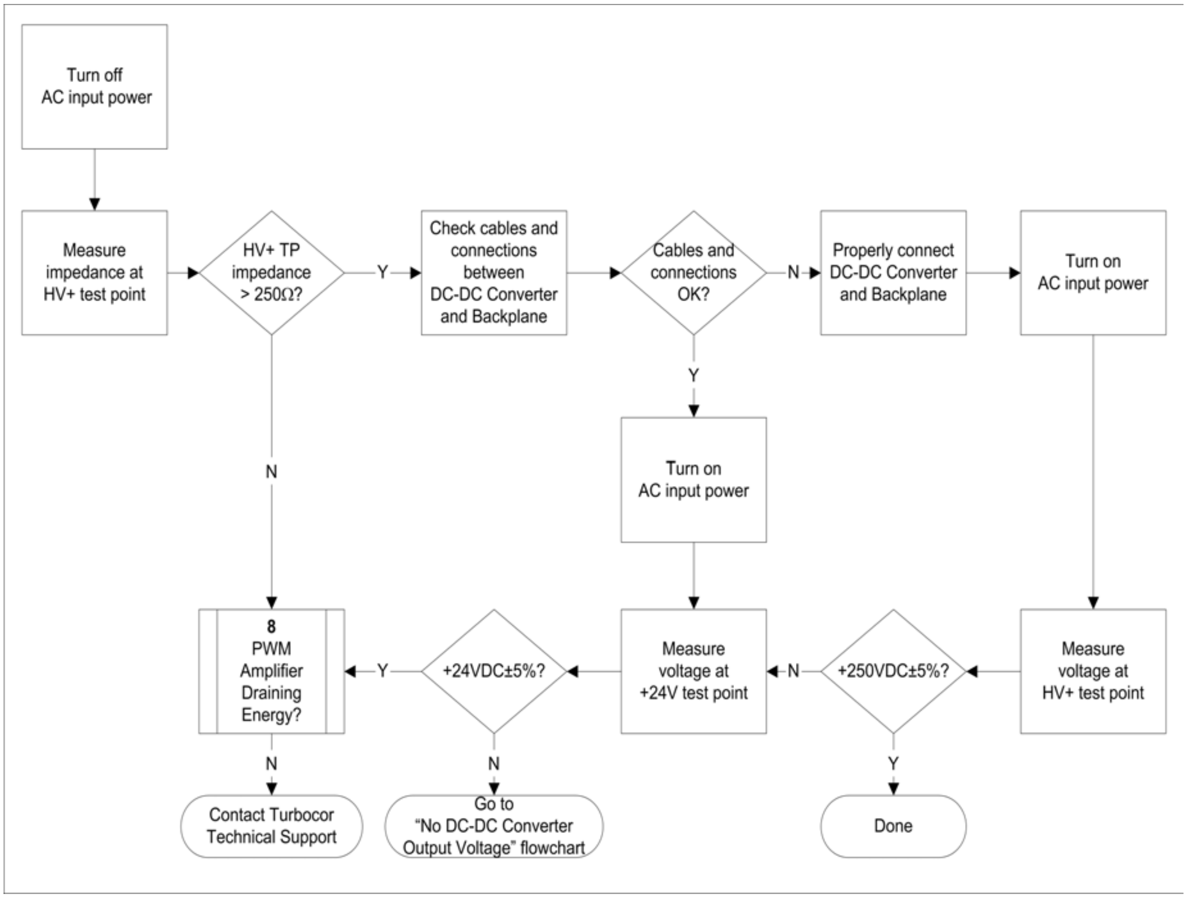


Figure 4-5 No (Low) HV+ Voltage on Backplane Flowchart

1. Turn OFF the AC input power to the compressor.
2. Measure the resistance at the HV+ test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Minimum Resistance Measurement" on page 72. If the resistance is greater than 250Ω, then continue with the next step; otherwise, skip to step 8.
3. Check the cables and connections between the DC-DC Converter and Backplane. Verify that the cables at the DC-DC Converter output ports J2 and J3, and the cables at the Backplane input ports J4 and J24, are properly connected and the cables are not broken. Refer to 3.2.2 "High-voltage DC-DC Converter I/O" on page 8, and 3.2.3 "Backplane I/O" on page 9, for input/output port locations. If the cables are not broken and they are properly connected, proceed with step 7; otherwise, proceed with the next step.
4. Properly attach the cables between the DC-DC Converter and the Backplane.
5. Turn ON the AC input power to the compressor.
6. Measure the voltage at the HV+ test point on the Backplane. Refer 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. If the HV+ test point still does not output 250VDC±5%, proceed with the next step.
7. Measure the voltage at the +24V test point on the Backplane. Refer 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. If the +24V test point does not output a voltage of +24VDC±5%, continue to troubleshoot with 4.3.2 "No HV DC-DC Converter Output Voltage" on page 32; otherwise, continue with the next step.

8. Determine if the PWM Amplifier is draining the energy. Refer to 4.6.3 "PWM Amplifier Draining Energy" on page 83. If the PWM Amplifier is not the cause of energy drain, contact Turbocor Technical Support.

4.3.4.2 No (Low) +24V Voltage

Measure the voltage at the +24V test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71.

The +24V test point is expected to output a voltage of +24VDC±5% with respect to 0VDC. If there is no (low) voltage outputted from the +24V test point, then follow the troubleshooting steps outlined in Figure 4-6 to determine the source of the problem.

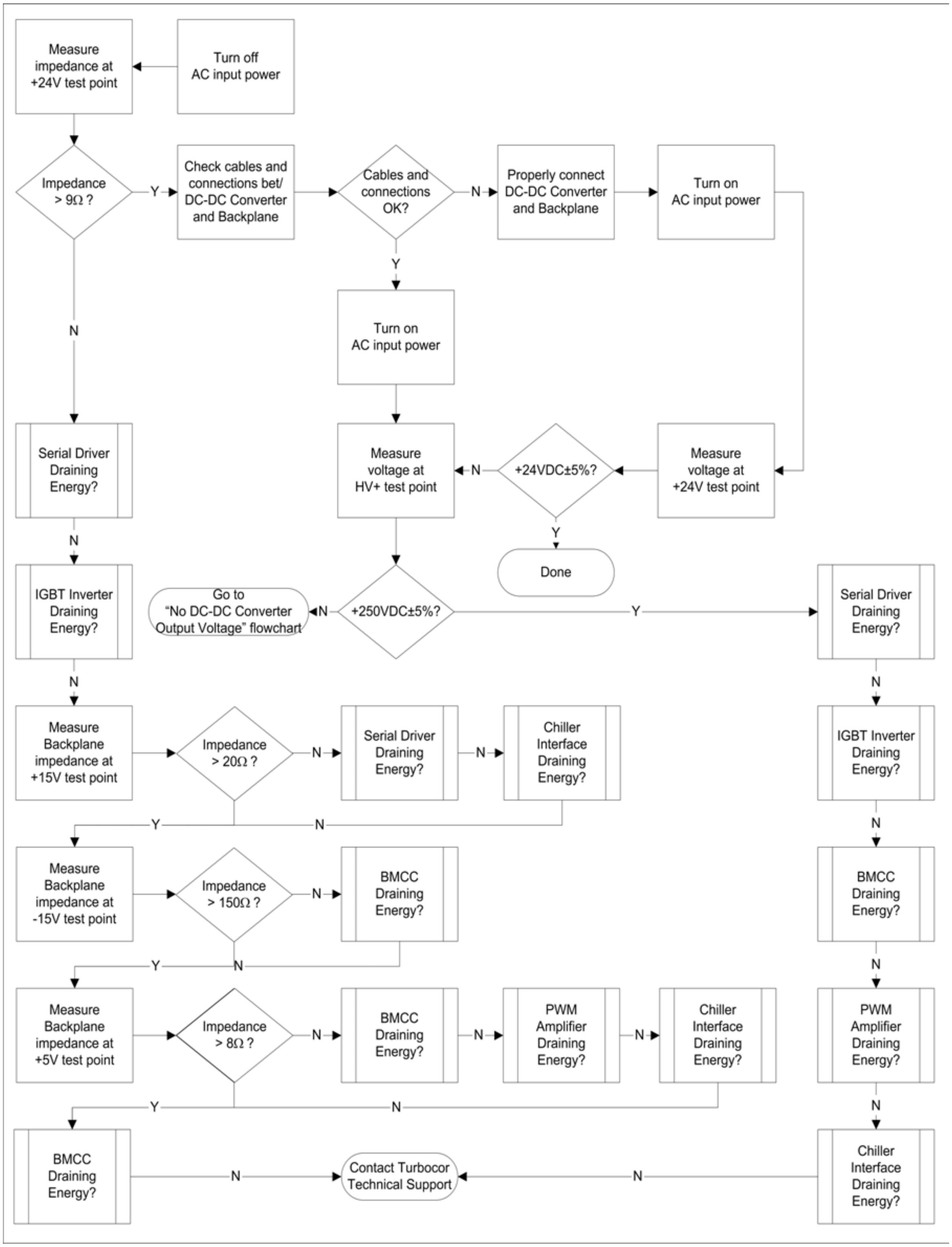


Figure 4-6 No (Low) +24V Voltage on Backplane Flowchart

1. Turn OFF the AC input power to the compressor.
2. Measure the resistance at the +24V test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Minimum Resistance Measurement" on page 72. If the resistance is greater than 9Ω, go to step 15; otherwise, proceed with the next step.
3. Determine if the Serial Driver is draining all the energy by following the procedure outlined in “Serial Driver Draining Energy” on page 81. If it is not, then proceed with the next step.
4. Determine if the IGBT Inverter is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, then proceed with the next step.
5. Measure the resistance at the +15V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 20Ω, then continue with step 9; otherwise, proceed with the next step.
6. Determine if the Serial Driver is draining all the energy by following the procedure outlined in “Serial Driver Draining Energy” on page 81. If it is not, proceed with the next step.
7. Determine if the Compressor Interface is draining all the energy by following the procedure outlined in “Compressor Interface Module Draining Energy” on page 85. If it is not, proceed with the next step.
8. Measure the resistance at the -15V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 150Ω, continue with step 11; otherwise, proceed with the next step.
9. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, proceed with the next step.
10. Measure the resistance at the +5V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance is at least 8Ω, continue with step 15; otherwise, proceed with the next step.
11. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, proceed with the next step.
12. Determine if the PWM Amplifier is draining all the energy by following the procedure outlined in “PWM Amplifier Draining Energy” on page 83. If it is not, proceed with the next step.
13. Determine if the Compressor Interface is draining all the energy by following the procedure outlined in “Compressor Interface Module Draining Energy” on page 85. If it is not, proceed with the next step.
14. Determine if the BMCC is draining all the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If it is not, ensure all troubleshooting steps have been properly followed, contact Turbocor technical support if the problem persists.
15. Check the cables and connections between the DC-DC Converter and the Backplane. Verify that the cables at the DC-DC Converter output ports J2 and J3, and the cables at the Backplane input ports J4 and J24, are not broken and that they are properly connected. Refer to 3.2.2 "High-voltage DC-DC Converter I/O" on page 8, and 3.2.3 "Backplane I/O" on page 9, for the input/output port locations. If the cables are not broken and they are properly connected, turn ON AC input power and continue with step 19; otherwise, proceed with the next step.
16. Properly attach the cables between the DC-DC Converter and the Backplane.
17. Turn ON the AC input power to the compressor.
18. Measure the voltage at the +24V test point on the Backplane. Refer 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. If the +24V test point still does not output +24VDC±5%, proceed with the next step.
19. Measure the voltage at the HV+ test point on the Backplane. Refer 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. If a voltage of +250VDC±5% is not measured, continue to troubleshoot with 4.3.2 "No HV DC-DC Converter Output Voltage" on page 32. Otherwise, continue with the next step.
20. Determine if the Serial Driver is draining the energy. Refer to 4.6.1 "Serial Driver Draining Energy" on page 81. If the Serial Driver is not the cause of energy drain, proceed with the next step.

21. Determine if the IGBT Inverter is draining the energy. Refer to 4.6.5 "IGBT Inverter Draining Energy" on page 86. If the IGBT Inverter is not the cause of energy drain, proceed with the next step.
22. Determine if the BMCC is draining the energy. Refer to 4.6.2 "BMCC Draining Energy" on page 82. If the BMCC is not the cause of energy drain, proceed with the next step.
23. Determine if the PWM Amplifier is draining the energy. Refer to 4.6.3 "PWM Amplifier Draining Energy" on page 83. If the PWM Amplifier is not the cause of energy drain, proceed with the next step.
24. Determine if the Compressor Interface is draining the energy. Refer to 4.6.4 "Compressor Interface Module Draining Energy" on page 85. If the Compressor Interface is not the cause of energy drain, ensure that all troubleshooting steps have properly been followed, then contact Turbocor technical support if the problem persists.

4.3.4.3 No (Low) +17HV Voltage

Measure the voltage at the +17HV test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. The +17HV test point is expected to output a voltage of +17VDC±5% with respect to HV-. If there is no (low) voltage outputted from the +17HV test point, follow the troubleshooting steps outlined in Figure 4-7 to determine the source of the problem.

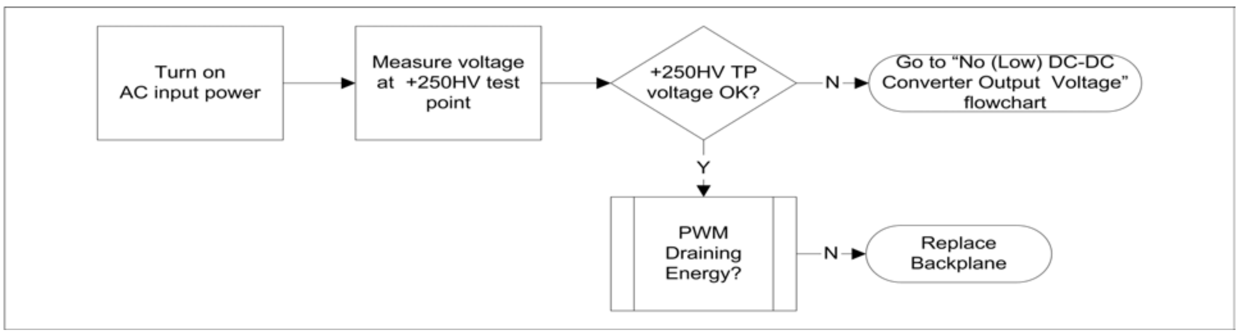


Figure 4-7 No (Low) +17HV Voltage Flowchart

1. Turn ON the AC input power to the compressor.
2. Measure the voltage at the +250HV test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71. If the measured voltage is 250VDC±5%, proceed with the next step; otherwise, continue to troubleshoot following the procedure outlined in 4.3.2 "No HV DC-DC Converter Output Voltage" on page 32.
3. Determine if the PWM Amplifier is draining the energy. Refer to 4.6.3 "PWM Amplifier Draining Energy" on page 83. If the PWM Amplifier is not the cause of energy drain, then the Backplane is faulty and needs to be replaced.

4.3.4.4 No (Low) +15V Voltage

Measure the voltage at the +15V test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. The +15V test point is expected to output a voltage of +15VDC±5% with respect to 0VDC. If there is no (low) voltage outputted from the +15V test point, follow the troubleshooting steps outlined in Figure 4-8 to determine the source of the problem.

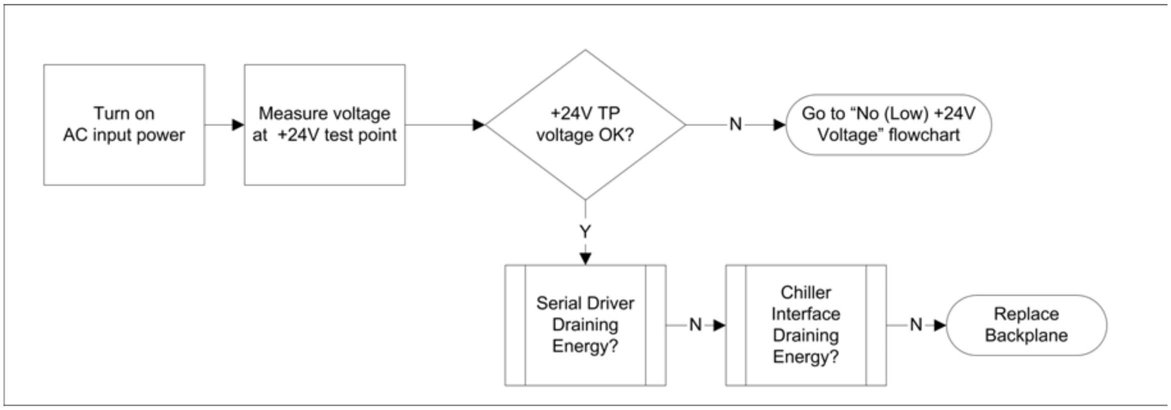


Figure 4-8 No (Low) +15V Voltage Flowchart

1. Turn ON the AC input power to the compressor.
2. Measure the voltage at the +24V test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71. If the measured voltage is 24VDC±5%, proceed with the next step; otherwise, continue to troubleshoot following the procedure outlined in 4.3.4.2 "No (Low) +24V Voltage" on page 36.
3. Determine if the Serial Driver is draining the energy by following the procedure outlined in "Serial Driver Draining Energy" on page 81. If it is not, proceed with the next step.
4. Determine if the Compressor Interface is draining the energy by following the procedure outlined in "Compressor Interface Module Draining Energy" on page 85. If the Compressor Interface is not the cause of energy drain, the Backplane is faulty and needs to be replaced.

4.3.4.5 No (Low) -15V Voltage

Measure the voltage at the -15V test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. The -15V test point is expected to output a voltage of -15VDC±5% with respect to 0VDC. If there is no (low) voltage outputted from the -15V test point, then follow the troubleshooting steps outlined in Figure 4-9 to determine the source of the problem.

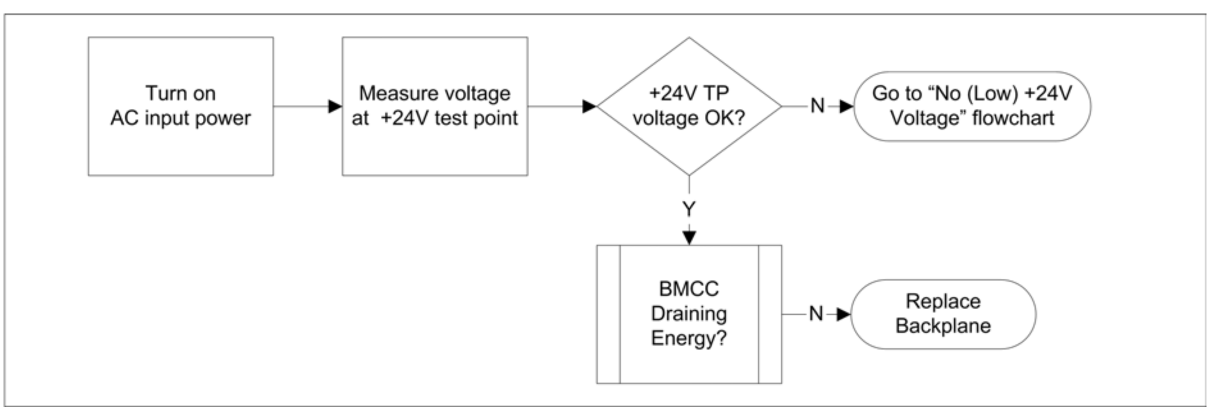


Figure 4-9 No (Low) -15V Voltage Flowchart

1. Turn ON the AC input power to the compressor.
2. Measure the voltage at the +24V test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71. If the measured voltage is 24VDC±5%, proceed with the next step; otherwise, continue to troubleshoot following the procedure outlined in 4.3.4.2 "No (Low) +24V Voltage" on page 36.
3. Determine if the BMCC is draining the energy by following the procedure outlined in "BMCC Draining Energy" on page 82. If the BMCC is not the cause of energy drain, the Backplane is faulty and needs to be replaced.

4.3.4.6 No (Low) +15V BMCC Voltage

Measure the voltage at the +15V test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "BMCC Voltage Source Measurement" on page 72. The BMCC source is expected to output a voltage of +15VDC±5% with respect to 0VDC. If there is no (low) voltage outputted from the +15V source to the BMCC, follow the troubleshooting steps outlined in Figure 4-10 to determine the source of the problem.

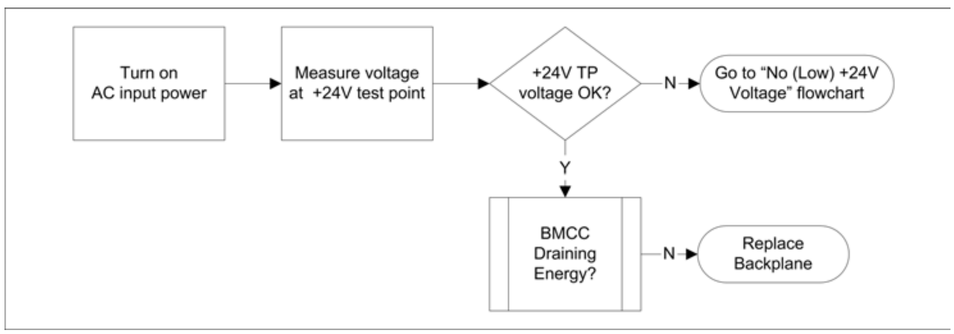


Figure 4-10 No (Low) +15V BMCC Voltage Flowchart

1. Turn ON the AC input power to the compressor.
2. Measure the voltage at the +24V test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71. If the measured voltage is 24VDC±5%, proceed with the next step; otherwise, continue to troubleshoot following the procedure outlined in 4.3.4.2 "No (Low) +24V Voltage" on page 36.
3. Determine if the BMCC is draining the energy by following the procedure outlined in "BMCC Draining Energy" on page 82. If the BMCC is not the cause of energy drain, the Backplane is faulty and needs to be replaced.

4.3.4.7 No (Low) +5V Voltage

Measure the voltage at the +5V test point on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71. The +5V test point is expected to output a voltage of +5VDC±5% with respect to 0VDC. If there is no (low) voltage outputted from the +5V test point, follow the troubleshooting steps outlined in Figure 4-11 to determine the source of the problem.

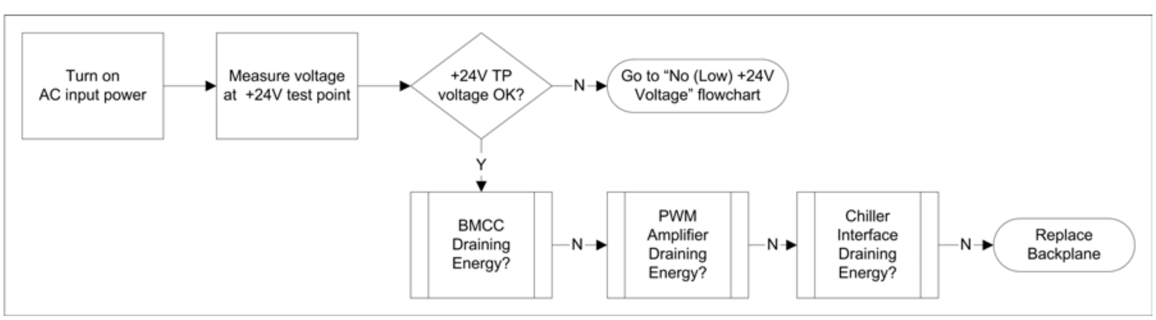


Figure 4-11 No (Low) +5 Voltage Flowchart

1. Turn ON the AC input power to the compressor.
2. Measure the voltage at the +24V test point. Refer to 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71. If the measured voltage is 24VDC±5%, proceed with the next step; otherwise, continue to troubleshoot following the procedure outlined in 4.3.4.2 "No (Low) +24V Voltage" on page 36.
3. Determine if the BMCC is draining the energy by following the procedure outlined in “BMCC Draining Energy” on page 82. If the BMCC is not the cause of energy drain, proceed with the next step.
4. Determine if the PWM Amplifier is draining the energy by following the procedure outlined in “PWM Amplifier Draining Energy” on page 83. If the PWM Amplifier is not the cause of energy drain, proceed with the next step.
5. Determine if the Compressor Interface is draining the energy by following the procedure outlined in “Compressor Interface Module Draining Energy” on page 85. If the Compressor Interface is not the cause of energy drain, the Backplane is faulty and needs to be replaced.

4.4 Troubleshooting with the Monitor Program

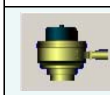
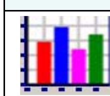
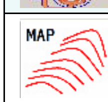
4.4.1 Toolbar Icons

The monitor program toolbar (located under the menu bar) provides the user with easy access to the monitoring windows. Table 4-5 lists the name of each icon on the toolbar. Use this list to familiarize yourself with the icons that are referenced in the procedures.

Table 4-5 Monitor Program Toolbar Icons

Icon	Name
	Serial Port Connection
	Compressor Controller Parameters
	Motor Monitor
	Magnetic Bearings

Table 4-5 Monitor Program Toolbar Icons

Icon	Name
	Expansion Valves
	Event Log
	EEPROM Settings
	Load Profile Graphs
	Fault Captures
	Trending
	Chiller Control
	Compressor Envelope

4.4.2 Bearing Faults

This section describes the possible faults displayed in the "Magnetic Bearing Monitoring" window, and provides the troubleshooting steps to follow for each fault.

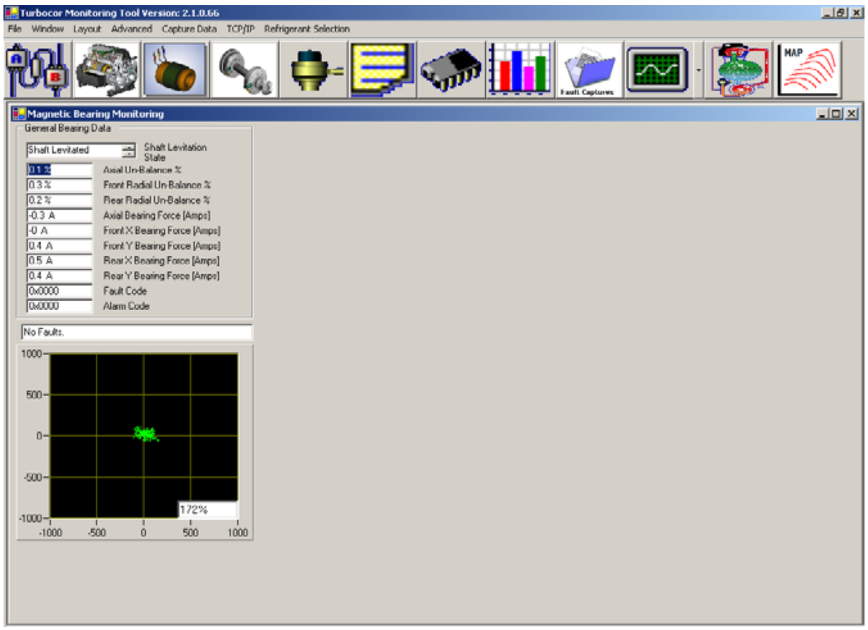


Figure 4-12 Monitor Program - Bearing Monitoring Window

4.4.2.1 Calibration Failed

The fault message "Calibration Failed" indicates that the manual calibration performed on the compressor failed.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. See the"Calibration Data Interpretation" on page 76.

If the bearings cannot be calibrated, contact Turbocor technical support.

4.4.2.2 Startup Check Failed

During compressor startup, the bearing calibration procedure is automatically performed. The fault message "Startup Check Failed" indicates that the calibration failed during compressor startup.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. See the"Calibration Data Interpretation" on page 76.

If the bearings cannot be calibrated, contact Turbocor technical support.

4.4.2.3 Axial Displacement Fault

The fault message "Axial Displacement Fault" indicates that the force current drawn by the axial bearing exceeds 60% of the calibration value.

1. Open the "Compressor Controller Form". Click on the "Compressor Controller Parameters" icon located below the menu bar.
2. From the "Compressor Control Mode", select "Manual Control" from the drop down menu.
3. Open the "Magnetic Bearing Monitoring" window. From the menu bar, select "Window"→ "Bearing", or click on the "Magnetic Bearings" icon located below the menu bar.
4. If the "Shaft Levitation State" parameter box is set to "Shaft Levitated", then click on the up arrow to set the shaft state to "Shaft De-Levitated"
5. Select the down arrow in the "Shaft Levitation State" parameter box to set the shaft state to "Shaft Levitated".

6. Observe the shaft orbit from the “Magnetic Bearing Monitoring” graph. See Figure 4-12. If the shaft (represented by a green dots) exceeds 500 units in any direction (left, right, up, down), then check the external refrigeration circuit. Otherwise, proceed with the next step.
7. Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. See“Calibration Data Interpretation” on page 76.

If the “Axial Displacement Fault” persists, then contact Turbocor technical support.

4.4.2.4 Front Radial Displacement Fault

The fault message “Front Radial Displacement Fault” indicates that the force current drawn by the front radial bearing exceeds 60% of the calibration value.

Follow troubleshooting steps 1 to 7 in 4.4.2.3 "Axial Displacement Fault".

If the “Front Radial Displacement Fault” persists, then contact Turbocor technical support.

4.4.2.5 Back Radial Displacement Fault

The fault message “Back Radial Displacement Fault” indicates that the force current drawn by the rear radial bearing exceeds 60% of the calibration value.

Follow troubleshooting steps 1 to 7 in 4.4.2.3 "Axial Displacement Fault".

If the “Back Radial Displacement Fault” persists, then contact Turbocor technical support.

4.4.2.6 Axial Static Load

The fault message “Axial Static Load” indicates that the force current drawn by the axial bearing exceeds 2.5 amps.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. Continue to troubleshoot by following the“Calibration Data Interpretation” on page 76.

If the bearings can not be calibrated, or the “Axial Static Load” fault persists, then contact Turbocor technical support.

4.4.2.7 Front Radial Static Load

The fault message “Front Radial Static Load” indicates that the force current drawn by the front radial bearing exceeds 2.5 amps.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. Continue to troubleshoot by following the“Calibration Data Interpretation” on page 76.

If the bearings can not be calibrated, or the “Front Radial Static Load” fault persists, then contact Turbocor technical support.

4.4.2.8 Back Radial Static Load

The fault message “Back Radial Static Load” indicates that the force current drawn by the back radial bearing exceeds 2.5 amps.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. Continue to troubleshoot by following the“Calibration Data Interpretation” on page 76.

If the bearings cannot be calibrated, or the “Back Radial Static Load” fault persists, then contact Turbocor technical support.

4.4.2.9 Shaft Will Not Levitate

Open the “Compressor Event Log” window. Select “Window”→ “Event Log” from the menu bar, or click on the “Event Log” icon located below the menu bar.

If the following errors are logged:

- “Bearing Error Detected: Axial Displacement Fault.”
- “Bearing Error Detected: Front Radial Displacement.”
- “Bearing Error Detected: Back Radial Displacement.”

Then follow the troubleshooting steps outlined in Figure 4-13 to determine the source of the problem.

If there are other errors logged, troubleshoot accordingly.

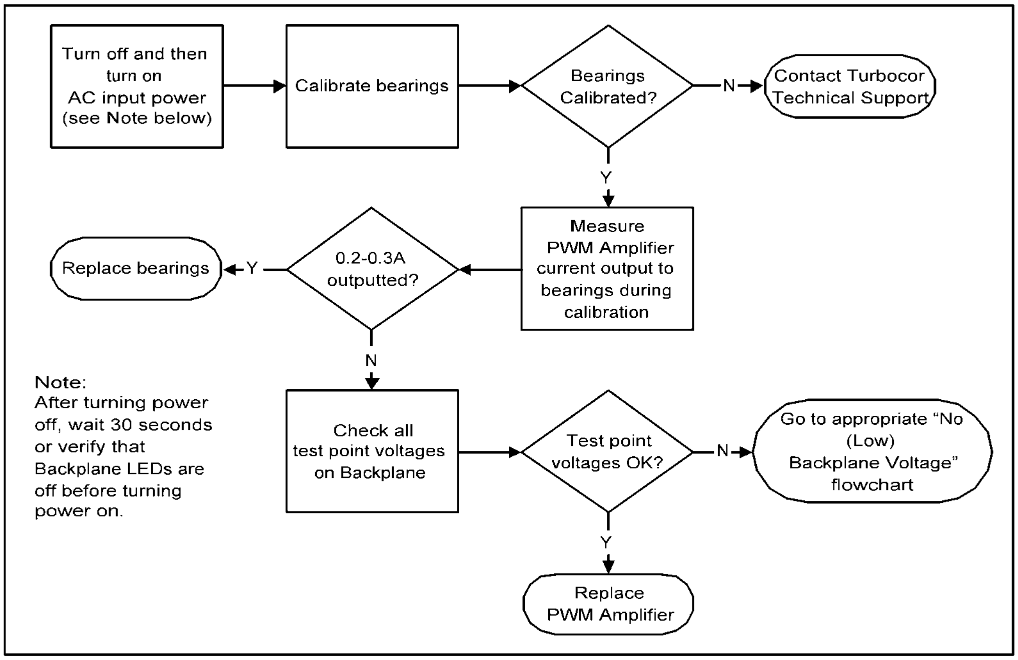


Figure 4-13 Bearing Will Not Levitate Troubleshooting Flow Chart

1. Turn OFF AC input power to the compressor. Wait either 30 seconds or until the Backplane LEDs are off. Turn ON AC input power.
2. Calibrate the bearings. Refer to 4.5.12 "Bearing Calibration" on page 75. Proceed to step 3 after calibrating the bearings. If the bearings do not calibrate, ensure that the calibrations steps have been properly performed, then contact Turbocor Technical Support.
3. Measure the PWM Amplifier current output to the front, rear and axial bearings. Refer to section 4.5.11 "PWM Amplifier Verification" - "Current Output to Bearings Measurement". If a current output of 0.2-0.3A is measured for each bearing, the bearings are mechanically faulty. Replace the bearings; otherwise, proceed to the next step.
4. Verify all the test point voltages on the Backplane. Refer to section 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If the all the test points output the expected voltage, the PWM Amplifier is faulty and needs to be replaced; otherwise, continue to troubleshoot with 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.4.3 Motor Faults

This section describes the possible faults displayed in the "Variable Speed Permanent Magnet Motor Monitoring" window, and provides the troubleshooting steps to follow for each fault.

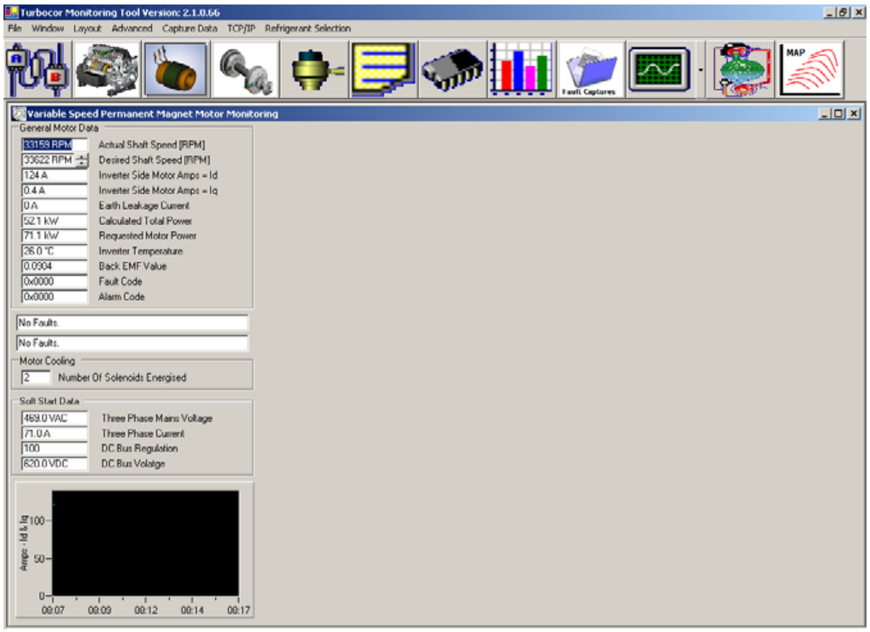


Figure 4-14 Monitor Program - Motor Monitoring Window

4.4.3.1 Motor Single Phase Over-Current Detected

The fault message “Motor Single Phase Over-Current Detected” indicates that there is excess liquid at the suction valve, thus causing the motor to overwork and generate too much current.

1. Check for excess liquid at the suction pipe through the sight glass window.
2. Throttle the suction valve (turn the valve in the clockwise direction) to control the amount of liquid entering the compressor.
3. Start up the compressor again.
4. Gradually open the suction valve (turn the valve in the counter-clockwise direction) as the compressor speed ramps up.

If the “Motor Single Phase Over-Current Detected” fault persists, contact Turbocor technical support.

4.4.3.2 DC-Bus Over-Voltage Detected

The fault message “DC-Bus Over-Voltage Detected” indicates that the DC bus voltage is too high.

Measure the DC bus voltage as per 4.5.2 "DC Bus Verification" on page 61.

If the measured DC bus voltage exceeds the expected DC voltage range, then the Soft-Start Controller is faulty and needs to be replaced.

4.4.3.3 Motor High Current Warning

A “Motor High Current Warning” fault will slow down the motor. Two possible reasons for this fault are:

- AC input voltage is too low
- Compressor is overloaded

1. Verify the 3-phase AC input voltage. Refer to 4.5.1 "3-phase AC Input Verification" on page 57. If the measured AC input voltage is less than the expected AC voltage range, it will cause a high motor current. Check the power switch board. If the measured AC input voltage is within the expected AC voltage range, then proceed with the next step.
2. Open the “Compressor Controller Form”. Click on the “Compressor Controller Parameters” icon located below the menu bar.
3. Check the super heat (SH) value on the title bar of the “Compressor Controller Form”. See Figure 4-15.

If the super heat absolute value is not greater than 5, then it implies the gas is wet. As wet gas is heavier than dry gas, it causes the motor to overwork. Adjust the expansion device setting.

If the super heat value is greater than 5, then check the compressor load. Open the “Compressor Map” window. Click on the “Compressor Envelope” icon located below the menu bar. The graph shows saturated discharge temperature (SDT) versus the evaporator capacity; refer to Figure 4-16. The blue dot represents the current operating point (i.e. the current evaporator load). If the current load is greater than the maximum compressor load capacity, then reduce the load. Alternatively, contact the Turbocor Sales Office to obtain a compressor model designed to handle a greater load capacity.

If the “Motor High Current Warning” persists while the 3-phase AC input voltage is within the specified voltage range and the compressor load is within the capacity specification, contact Turbocor technical support.

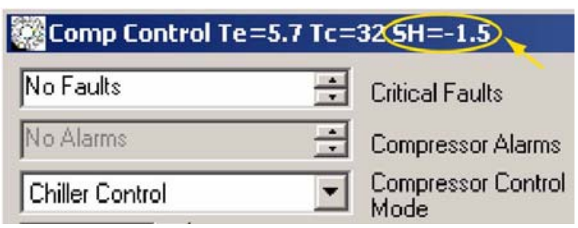


Figure 4-15 Super Heat Value

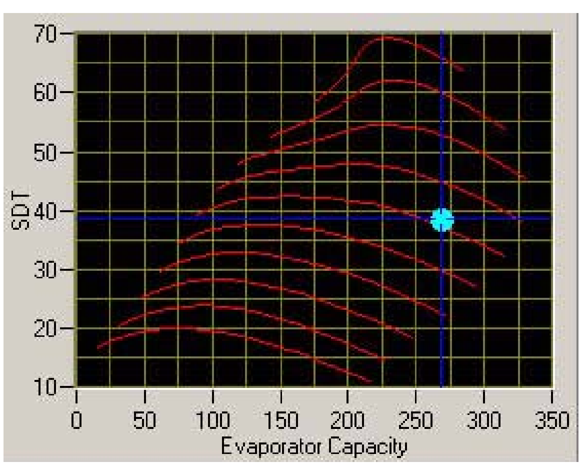


Figure 4-16 Compressor Load Capacity

4.4.3.4 Motor High Current Fault

A “Motor High Current Fault” will stop the motor. Two possible reasons for this fault are:

- AC input voltage is too low
- Compressor is overloaded

Follow the troubleshooting steps 1 to 3 of 4.4.3.3 "Motor High Current Warning".

If the “Motor High Current Fault” persists while the 3-phase AC input voltage is within the specified voltage range and the compressor load is within the capacity specification, contact Turbocor technical support.

4.4.3.5 Inverter Error Signal

The fault message “Inverter Error Signal” indicates that there is an error with the IGBT Inverter.

Verify the IGBT Inverter. Refer to 4.5.6 "IGBT Inverter Verification" on page 67.

If the “Inverter Error Signal” persists after the IGBT Inverter is verified to be not faulty, contact Turbocor technical support.

4.4.3.6 Over-Current During Startup - Rotor May Be Locked

The fault message “Over-Current During Startup - Rotor May Be Locked” indicates that too much current is outputted to the shaft (rotor) during compressor startup.

1. Disconnect and reconnect the ribbon cable connecting the Backplane to the IGBT Inverter. Refer to 5.6.1.7 "Disconnecting the Backplane from the IGBT Inverter" on page 93 and 5.6.2.3 "Disconnecting the IGBT Inverter from the Backplane" on page 94.
2. Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75. See the“Calibration Data Interpretation” on page 76.

If the “Over-Current During Startup - Rotor May Be Locked” fault persists, contact Turbocor technical support.

4.4.3.7 Bearing Warning Active

The fault message “Bearing Warning Active” will slow down the motor. The possible reasons for this fault are:

- The shaft is out of orbit
- Compressor communication is affected by noise

- Excessive compressor load

1. Open the “Magnetic Bearing Monitoring” window. From the menu bar, select “Window”→ “Bearing”, or click on the “Magnetic Bearings” icon located below the menu bar.
2. Observe the shaft orbit from the “Magnetic Bearing Monitoring” graph. See Figure 4-17. If the shaft (represented by green dots) exceeds 500 units in any direction (left, right, up, down), then proceed with the next step, otherwise continue with step 4.

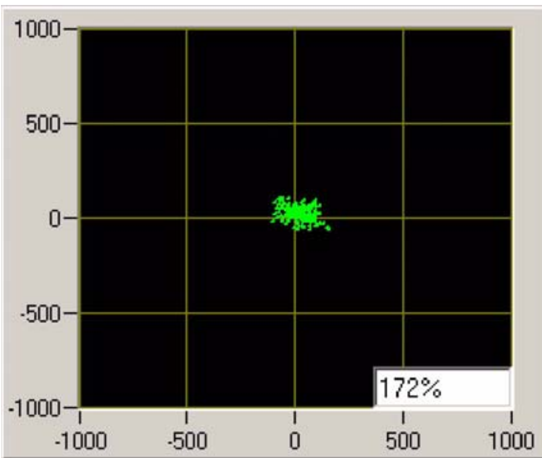


Figure 4-17 Shaft Orbit

3. Relieve the compressor load by reducing the external compressor resistance. Either increase the suction or reduce the discharge pressure.
4. Check that all communication cables are properly connected. Check the cable connection between the user interface and the Compressor Interface (at port J1 for RS485 communication; at port J7 for RS232 communication). Check the cable connection between the Compressor Interface (at port J6) and the Backplane (at port J7). Refer to 3.2.3 "Backplane I/O" on page 9 and 3.2.4 "Compressor Interface I/O" on page 13.

If the “Bearing Warning Active” fault persists, contact Turbocor technical support.

4.4.3.8 Bearing Error Active

The fault message “Bearing Error Active” indicates that a bearing error has stopped the motor.

Manually calibrate the bearings according to the procedure described in 4.5.12 "Bearing Calibration" on page 75.

Continue to troubleshoot by following the“Calibration Data Interpretation” on page 76.

If the “Bearing Error Active” fault persists, contact Turbocor technical support.

4.4.3.9 Output Voltage on the Motor Generates No Current

The fault message “Output voltage on the motor generates no current” indicates a problem with the IGBT Inverter.

1. Disconnect and reconnect the ribbon cable connecting the Backplane to the IGBT Inverter. Refer to 5.6.1.7 "Disconnecting the Backplane from the IGBT Inverter" on page 93 and 5.6.2.3 "Disconnecting the IGBT Inverter from the Backplane" on page 94.
2. Verify the IGBT Inverter. Follow the procedures outlined in 4.5.6 "IGBT Inverter Verification" on page 67.

If the “Output voltage on the motor generates no current” fault persists, contact Turbocor technical support.

4.4.3.10 Soft Start Error Detected

The fault message “Soft Start Error Detected” indicates that there is a problem with the Soft-Start Controller.

Follow the procedures outlined in 4.5.3 "Soft-Start Controller Verification" on page 61.

4.4.3.11 24Vdc Fault

The fault message “24Vdc Fault” indicates that the 24VDC supply is faulty. Troubleshoot the 24VDC supply by following the steps outlined in 4.3.4.2 "No (Low) +24V Voltage" on page 36.

4.4.3.12 Motor Back EMF is Low

The fault message “Motor back EMF is low” indicates that the motor magnet is not strong enough, possibly caused by insufficient cooling.

1. Verify that the motor-cooling solenoids are not faulty, and ensure that the motor-cooling paths are not blocked. Refer to 4.5.14 "Motor-Cooling Solenoid Verification" on page 77.
2. Check if the “Motor back EMF is low” fault is still present. If so, it is probable that the motor magnetic field strength is degraded.

   Under heavy load, the motor may trip due to high current. To strengthen the motor magnetic field, contact Turbocor technical support.

4.4.3.13 EEPROM Checksum Error

The fault message "EEPROM checksum error" indicates a fault with the BMCC. Replace the BMCC.

4.4.3.14 Generator Mode Active

The message "Generator mode active" is not a fault message. It indicates that the compressor is coasting down due to a loss of power. Verify the power switch board.

4.4.3.15 SCR Phase Loss

The fault message "SCR phase loss" indicates that an excessive imbalance may exist between the phases.

Measure the difference in current between the input phases. Refer to 4.5.1.5 "Verifying Phase Current" on page 61.

If there is a current imbalance between the phases, verify the power switch board.

4.4.3.16 No Motor Drive

- **DC Bus Voltage OK**

Ensure that the compressor is able to start up by measuring the DC bus voltage. Refer to "DC Bus Verification" on page 61.

If the DC bus voltage is less than 15VDC, continue to troubleshoot with "No (Low) DC Bus Voltage" on page 29.

- **HV+ Voltage OK**

Check that the HV+ voltage on the backplane is +250VDC±5%. Refer to section 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement" on page 71.

- **No 24VDC Fault**

Open the "Compressor Event Log" window. Select "Window"→ "Event Log" from the menu bar, or click on the "Event Log" icon located below the menu bar.

Check that the following message is *not* logged: "24V out of bounds. Udc24=*x*. Exceeded boundary = *y*", where x, y are the actual and boundary voltages, respectively.

If there is a 24VDC fault, troubleshoot accordingly.

- **Error Logged**

Check if the following message is logged: "The shaft may be locked. Iq=*x*", where *x* represents some non-negative value. If there are other errors logged, troubleshoot accordingly.

Under normal conditions, when the motor is driving, the "Inverter Side Motor Amps = Iq" parameter should decrease to at least -1 during compressor start-up, and the "Amps - Id & Iq" graph should look like Figure 4-18.

NOTE:
The turquoise line represents the "Inverter Side Motor Amps = Id" parameter, and the red line represents the "Inverter Side Motor Amps = Iq" parameter.

Notice that the red line (Iq) dips to negative values. If the "Inverter Side Motor Amps = Iq" does not decrease to negative values during compressor start-up, then there is no motor drive.

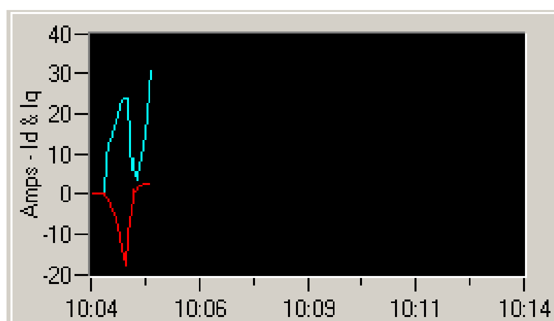


Figure 4-18 Id & Iq During Compressor Start-Up

If the above symptoms are present, then follow the troubleshooting steps outlined in Figure 4-19 to determine the source of the problem.

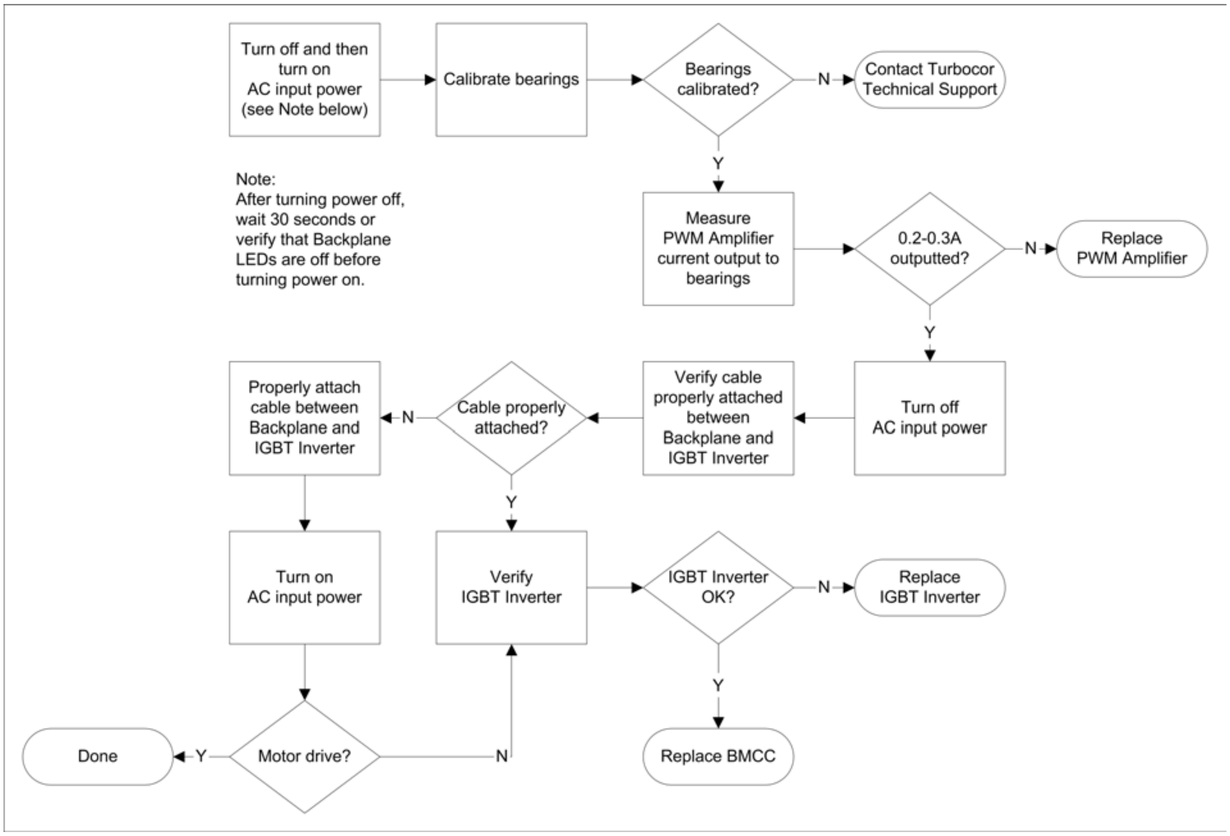


Figure 4-19 No Motor Drive Troubleshooting Flow Chart

1. Turn OFF AC input power to the compressor. Wait either 30 seconds or until the Backplane LEDs are off. Turn ON AC input power.
2. Calibrate the bearings. See section “Bearing Calibration” on page 75. If the bearings can not be calibrated, contact Turbocor technical support; otherwise, continue with the next step.
3. Measure the PWM Amplifier current output to the front, rear and axial bearings. Refer to section 4.5.13 "Current Output to Bearings Measurement" on page 76. If the current output *does not* measures 0.2-0.3A for each bearing, the PWM Amplifier is faulty and needs to be replaced; otherwise, proceed to the next step.
4. Turn OFF the AC input power to the compressor.
5. Verify that the interface cable is properly attached between the IGBT Inverter and the Backplane. The interface cable is attached on top of the IGBT Inverter (as shown in point 5 of Figure 3-16-"Compressor Energy and Signal Flow Connections" on page 20), and on the Backplane at port J6 (refer to Figure 3-7-"Backplane Input/Output" on page 10 for port locations). If the interface cable is already attached properly, proceed to step 8; otherwise, continue with the next step.
6. Properly attach the interface cable between the IGBT Inverter and the Backplane.
7. Turn ON the AC input power to the compressor. If there is still no motor drive, continue with the next step.

NOTE:
To determine if there is no motor drive, check if the error “The shaft may be locked. Iq=*x*”, where *x* represents some non-negative value, is logged in the “Compressor Event Log” window.

8. Verify the IGBT Inverter. Refer to “IGBT Inverter Verification” on page 67. If the IGBT Inverter is

verified to be okay, then replace the BMCC; otherwise, replace the IGBT Inverter.

4.4.4 IGV Fault

Open the “Compressor Controller Form”. Click on the “Compressor Controller Parameters” icon located below the menu bar.

Set the “Compressor Control Mode” to “Manual Control”. Select “Manual Control” from the “Compressor Control Mode” drop down list.

In the “Inlet Guide Vane” parameter box, input a smaller value than the current value. The IGV position indicator should “close”. (see point 7 of Figure 3-3-"Compressor Sensors, Cables, and Indicators" on page 5, to locate the IGV position indicator)

Next, in the “Inlet Guide Vane” parameter box, input a value greater than the original value. The IGV position indicator should “open”.

If the IGV position indicator does not “open” and “close” as expected, follow the steps outlined in Figure 4-20 to determine the source of the problem.

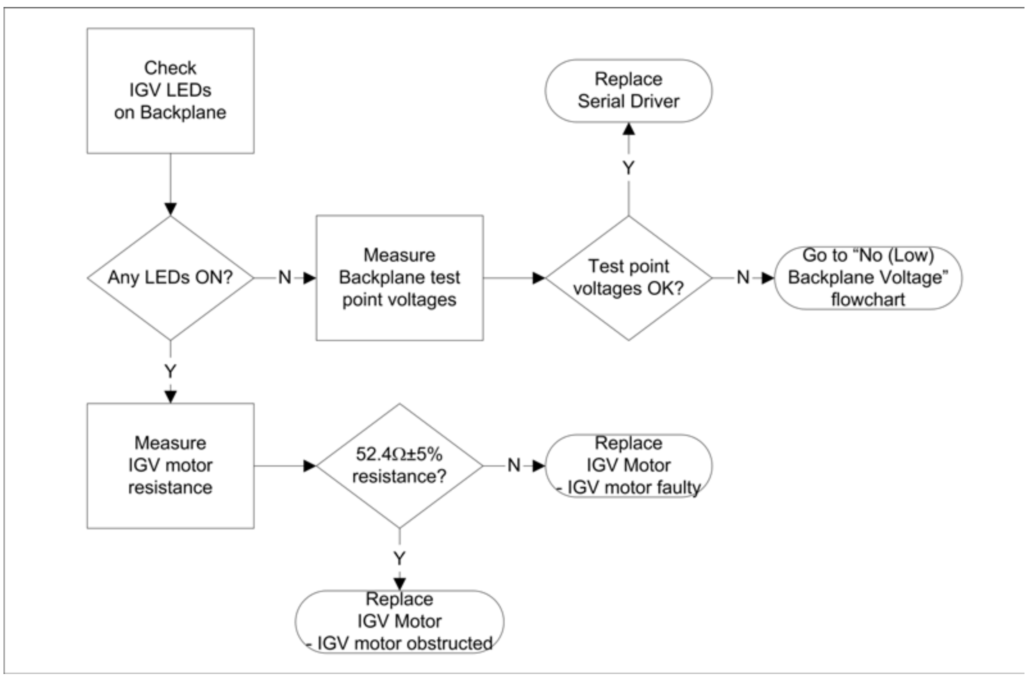


Figure 4-20 IGV Motor Troubleshooting Flow Chart

1. Check the IGV LEDs (D16-D13) on the Backplane. Refer to 3.2.3 "Backplane I/O" on page 9 for LED locations. If *any* of the LEDs are ON, it indicates that power and signals are being transmitted to the IGV motor from the Serial Driver; if this is the case, proceed with the next step. If none of the LEDs are ON, it indicates that no power or signal is being transmitted to the IGV motor; in this case, proceed to step 3.
2. Measure the IGV motor resistance. Refer to 4.5.18 "Inlet Guide Vane (IGV) Motor Verification"-"Resistance Measurement" on page 78. If the IGV resistance is 52.4Ω±5%, the IGV motor is obstructed; otherwise, the IGV motor is faulty. In either case, the IGV motor must be replaced.
3. Verify all the test point voltages on the Backplane. Refer to section 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If all the test points output the expected voltage, the Serial Driver is faulty and needs to be replaced; otherwise, continue to troubleshoot with 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.4.5 Interlock Fault

Check that the circuit connected to I/LOCK+ and I/LOCK- on the Compressor Interface module (at port J2) is closed. Refer to 3.2.4 "Compressor Interface I/O" on page 13 for the port location.

Monitor Program Detects Open Interlock

Open the “Compressor Controller Form”. Click on the “Compressor Controller Parameters” icon located below the menu bar. If the “Interlock Contact” parameter reads “Open”, and the message “waiting for interlock to close” is shown in the “System Messages” box, then follow the troubleshooting steps outlined in Figure 4-21 to determine the source of the problem.

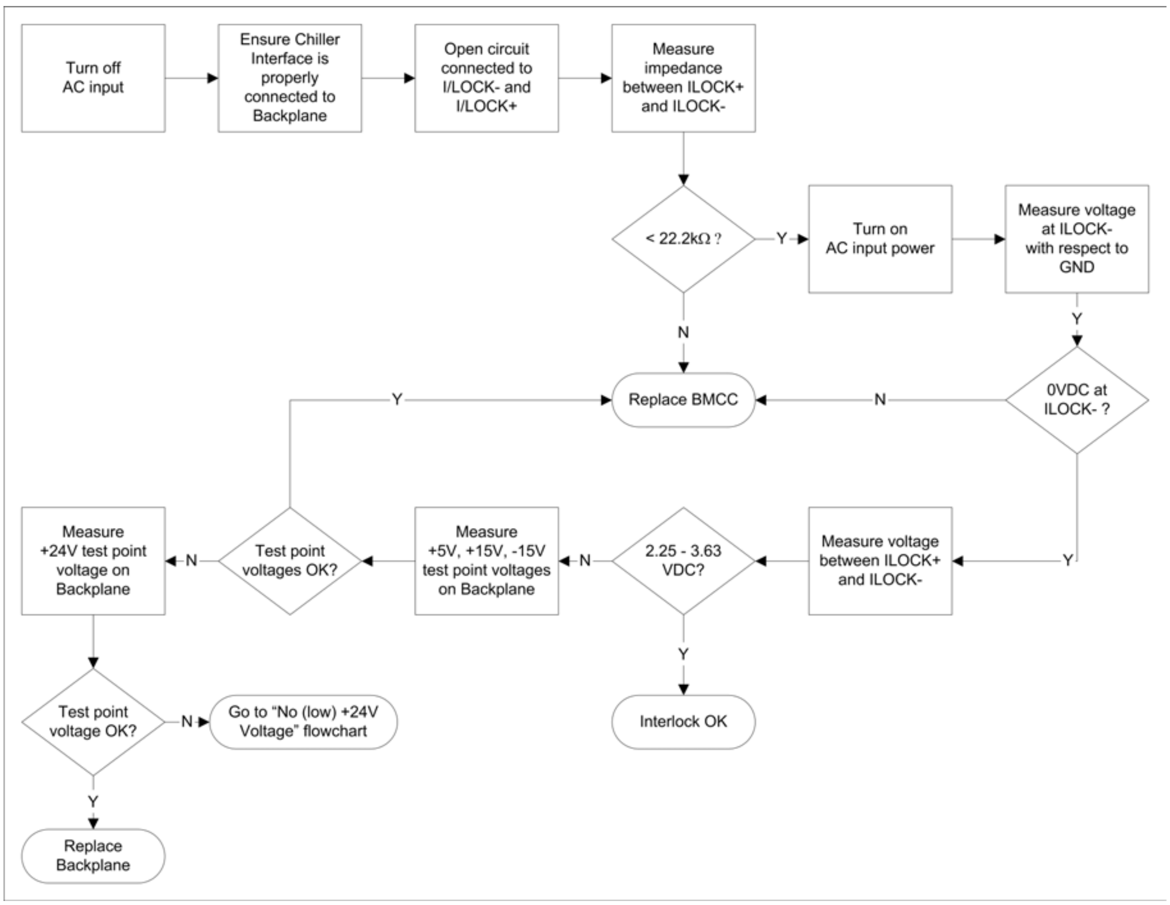


Figure 4-21 Interlock Troubleshooting Flow Chart

1. Turn OFF the AC input power to the compressor.
2. Make sure the Compressor Interface cable is properly attached to the Backplane and to the Compressor Interface module before proceeding with the following steps.
3. Open the circuit connected to I/LOCK+ and I/LOCK- on the Compressor Interface module. Refer to 3.2.4 "Compressor Interface I/O" on page 13 for the location of the interlock (I/LOCK) at port J2.
4. Set the multimeter for resistance measurement. Place the meter probes on I/LOCK+ and I/LOCK-. Measure and record the resistance. Swap the probes. Both resistance measurements should show a resistance < 22.2kΩ; if not, the 1kΩ resistor in the I/LOCK circuit is

burned. Consequently, the BMCC needs to be replaced; otherwise, proceed with the next step.

5. Turn ON the AC input power to the compressor.
6. Set the multimeter for DC voltage measurement, and measure the voltage at I/LOCK- on the Compressor Interface. Place the red (+) meter probe on I/LOCK-, and place the black (-) meter probe on the compressor casing (compressor ground). If the measured value at I/LOCK- is not 0VDC, the 10kΩ resistor of the I/LOCK circuit is burned. Consequently, the BMCC needs to be replaced; otherwise, proceed with the next step.
7. Measure the voltage between I/LOCK+ and I/LOCK-. Place the red (+) meter probe on I/LOCK+, and the black (-) meter probe on I/LOCK-. If the meter shows a voltage between 2.25VDC and 3.63VDC, the interlock circuit is not faulty; otherwise, proceed with the next step.
8. Measure the +5V, +15V, and -15V test point voltages on the Backplane. Refer to section 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement". If the test point voltages are as expected, the BMCC is faulty and needs to be replaced; otherwise, proceed with the next step.
9. Measure the +24V test point voltage on the Backplane. Refer to section 4.5.8 "Backplane Verification"-"Test Point Voltage Measurement". If the measured voltage is 24V±5%, the Backplane is faulty and needs to be replaced; otherwise, continue to troubleshoot with 4.3.4.2 "No (Low) +24V Voltage" on page 36.

4.4.6 Compressor Control Faults and Alarms

This section describes the possible “Critical Faults” and “Compressor Alarms” displayed in the “Compressor Controller” window, and provides the troubleshooting steps for each fault.

NOTE:
A “Compressor Alarm” will slow down the motor, whereas a “Critical Fault” will trip the motor. A “Compressor Alarm” occurs when a compressor parameter (e.g. temperature/pressure) has exceeded its alarm limit setting. A “Critical Fault” occurs when a compressor parameter has exceeded its fault limit setting.

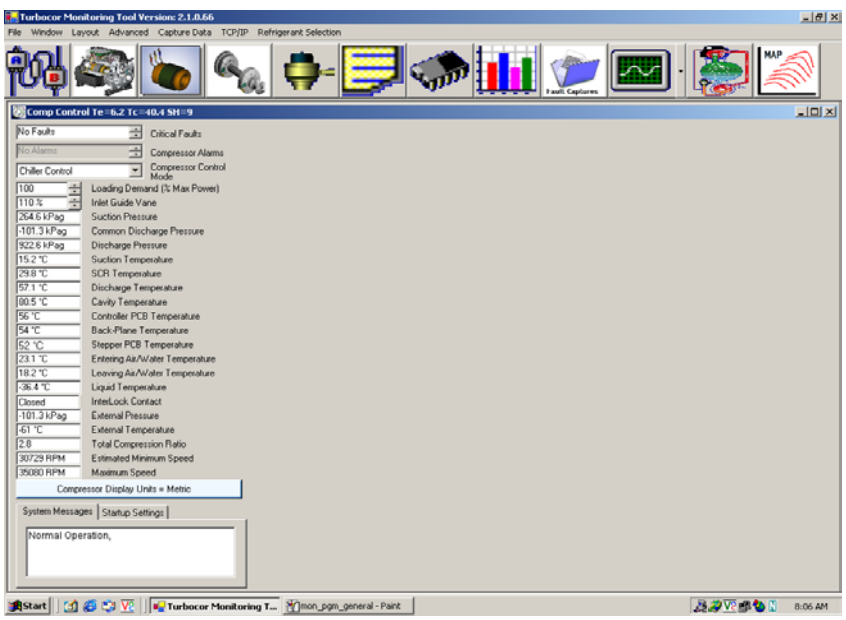


Figure 4-22 Monitoring Program - Compressor Control Window

NOTE:
If a compressor controller fault/alarm occurs, it is an indication that the EEPROM fault/alarm limit setting has been exceeded. Check that the EEPROM settings are adequate for the current compressor load. From the menu bar, select "Window"→ "Eeprom Settings", or click on the "Eeprom Settings" icon located below the menu bar. Select the "CC Alarm Limits" tab to view the "Compressor General Alarm Limits"; or select the "CC Trip Limits" tab to view the "Compressor General Fault Limits". See Figure 4-23. If the current user access level does not permit viewing of the EEPROM settings, contact a service technician with a higher access level.

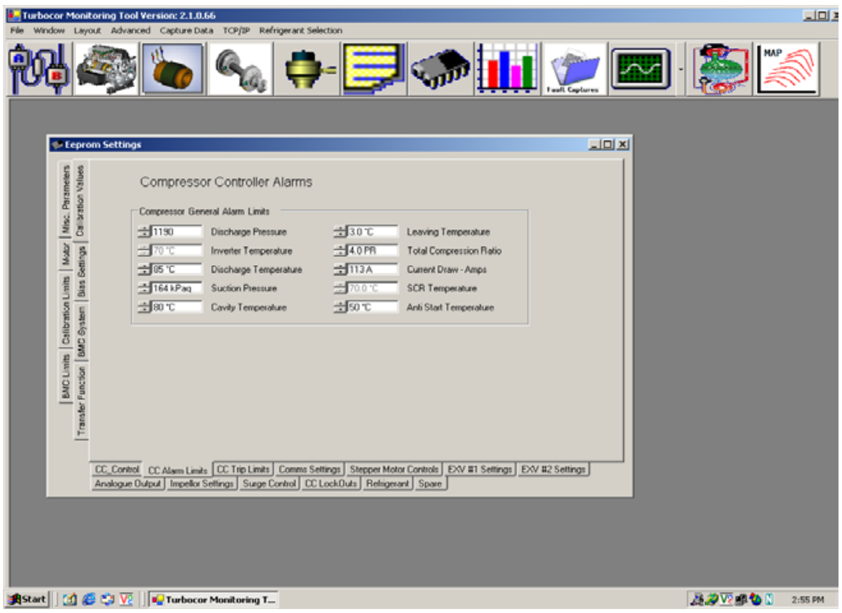


Figure 4-23 Monitoring Program - EEPROM Settings Window

4.4.6.1 Inverter Temperature Fault/Alarm

An "Inverter Temperature" fault/alarm indicates that the motor cooling is insufficient. Verify that the motor-cooling solenoids are not faulty, and ensure that the motor-cooling paths are not blocked. Refer to 4.5.14 "Motor-Cooling Solenoid Verification" on page 77.

It is possible that the inverter temperature has exceeded its fault/alarm limit. The "Inverter Temperature" fault/alarm limit may be viewed from the "Eeprom Settings" window (refer to Figure 4-23). If access to the "Eeproms Settings" window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.2 Discharge Temperature Fault/Alarm

A "Discharge Temperature" fault/alarm suggests that there may be insufficient charge (i.e. not enough gas). Check the compressor charge.

It is possible that the discharge temperature has exceeded its fault/alarm limit. The "Discharge Temperature" fault/alarm limit may be viewed from the "Eeprom Settings" window (refer to Figure 4-23). In the case of an alarm, the "Discharge Temperature" alarm limit may be adjusted as necessary to meet the application's needs. If access to the "Eeproms Settings" window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.3 Suction Pressure Fault/Alarm

A "Suction Pressure" fault/alarm suggests either insufficient charge, or insufficient system load. Check the charge and system load.

It is possible that the suction pressure has exceeded its fault/alarm limit. The "Suction Pressure" fault/alarm limit may be viewed from the "Eeprom Settings" window (refer to Figure 4-23). Adjust the "Suction Pressure" fault/alarm limit as necessary to meet the application's needs. If access to the "Eeproms Settings" window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.4 Discharge Pressure Fault/Alarm

A “Discharge Pressure” fault/alarm suggests that the condenser may be faulty. Check the condenser.

It is possible that the discharge pressure has exceeded its fault/alarm limit. The “Discharge Pressure” fault/alarm limit may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). In the case of an alarm, the “Discharge Pressure” alarm limit may be adjusted as necessary to meet the application’s needs. If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.5 3-Phase Over-Current Fault/Alarm

A “3-Phase Over-Current Fault” indicates that there may be an excessive load on the system. Adjust the system control parameters.

4.4.6.6 Cavity Temperature Fault/Alarm

A “Cavity Temperature” fault/alarm indicates that the motor cooling is insufficient. Verify that the motor-cooling solenoids are not faulty, and ensure that the motor-cooling paths are not blocked. Refer to 4.5.14 "Motor-Cooling Solenoid Verification" on page 77.

It is possible that the cavity temperature has exceeded its fault/alarm limit. The “Cavity Temperature” fault/alarm limit may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). In the case of an alarm, the “Cavity Temperature” alarm limit may be adjusted as necessary to meet the application’s needs. If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.7 Leaving Water Temp Fault/Alarm

A “Leaving Water Temp” fault/alarm suggests that there may be insufficient water flow due to air gaps in the water.

It is possible that the leaving water temperature has exceeded its fault/alarm limit. The “Leaving Temperature” fault/alarm limit may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). Adjust the “Leaving Temperature” fault/alarm limit as necessary to meet the application’s needs. If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.8 Compression Ratio Fault/Alarm

A “Compression Ratio” fault/alarm suggests that either the condenser may be faulty, or there is not enough load on the evaporator. Check the condenser and evaporator loads.

It is possible that the total compression ratio has exceeded its fault/alarm limit. The “Total Compression Ratio” fault/alarm limit may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). Adjust the “Total Compression Ratio” fault/alarm limit as necessary to meet the application’s needs. If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.9 BMC Fault

A “BMC Fault” indicates that the BMCC is faulty. Replace the BMCC module.

4.4.6.10 Sensor Fault

A “Sensor Fault” indicates a problem with one or more of the compressor sensors. First, check the wires and connections for all sensors listed below (refer to 3.2.3 "Backplane I/O" on page 9, and 3.2.4 "Compressor Interface I/O" on page 13 for the sensor locations), then check the BMCC (refer to 4.5.10 "BMCC Verification" on page 73).

Sensors:

- Discharge Temperature/Pressure Sensor (check point 1 of Figure 3-3-"Compressor Sensors, Cables, and Indicators" on page 5; and check Backplane, port J19).
- Suction Temperature/Pressure Sensor (check point 6 of Figure 3-3-"Compressor Sensors, Cables, and Indicators" on page 5; and check Backplane, port J18).
- Motor Winding Sensor (check point 2 of Figure 3-3-"Compressor Sensors, Cables, and Indicators" on page 5; and check Backplane, port J20).
- Shaft position from rear bearing sensor (check Backplane, port J9)
- Shaft position from front bearing sensor (check Backplane, port J10).
- Cavity sensor (check Backplane, port J23).
- Liquid temperature sensor (check Compressor Interface, port J2, pin 9).

- Entering water temperature sensor (check Compressor Interface, port J3, pin 5; unless the ENTRY jumper is installed on Compressor Interface).
- Leaving water temperature sensors (Compressor Interface, port J3, pin 7; unless the LEAVE jumper is installed on Compressor Interface).
- Liquid level sensors driving the external expansion valves 1 and 2 (check Compressor Interface, port J5)
- Spare pressure sensor (check Compressor Interface, port J6, pin 1).
- Spare temperature sensor (check Compressor Interface, port J6, pin 4).

4.4.6.11 SCR Temperature Fault/Alarm

An “SCR Temperature” fault/alarm indicates insufficient cooling to the SCR plate.

It is possible that the SCR temperature has exceeded its fault/alarm limit. The “SCR Temperature” fault/alarm limit may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

4.4.6.12 Lock Out Fault

The compressor will start up even if an anti-start temperature alarm, inverter temperture alarm, cavity temperature alarm, or SCR temperature alarm occurs. If any (or a combination of) the aforementioned alarms occurs more than 3 times within 30 minutes, a “Lock Out Fault” occurs.

The alarm limits may be viewed from the “Eeprom Settings” window (refer to Figure 4-23). Check that the “Anti Start Temperature” and “Cavity Temperature” alarm limit is at an adequate setting. Adjust the “Anti Start Temperature” and “Cavity Temperature” alarm limit as necessary to meet the application’s needs. If access to the “Eeproms Settings” window is not permitted, contact a user with a higher access level to view the fault/alarm limit.

A “Lock Out Fault” also suggests that the compressor motor cooling is insufficient. Verify that the motor-cooling solenoids are not faulty, and ensure that the motor-cooling paths are not blocked. Refer to 4.5.14 "Motor-Cooling Solenoid Verification" on page 77.

4.4.6.13 Winding Temperature Fault

A “Winding Temperature Fault” indicates that the motor winding temperature has exceeded 155°C. The compressor needs to be cooled down before resuming operation. Verify that the motor-cooling solenoids are not faulty, and ensure that the motor-cooling paths are not blocked. Refer to 4.5.14 "Motor-Cooling Solenoid Verification" on page 77.

4.4.7 Event Log Faults

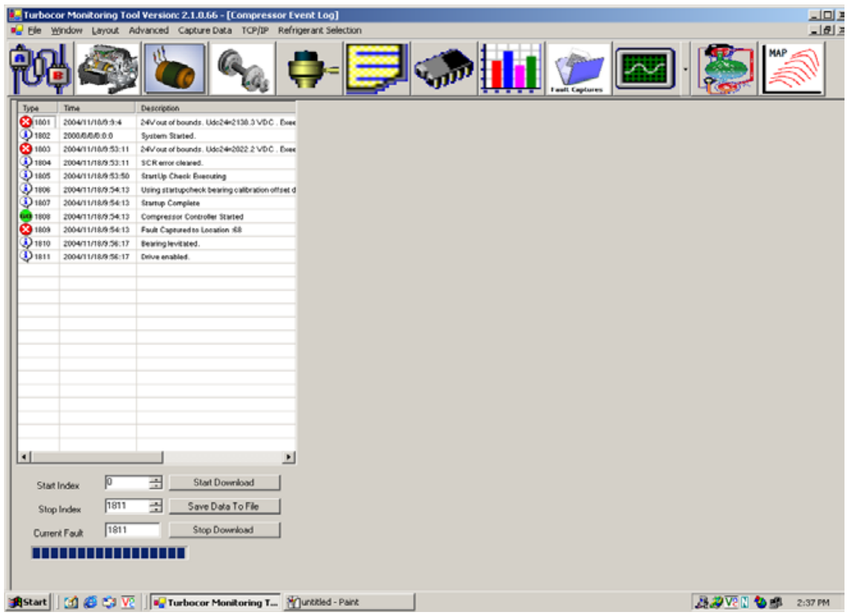
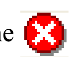


Figure 4-24 Monitoring Program - Event Log Window

The compressor event log provides details about the compressor events and faults.

The "Type" column describes the type of event or fault logged:

- The  icon indicates that the compressor controller has started
- The  icon denotes information about the compressor events.
- The  icon denotes a compressor fault.

In the case of a compressor fault, check the timestamp in the "Time" column. To help in troubleshooting the compressor fault, look at all the events and faults that occurred before the fault (i.e. events and faults logged with an earlier timestamp). In particular, note the information logged immediately before the fault occurred, as it provides hints to the possible events causing the fault.

4.5 Verification Procedures

CAUTION

Refer to section 1 "Safety Considerations" prior to commencing verification procedures.

4.5.1 3-phase AC Input Verification

DANGER

This equipment contains hazardous voltages that can cause injury or death. Exercise extreme caution when working on energized circuits.

⚠ DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

Service Tools/Test Equipment:

- Multimeter
- Safety Glasses

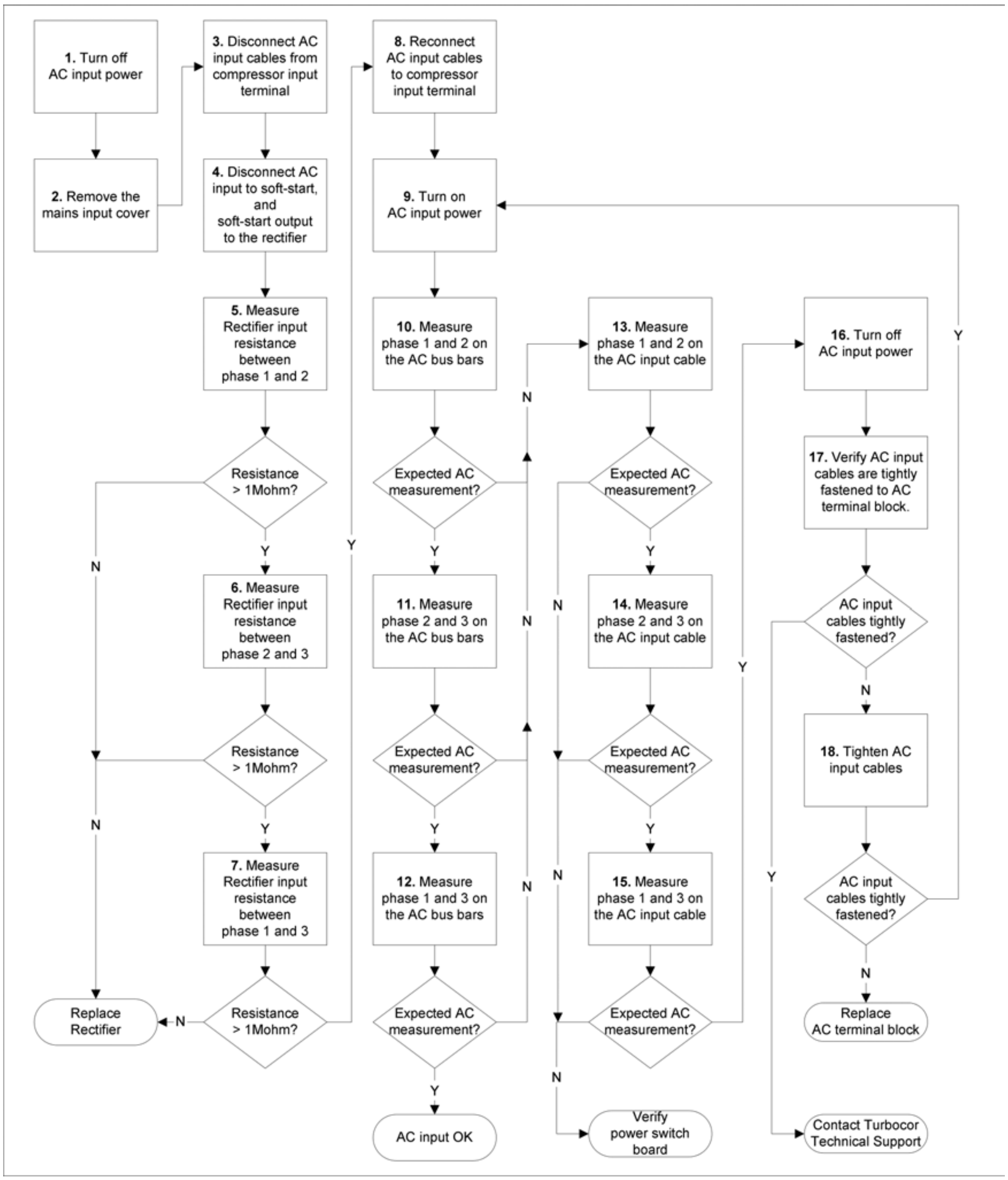


Figure 4-25 AC Input Voltage Verification Flowchart

4.5.1.1 Measuring the Rectifier Input Resistance

1. Turn OFF the AC power input.
2. Remove the mains input cover (refer to section 6.4.1).
3. Disconnect the AC input cables from the compressor (see section paragraph 5.6.1.1).
4. Disconnect the AC input from the Soft-Start Controller (see section paragraph 5.6.1.2), and disconnect the Rectifier from the Soft-Start Controller output. (see section paragraph 5.6.1.3).
5. Set the multimeter to measure resistance.

   Measure the resistance between phase 1 and phase 2 of the AC input. Place the red (+) meter probe on phase 1, and the black (-) meter probe on phase 2. Verify the meter shows a resistance > 1MΩ.

   Reverse the probes between phase 1 and phase 2 of the AC input. Verify that the meter shows a resistance > 1MΩ.

   If the measured result does not correspond to the expected results, then the Rectifier is faulty and needs to be replaced; otherwise proceed with the next step.
6. Repeat step 5 for phase 2 and phase 3.
7. Repeat step 5 for phase 1 and phase 3.

WARNING

If the measured results do not correspond to the expected results, then the Rectifier is faulty and needs to be replaced. DO *not* attempt to power the compressor until the Rectifier is replaced.

4.5.1.2 Measuring the 3-phase AC Input Voltage from the AC Bars

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DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

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1. Reconnect the AC input cables to the compressor (reverse the procedure outlined in section paragraph 5.6.1.1).
2. Turn ON the AC input power.
3. Set the multimeter to AC mode for voltage measurements.

   Place the red (+) meter probe on phase 1 of the AC input bars, and place the black (-) meter probe on phase 2 of the AC input bars, as shown in Figure 4-26.

   Verify that the meter shows the expected AC measurement as per the range indicated in Table 4-6. Note that the acceptable AC input voltage range is set to -10% and +10% of the standard AC input voltage.

   If the meter does not show any reading, it is possible there is no power from the AC source. Make sure the AC power source is turned on and try again. If the AC power source is turned on and there is still no reading from the meter, or if the measured values do not correspond to the values specified, then proceed to "Measuring the 3-phase AC Input Voltage from the AC Input Cables"; otherwise proceed with the next step.

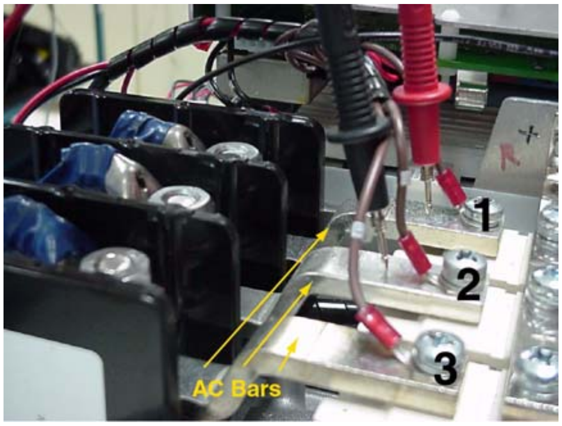


Figure 4-26 Measuring the AC Input Voltage on the AC bars

Table 4-6 Expected AC Voltage Range

Country	AC Input	
	Standard Voltage	Acceptable Voltage Range
United States	460VAC	414-506VAC
Europe	400VAC	360-440VAC
Asia	380VAC	342-418VAC

4. Place the red (+) meter probe on phase 2 of the AC input bars, and place the black (-) meter probe on phase 3 of the AC input bars. Repeat step 3.
5. Place the red (+) meter probe on phase 1 of the AC input bars, and place the black (-) meter probe on phase 3 of the AC input bars. Repeat step 3.

If the measured values correspond to the specified values for all phases, then the AC input voltage is okay.

4.5.1.3 Measuring the 3-phase AC Input Voltage from the AC Input Cables

DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

1. Set the multimeter to AC mode for voltage measurements.

NOTE:
Place the meter probes such that they are in contact with the the AC input cable, and not with the bolts, screws, or studs which connect the cables to the input terminal block.

Using a multimeter, place the red (+) meter probe on phase 1 of the AC cables, and place the black (-) meter probe on phase 2 of the AC cables, as shown in Figure 4-27.

Verify that the meter shows the expected AC measurement indicated in Table 4-6.

If the meter does not show any reading, it is possible there is no power from the AC source. Make sure the AC power source is turned on and try again. If the AC power source is turned on and there is still no reading on the meter, then the AC power source is faulty. If the measured values do not correspond to the values specified, then there is phase loss, and the AC power source is faulty. In both cases, verify and repair the power switch board. Otherwise, proceed with the next step.

.

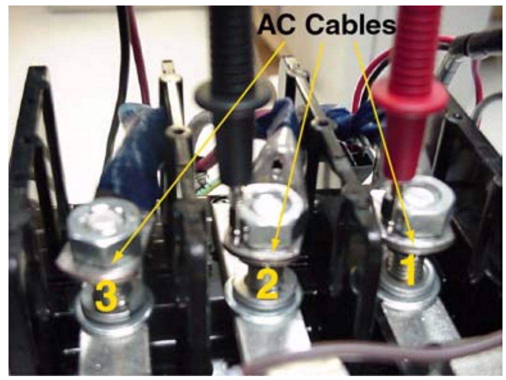


Figure 4-27 Measuring the AC Input Voltage from the AC Input Cables

2. Place the red (+) meter probe on phase 2 of the AC input bars, and place the black (-) meter probe on phase 3 of the AC input bars. Repeat step 1.
3. Place the red (+) meter probe on phase 1 of the AC input bars, and place the black (-) meter probe on phase 3 of the AC input bars. Repeat step 1.

If the AC input voltage, measured from the AC input cables, is as expected, then proceed to "Verifying the AC Cable Connections".

4.5.1.4 Verifying the AC Cable Connections

1. Turn OFF the AC input power to the compressor.
2. Verify that the AC cables are tightly fastened to the input terminal block. You should not be able to move the AC input cables at the compressor input terminal. If the cables are not tightly fastened, proceed to the next step. Otherwise, ensure that all troubleshooting steps have been followed and properly performed. If the problem persists, then contact Turbocor technical support.
3. Tightly fasten the cables. If the cables can be tightly fastened, then return to "Measuring the 3-phase AC Input Voltage from the AC Bars". If the cables can not be tightly fastened to the input terminal, then the terminal block is damaged and needs to be replaced.

4.5.1.5 Verifying Phase Current

Service Tools/Test Equipment:

- Multimeter with ammeter clamp

DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

1. Turn OFF the AC power input.
2. Remove the mains input cover (refer to section 6.4.1).
3. Set the multimeter for current measurement.
4. Turn ON the AC input power to the compressor.
5. Measure and record the current for each phase. See Figure 4-28.

The difference between the phase currents, should be less than 15% of the largest measured value.

Figure 4-28 Phase Current Measurement

4.5.2 DC Bus Verification

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- Multimeter
- Safety glasses

DANGER

This equipment contains hazardous voltages that can cause injury or death. Exercise extreme caution when working on energized circuits.

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top access cover (refer to section 6.4.3).
3. Set the multimeter to DC mode for a voltage measurement to cover 750VDC.
4. Measure the voltage between the + DC bus and the - DC bus. The DC bus voltage measurement should correspond to the values indicated in Table 4-7. The lower limit of the DC voltage range is 1.35 times the standard AC input voltage -10%; the upper limit of the DC voltage range is 1.414 times the standard AC input +10%.

Table 4-7 Expected DC Voltage Range

Country	DC Voltage Range
United States	550 - 720 VDC
Europe	485 - 625 VDC
Asia	460 - 595 VDC

4.5.3 Soft-Start Controller Verification

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- Multimeter with scope

If a multimeter with a scope is not available, use the following equipment:

- Isolation transformer or Isolation probe
- Oscilloscope

⚠ DANGER

This equipment contains hazardous voltages that can cause injury or death. Exercise extreme caution when working on energized circuits.

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

4.5.3.1 Input Voltage Measurement

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3)
3. Unplug the input cable to the Soft-Start Controller. See “Disconnecting Soft-Start Controller Input” on page 92.
4. Set the multimeter for AC voltage measurement.
5. Turn ON the AC input power.
6. Place the red (+) meter probe to measure phase 1 of the input cable, and place the black (-) meter probe to measure phase 2 of the input cable. See Figure 4-29.

NOTE:
The three brown cables corresponds to the 3-phase AC voltage.

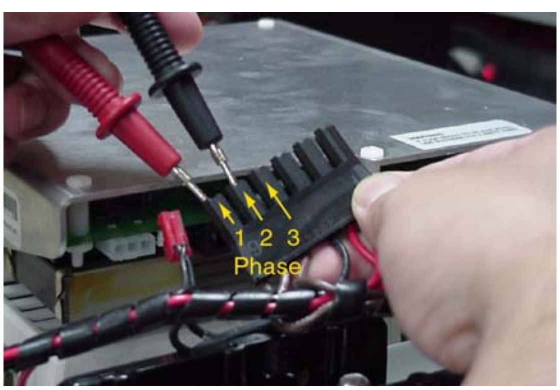


Figure 4-29 Measuring the AC input to the Soft-Start Controller

7. Verify that the meter shows the expected AC measurement as per the range indicated in Table 4-8.

Note that the acceptable AC input voltage range is set to ±10% of the standard AC input voltage.

Table 4-8 Expected AC Voltage Range

Country	AC Input	
	Standard Voltage	Acceptable Voltage Range
United States	460VAC	414 - 506VAC
Europe	400VAC	360 - 440VAC
Asia	380VAC	342 - 418VAC

8. Repeats steps 6 and 7, placing the red (+) meter probe to measure phase 2, and the black (-) meter probe to measure phase 3 of the input cable.
9. Repeats steps 6 and 7, placing the red (+) meter probe to measure phase 1, and the black (-) meter probe to measure phase 3 of the input cable.
10. Set the multimeter for DC voltage measurement.
11. Place the red (+) meter probe to measure the (+) DC bus voltage, and the black (-) meter probe to measure the (-) DC bus voltage, as shown in Figure 4-30.

NOTE:
The two red cables correspond to the (+) DC bus voltage, whereas the black cable corresponds to the (-) DC bus voltage.

12. Verify that the measured value corresponds to the values indicated in Table 4-9.

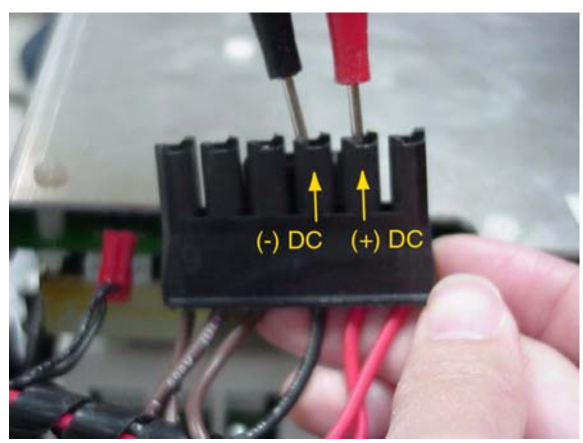


Figure 4-30 Measuring the DC input to the Soft-Start Controller

Table 4-9 Expected DC Voltage Range

Country	DC Input Range
United States	555 - 720 VDC
Europe	485 - 625 VDC
Asia	460 - 595 VDC

4.5.3.2 Output Voltage Measurement

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3)
3. Disconnect the Rectifier from the Soft-Start Controller as described in section “Disconnecting the Rectifier from the Soft-Start Controller” on page 92.

If using a multimeter with scope, proceed to step 5.

WARNING

If not using a meter with scope, it is essential to use an isolation transformer or an isolation probe. Testing the compressor without an isolation transformer or an isolation probe will severely damage the oscilloscope.

4. *If using an isolation transformer:*
   Connect one side of the isolation transformer to the oscilloscope, and connect the other side to the power jack. Attach one pair of test probes to the oscilloscope.

   If using an isolation probe:
   Attach the isolation probe to the oscilloscope. Connect the oscilloscope to the power jack.
5. Hook the common (ground) test probe to one of the Soft-Start output GND pins, and hook the other test probe to phase 1 of the Soft-Start output pins, as shown in Figure 4-31.

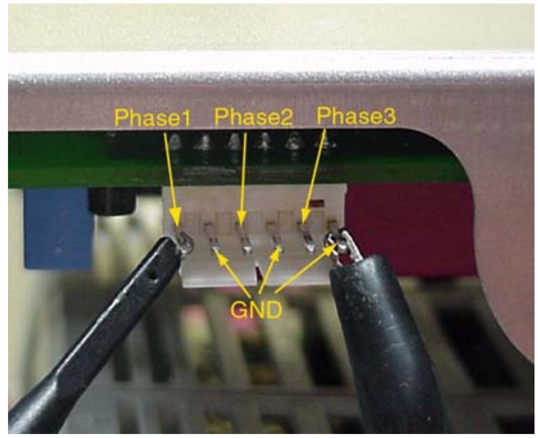


Figure 4-31 Soft-Start Phase 1 Output Pulse Measurement

6. Turn ON the scope.
7. Turn ON the AC input power.
8. Set the scope to view 5V/div and 50us/div.
9. Verify from the scope that the Soft-Start output pulses are as shown in Figure 4-32. The Soft-Start should output about 4-6 pulses, each of height 12V± 5%. The pulses should be separated by 0.1ms.

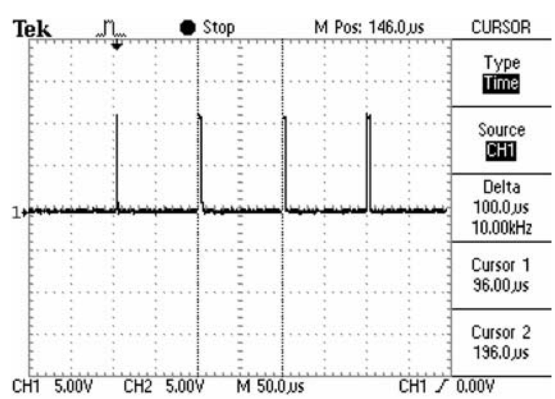


Figure 4-32 Expected Soft-Start Output Pulses

10. Change the scope setting to 5us/div.

11. Verify from the scope that the pulse width is 5us, as shown in Figure 4-33.

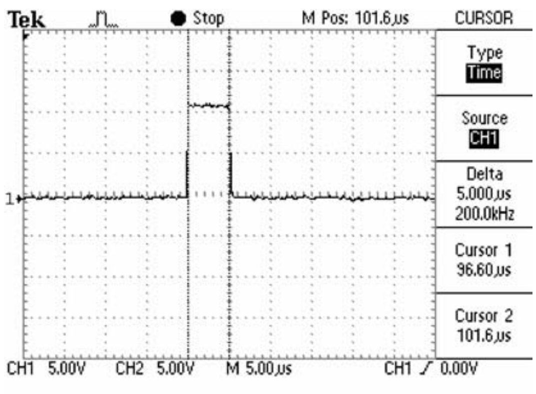


Figure 4-33 Expected Soft-Start Output Pulse Width

12. Hook the scope test probe to phase 2 of the Soft-Start output pins, as shown in Figure 4-34. Repeat steps 8 to 11.

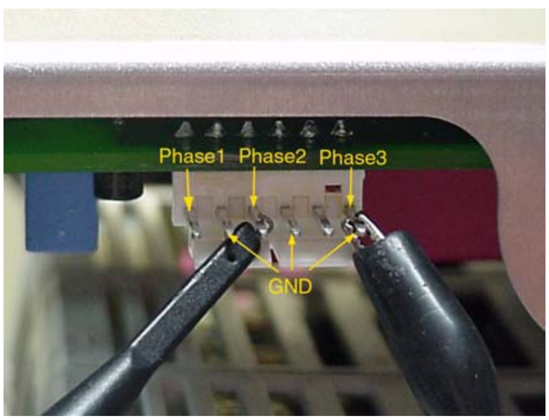


Figure 4-34 Soft-Start Phase 2 Output Pulse Measurement

13. Hook the scope test probe to phase 3 of the Soft-Start output pins, as shown in Figure 4-35. Repeat steps 8 to 11.

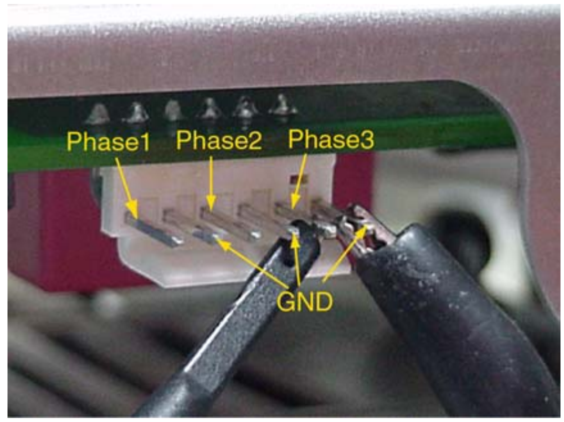


Figure 4-35 Soft-Start phase 3 Output Pulse Measurement

If the measured values do not correspond to the expected values, the Soft-Start is faulty and needs to be replaced.

4.5.4 Silicon-controlled Rectifier (SCR) Verification

Service Tools/Test Equipment:

- Multimeter

1. Turn OFF the AC input power.
2. Disconnect the AC input to the Soft-Start Controller (refer to section paragraph 5.6.1.2).
3. Isolate the main SCR bus bars from the capacitor bus bar.
4. Set the multimeter for diode measurements.

5. Place the red (+) meter probe on phase 1 of terminal 1, and the black (-) probe on terminal 2, as shown in Figure 4-36. The measured value should be infinite.

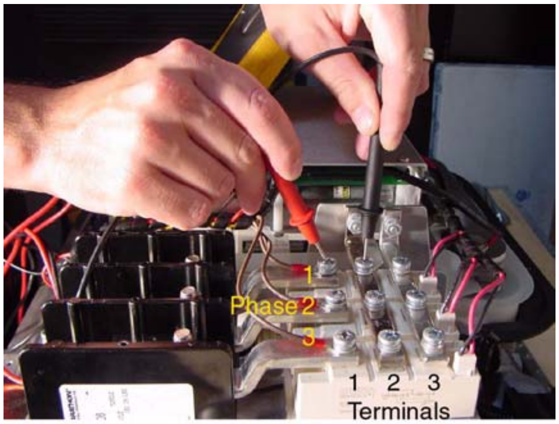


Figure 4-36 Verifying the Rectifier (1 of 2)

6. Reverse the probes on the terminals. The measured value should be infinite.
7. Place the red (+) probe on phase 1 of terminal 1, and the black (-) probe on terminal 3, as shown in Figure 4-37. The measured value should be infinite.

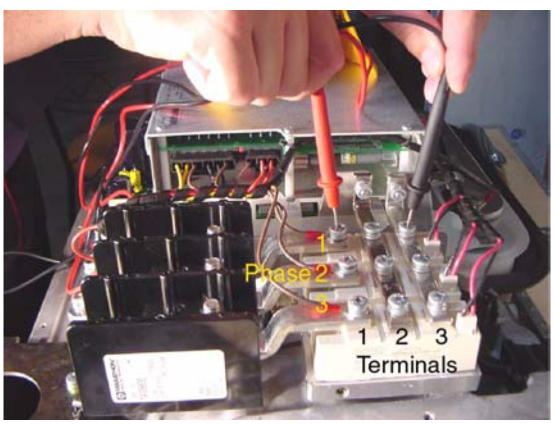


Figure 4-37 Verifying the Rectifier (2 of 2)

8. Reverse the probes on the terminals. The measured value should be 0.30 - 0.45V.
9. Repeat steps 5 to 8 for phase 2 and 3.

If the measured values do not correspond to the expected values, the Rectifier is faulty and needs to be replaced.

4.5.5 DC-Link Capacitor Verification

Service Tools/Test Equipment:

- Multimeter
- Phillips #2 screwdriver

4.5.5.1 Capacitor Check

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3).
3. Set the multimeter to measure resistance.
4. Place the black (-) meter test probe on one of the negative capacitor terminals, and place the red (+) meter test probe on the associated positive capacitor terminal, as shown in Figure 4-38.

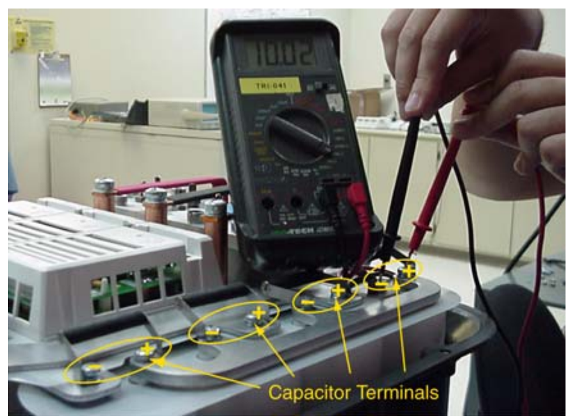


Figure 4-38 Capacitor Measurement

5. Wait for approximately 30 seconds. The meter reading should slowly increase to surpass 10kΩ.
6. Repeat steps 4 and 5 for the remaining 3 capacitors.

If the resistance measurement does not reach the specified value, then the capacitor is faulty and needs to be replaced.

4.5.5.2 Mid-Point Voltage Measurement

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3).
3. Set the multimeter for DC voltage measurement.

4. Turn ON the AC input power.
5. Place the black (-) meter probe on the negative DC bus and the red (+) meter probe on the capacitor mid-connection bar. See Figure 4-39. The measured voltage range is expected to be half of the DC bus voltage. Refer to Table 4-10.

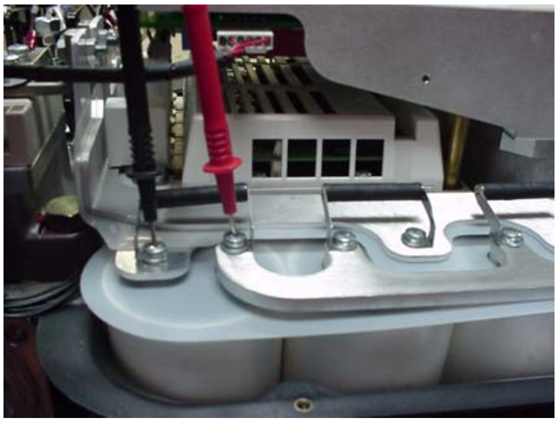


Figure 4-39 Capacitor (-) mid-point voltage measurement

6. Place the black (-) meter probe on the capacitor mid-connection bar, and place the red (+) meter probe on the positive DC bus. See Figure 4-40. The measured voltage range is expected to be half of the DC bus voltage. Refer to Table 4-10.

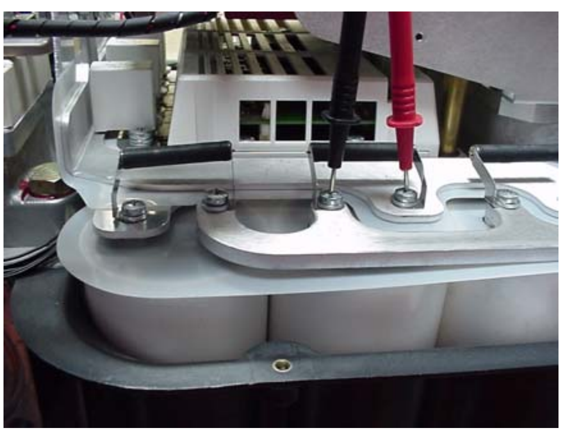


Figure 4-40 Capacitor (+) mid-point voltage measurement

Table 4-10 Expected Mid-Point Voltage Range

Country	Mid-Point Voltage Range
United States	277 - 360 VDC
Europe	242 - 312 VDC
Asia	230 - 297 VDC

4.5.5.3 Resistor Resistance Measurement

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3).
3. Set the multimeter to measure resistance.
4. Remove one of the Phillips-head screws securing the resistor, as shown in Figure 4-41.

Figure 4-41 Disconnecting Resistor

5. Measure the resistance across the resistor, as shown in Figure 4-42. The measured resistance should be 27kΩ±5%.

Figure 4-42 Resistor Resistance Measurement

6. Repeat steps 4 and 5 for the 3 remaining resistors.

If the measured resistance is not as expected, then the resistor needs to be replaced.

4.5.6 IGBT Inverter Verification

Service Tools/Test Equipment:

- Multimeter

1. Turn OFF the AC input power.
2. Remove the mains input cover (refer to section 6.4.1) and the top cover (refer to section 6.4.3).
3. Remove the snubber capacitors (see section 6.10.3), and disconnect the motor bus bars and Backplane from the IGBT (see sections 5.6.1.6, and 5.6.1.7 respectively).

NOTE:
There are 3 AC connection points, where the motor bus bars connect to the IGBT Inverter, and there are 3 pairs of DC connection points, where the DC bus connects to the IGBT Inverter. Each AC connection point is to be measured with the pair of DC connection point located directly across from it. Refer to Figure 4-43.

4. Set the multimeter for diode measurements.

NOTE:
Due to the capacitors, for the following steps, you must wait approximately 0.5-1 minute for the meter reading to stabilize before recording the measurement.

5. Place one meter probe on the (+) DC connection point, and place the other meter probe on the AC connection point located directly across, as shown in Figure 4-44. Record the measurement.

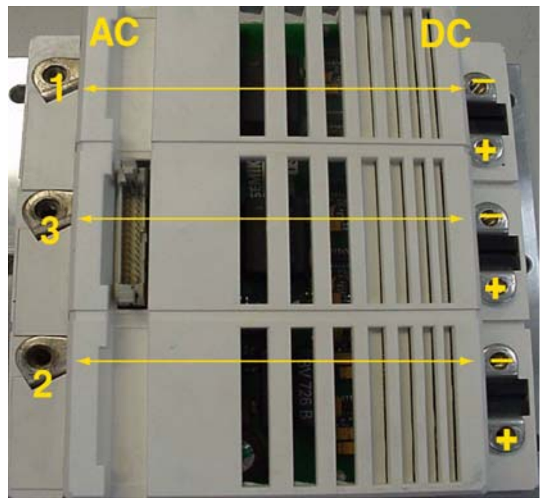


Figure 4-43 IGBT Inverter Connections

6.

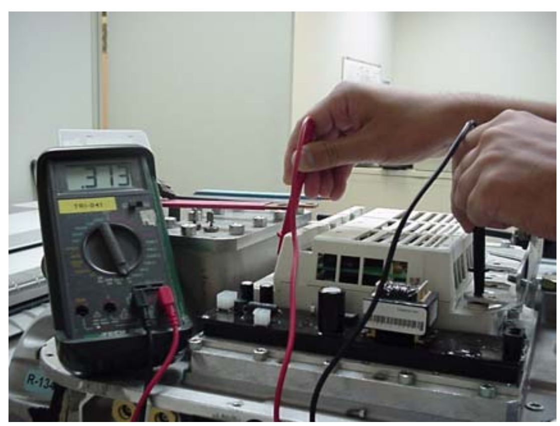


Figure 4-44 IGBT Inverter Verification

7. Reverse the meter probes and record the measurement.

8. The multimeter should read 0.3-0.4V in one direction, and open in the other direction.
9. Place one meter probe on the (-) DC connection, and place the other meter probe on the AC connection point point located directly across. Record the measurement.
10. Reverse the meter probes, and record the measurement.
11. The multimeter should read 0.3-0.4V in one direction, and open in the other direction.
12. Repeat steps 5 to 11 for the remaining sets of AC and DC connection points.

If the measured values do not correspond to the values specified, the IGBT is faulty and needs to be replaced.

4.5.7 High-Voltage DC-DC Converter Verification

Service Tools/Test Equipment:
• Multimeter

4.5.7.1 Minimum Input Resistance Measurement

1. Turn OFF AC input power to the compressor.
2. Remove the mains input cover (refer to section 6.4.1) and top access cover (refer to section 6.4.3).
3. Unplug the connectors at the 480-720VDC and 15VAC input ports (ports J1 and J4) on the HV DC-DC Converter. Refer to “High-voltage DC-DC Converter I/O” on page 8 for port locations.
4. Set the multimeter for resistance measurements.
5. Place the meter probes in the terminal of the DC input; see Figure 4-45. Record the measured resistance. Reverse the probes on the terminals. Both measured resistances should be > 1.3kΩ, but not infinity.

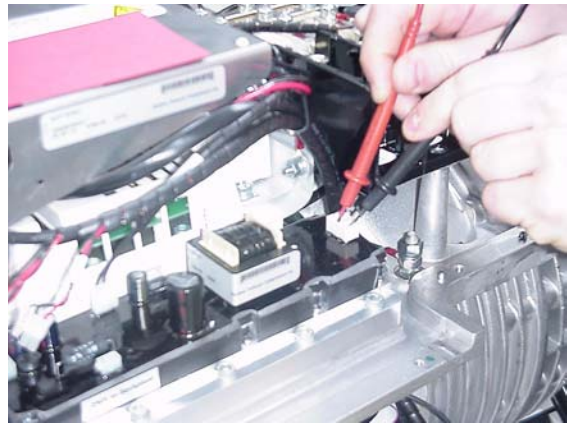


Figure 4-45 Measuring the DC-DC Converter Input Resistance at the DC Input

6. Place the meter probes in the 15 VAC input terminal (polarity unimportant), as shown in Figure 4-46. The meter should show a reading of > 1.5kΩ, but not infinity.

Figure 4-46 Measuring the HV DC-DC Converter Input Resistance at the AC Input

The procedure above is to measure the MINIMUM input resistance required for the HV DC-DC Converter. If the measured values do not correspond to the specified values, the HV DC-DC Converter is draining all the energy, and thus it is faulty and needs to be replaced. However, if the measured values correspond to the specified values, that does not imply that the HV DC-DC Converter is not faulty; it only implies that it is not draining all the energy.

4.5.7.2 Minimum Load Resistance Measurement

1. Turn OFF AC input power to the compressor.
2. Remove the mains input cover (refer to section 6.4.1) and top access cover (refer to section 6.4.3).
3. Unplug the connectors at the +250VDC and +24VDC output ports (ports J2 and J3) on the HV DC-DC Converter. Refer to “High-voltage DC-DC Converter I/O” on page 8 for port locations.
4. Set the multimeter for resistance measurement.
5. Place the meter probes in the 250VDC cable connector, as shown in Figure 4-47. Record the resistance measurement. Reverse the meter probes. In both cases, the meter should show a resistance > 500Ω.

Figure 4-47 DC-DC Converter 250V Load Resistance Measurement

6. Insert the meter probes in the middle row of the 24V cable connector, as shown in Figure 4-48. Record the resistance measured. Reverse the meter probes. In both cases, the meter should show a resistance > 6Ω.

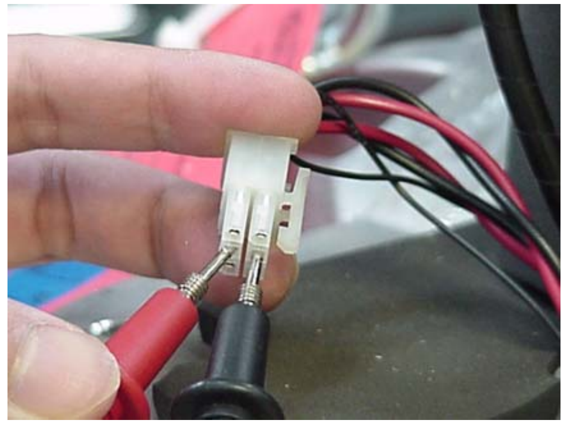


Figure 4-48 DC-DC Converter 24V Load Resistance Measurement

The procedure above is to measure the MINIMUM resistance required for the HV DC-DC Converter load. If the measured values do not correspond to the specified values, the HV DC-DC Converter load is draining all the energy, and thus one or more of the load components are faulty and need to be replaced. However, if the measured values correspond to the specified values, that does not imply that the load is not faulty; it only implies that the load is not draining all the energy.

4.5.7.3 Minimum Output Resistance Measurement

1. Turn OFF the AC input power to the compressor.
2. Remove the mains input cover (refer to section 6.4.1) and top access cover (refer to section 6.4.3).
3. Set the multimeter for resistance measurement.
4. Unplug the connectors at the +250VDC and +24VDC output ports (ports J2 and J3) on the HV DC-DC Converter. Refer to “High-voltage DC-DC Converter I/O” on page 8 for port locations.

5. Place the meter probes and measure the resistance at the 250VDC output port, as shown in Figure 4-49.

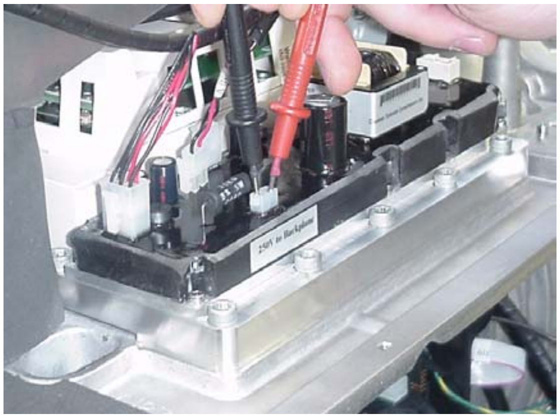


Figure 4-49 DC-DC Converter 250VDC Output Resistance Measurement

6. Reverse the meter probes and measure the resistance.
7. Place the meter probes in the middle row of the 24VDC output port and measure the resistance, as shown in Figure 4-50.
8. Reverse the meter probes and measure the resistance.

For all the output port resistance measurements, the meter should show a reading other than zero or infinity. If the meter reads zero or infinity, then the HV DC-DC Converter is faulty and needs to be replaced.

Figure 4-50 HV DC-DC Converter 24VDC Output Resistance Measurement

4.5.7.4 Input Voltage Measurement

1. Turn OFF the AC input power to the compressor.
2. Remove the mains input cover (refer to section 6.4.1) and top access cover (refer to section 6.4.3).
3. Unplug the cable from the AC input port J4, and the DC input port J1. Refer to “High-voltage DC-DC Converter I/O” on page 8 for the input/output port locations.
4. Turn ON the AC power input to the compressor.

AC Input Measurement

5. Set the multimeter for AC voltage measurement.
6. Insert the meter probes into the AC cable terminal (polarity unimportant), as shown in Figure 4-51. The meter should read 15VAC±10%.

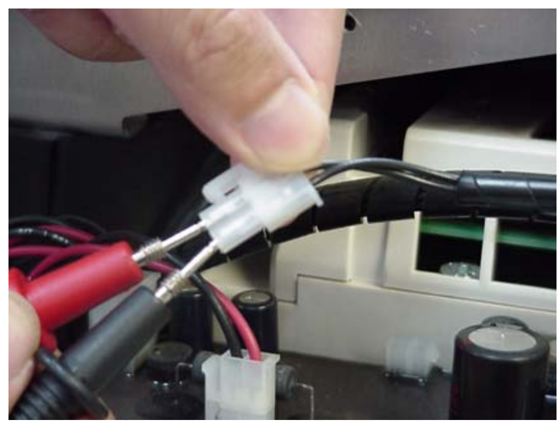


Figure 4-51 DC-DC Converter AC Input Voltage Measurement

DC Input Measurement

7. Set the multimeter for DC voltage measurement.
8. Insert the red (+) meter probe into the red (+) cable end of the DC cable connector, and the insert the black (-) meter probe into the black (-) cable end of the DC cable connector, as shown in Figure 4-52. The meter should read values in accordance with Table 4-11.

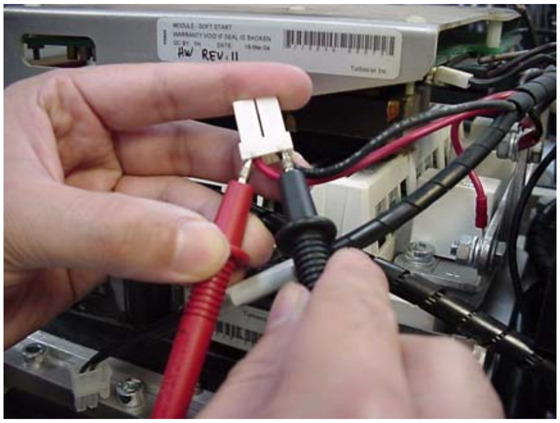


Figure 4-52 HV DC-DC Converter DC Input Voltage Measurement

Table 4-11 Expected DC Voltage Range

Country	DC Input Range
United States	555 - 720 VDC
Europe	485 - 625 VDC
Asia	460 - 595 VDC

4.5.7.5 Output Voltage Measurement

1. Turn OFF the AC power input to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Ensure the HV DC-DC Converter minimum input and output resistance are satisfied, refer to sections paragraph 4.5.7.1 and paragraph 4.5.7.3, respectively. If the minimum input resistance and output resistance are *not* satisfied, the HV DC-DC converter is faulty and needs to be replaced; otherwise, proceed to the next step.
4. Ensure all HV DC-DC Converter input/output cables are not broken and are properly connected. Refer to 3.2.2 "High-voltage DC-DC Converter I/O" on page 8 for the port locations.
5. Ensure the cables connected to ports J4 and J24 of the Backplane are not broken and are properly connected. Refer to 3.2.3 "Backplane I/O" on page 9 for the input port locations.
6. Set the multimeter for DC voltage measurement.
7. Turn ON the AC input power to the compressor.
8. On the Backplane, place the red (+) meter probe on the HV+ (+250VDC) test point and the black (-) meter probe on the HV- test point. The meter should show +250VDC±5%.
9. On the Backplane, place the red (+) meter probe on the +24V test point and the black (-) meter probe on the 0V test point. The meter should show +24VDC±5%.

4.5.8 Backplane Verification

Service Tools/Test Equipment:

- Multimeter

4.5.8.1 Test Point Voltage Measurement

NOTE:
If the test point LEDs are ON, it only indicates that a voltage is present. The test points must be measured to determined the actual voltage. Refer to 3.2.3 "Backplane I/O" on page 9 to locate the test points and test point LEDs on the Backplane.

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Set the multimeter for DC voltage measurements.
4. Turn ON the AC input power to the compressor.
5. Place the red (+) meter probe on the HV+ (+250VDC) test point and the black (-) meter probe on the HV- test point. The meter should show +250VDC±5%.
6. Place the red (+) meter probe on the +24V test point and the black (-) meter probe on the 0V test point. The meter should show +24VDC±5%.

If the specification in either step 5 or 6 is not satisfied, then there is “No DC Voltage”. Troubleshoot following the procedure outlined in 4.3.2 "No HV DC-DC Converter Output Voltage" on page 32. Otherwise, proceed with the next step.

7. Place the red (+) meter probe on the desired test point and the black (-) meter probe on the 0V test point. (If measuring the +17HV test point, place the black (-) meter probe on the HV- test point.) The meter should show the appropriate voltage ±5%.

If one of the test points does not output the appropriate voltage and it has been asserted that the HV+ and +24V test points output the correct voltage, then one of the compressor modules is draining the Backplane power supplies. Refer to 4.3.4 "No (Low) Backplane Voltage" on page 34 to determine the source of the problem.

4.5.8.2 BMCC Voltage Source Measurement

NOTE:
To minimize noise interference, the Backplane provides the BMCC with +15VDC from a source different than that used for the other modules.

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Set the multimeter for DC voltage measurements.
4. Disconnect the Serial Driver from the Backplane.
5. Disconnect the BMCC from the Backplane.
6. Make sure the IGBT Inverter is connected to the Backplane. Verify that the cable is properly attached to port J6 of the Backplane on one end, and that it is properly attached to the top of the IGBT Inverter on the other end. Refer to 3.2.3 "Backplane I/O" on page 9 to locate the input/output port locations of the Backplane; and refer to point 5 of Figure 3-16-"Compressor Energy and Signal Flow Connections" on page 20 to locate the Backplane connection to the IGBT Inverter.

⚠ WARNING
Either the BMCC or IGBT Inverter is required to be connected to the Backplane before turning on the compressor; thus, if the BMCC is disconnected from the Backplane, it is important that the IGBT Inverter is connected.

7. Turn ON the AC input power to the compressor.
8. Place the red (+) meter probe on the +15VDC BMCC test point, and the black (-) meter probe on the 0VDC test point. The meter should show +15VDC±5%.

4.5.8.3 Test Point Minimum Resistance Measurement

NOTE:
Due to the capacitors, you must wait approximately 0.5-1 minute for the meter reading to stabilize before recording the measurement in the following steps.

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Set the multimeter for resistance measurements.
4. Place the red (+) meter probe on the desired test point and the black (-) meter probe on the 0V test point. In the case of HV+ and +17HV test point measurements, place the black (-) meter probe on the HV- test point. Record the resistance measurement. Reverse the probes on the test points and measure the resistance. Both measured values should show a minimum resistance as indicated in Table 4-12.

The procedure above is to measure the MINIMUM resistance required for each test point. If the measured values do not correspond to the specified values, the test point load is draining all the energy, thus one or more of the load components are faulty and need to be replaced. However, if the measured values correspond to the specified values, that does not imply that the load is not faulty; it only implies that the load is not draining all the energy.

Table 4-12 Test Point Minimum Resistance

Test Point	Test Point Return	Minimum Resistance (Ω)
HV+	HV-	250
+17HV	HV-	28
+24V	0V	9
+15V	0V	20
-15V	0V	150
+5V	0V	8

4.5.8.4 High Voltage Test Point Diode Measurements

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Set the multimeter for diode measurements.

4. Place the red probe on the +HV test point and the black probe on the HV- test point. The measured value should be infinite.
5. Reverse the probes on the test points. The measured value should be about 0.6 - 0.7V.
6. Place the red probe on the +17HV test point and the black probe on the HV- test point. The measured value should be infinite.
7. Reverse the probes on the test points. The measured value should be 0.4 - 0.5V.

4.5.9 Serial Driver Verification

4.5.9.1 Input Voltage Verification

The Serial Driver is powered with +15VDC and +24VDC from the Backplane. Refer to Figure 3-17-"Compressor Energy and Control Flow Block Diagram" on page 21, .

To verify if the correct input voltage is being provided to the Serial Driver, measure the voltages at the +15V and +24V test points on the Backplane. Refer to 4.5.8 "Backplane Verification" - 4.5.8.1 "Test Point Voltage Measurement".

If the measured voltages are not as expected, then troubleshoot following the steps in 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.5.9.2 Output Voltage Verification

The Serial Driver provides +24VDC to the motor cooling solenoids, +15VDC to the IGV stepper motor, and +15VDC to the external expansion valves. Refer to Figure 3-17-"Compressor Energy and Control Flow Block Diagram" on page 21, .

Before proceeding with the Serial Driver output voltage verification, check that the Serial Driver is properly connected at port J8 on the Backplane. Refer to 3.2.3 "Backplane I/O" on page 9 for the port location.

Output Voltage to Solenoids Verification

To verify that the Serial Driver is providing power to the solenoids, check on the Backplane that the COOL-H (D7) and COOL-L (D10) LEDs are ON. Refer to 3.2.3 "Backplane I/O" on page 9 for the location of the LEDs.

Output Voltage to IGV Stepper Motor Verification

To verify that the Serial Driver is providing power to the IGV Stepper Motor, confirm that one or more of the IGV LEDs (D16-D13), on the Backplane, are ON. Refer to 3.2.3 "Backplane I/O" on page 9 for the location of the LEDs.

Output Voltage to Electronic Expansion Valves Verification

To verify that the Serial Driver is providing power to the Electronic Expansion Valves (EXV), first ensure that the Backplane and Compressor Interface are properly connected together. Check that, the interface cable is properly attached to port J7 on the Backplane and to port J6 on the Compressor Interface. Refer to 3.2.3 "Backplane I/O" on page 9 and 3.2.4 "Compressor Interface I/O" on page 13 for the input/output port locations.

On the Compressor Interface module, check that one or more of the EXV LEDs (D1-D8) are ON. Refer to 3.2.4 "Compressor Interface I/O" on page 13 for the location of the LEDs.

4.5.10 BMCC Verification

4.5.10.1 Input Voltage Verification

The BMCC is powered with +5VDC, +15VDC, and -15VDC from the Backplane. Refer to Figure 3-17-"Compressor Energy and Control Flow Block Diagram" on page 21,.

To verify the BMCC input voltage, first measure the voltages at the +5V and -15V test points on the Backplane. Refer to 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement" on page 71.

Measure the +15VDC voltage source output provided to the BMCC. Follow the procedure outlined in Refer to 4.5.8 "Backplane Verification" - "BMCC Voltage Source Measurement" on page 72.

If the measured voltages are not as expected, then troubleshoot following the steps in 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.5.10.2 Communication Verification

1. Launch the Monitor Program. If the Monitor Program is already opened, close it and open it again.
2. The “Serial Port Connection” window opens. Click on the “Connect” button.

If the system is able to connect, the BMCC is able to communicate with the user interface. Check the “Event Log” window to determine if the BMCC has faults or errors communicating with the other compressor modules. To open the “Event Log” window, select “Window”→ “Event Log” from the menu bar, or click on the “Event Log” icon located below the menu bar.

If the system is not able to connect, verify that:

- The BMCC is properly connected to the Backplane. Refer to Figure 3-2-"Compressor Electronic Circuit Components" on page 4 to identify the BMCC on the Backplane.
- The cable connection between the Backplane (at port J7) and the Compressor Interface module (at port J6) is properly attached. Refer to 3.2.3 "Backplane I/O" on page 9, and 3.2.4 "Compressor Interface I/O" on page 13, for the input/output port locations.
- The cable connection between the Compressor Interface module (at port J1 if using RS485 communication, or at port J7 if using RS232 communication) and the user interface (user PC) is properly attached. Refer to 3.2.4 "Compressor Interface I/O" on page 13, for the input/output port locations.

If all the connections are properly attached and you still cannot connect to the compressor via the Monitor Program, the BMCC is faulty and needs to replaced.

4.5.10.3 Output Voltage to Compressor Interface Verification

NOTE:
The Compressor Interface +5VDC source is provided by the BMCC via the Backplane. It is *not* the +5VDC source from the Backplane itself.

To verify that the BMCC is outputting +5VDC to the Compressor Interface, first check that:

- The BMCC is properly connected to the Backplane. Refer to Figure 3-2-"Compressor Electronic Circuit Components" on page 4 to identify the BMCC on the Backplane.
- The cable connection between the Backplane (at port J7) and the Compressor Interface (at port J6) is properly attached. Refer to 3.2.3 "Backplane I/O" on page 9, and 3.2.4 "Compressor Interface I/O" on page 13, for the input/output port locations.

Verify that the “Power ON” LED (D9) on the Compressor Interface is ON. Refer to 3.2.4 "Compressor Interface I/O" on page 13 for the location of the LED.

4.5.11 PWM Amplifier Verification

Service Tools/Test Equipment:

- Multimeter with ammeter clamp

4.5.11.1 Input Voltage Verification

The PWM Amplifier is powered with +5VDC, +17HV, and HV+ (+250VDC) from the Backplane. Refer to Figure 3-17-"Compressor Energy and Control Flow Block Diagram" on page 21, .

To verify if the correct input voltage is being provided to the PWM Amplifier, measure the voltages at +5V, +17HV, and HV+ test points on the Backplane. Refer to 4.5.8 "Backplane Verification" - 4.5.8.1 "Test Point Voltage Measurement".

If the measured voltages are not as expected, then troubleshoot following the steps in 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.5.12 Bearing Calibration

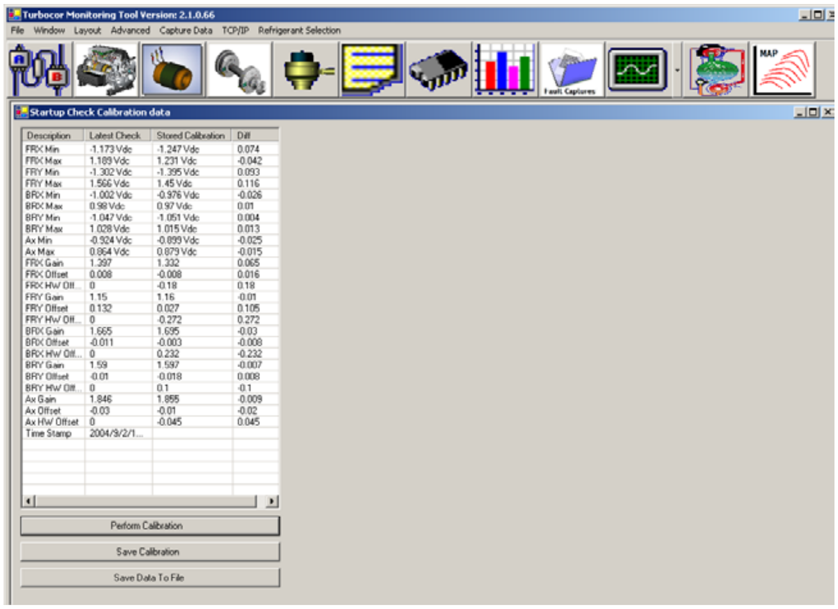


Figure 4-53 Monitor Program - Startup Check Calibration

For the bearing calibration to be performed:

- The shaft must be de-levitated
- The interlock connection on the Compressor Interface module must be opened

1. Turn OFF the AC input power to the compressor and wait 3-5 minutes for the capacitors to discharge.
2. Turn ON the AC input power to the compressor.
3. Launch the Monitor Program. If the Monitor Program is already opened, close it and open it again.
4. Change the compressor control mode to “Calibration Mode”. Open the “Compressor Controller Form”. Click on the “Compressor Controller Parameters” icon located below the menu bar, then change the “Compressor Control Mode” to “Calibration”.

NOTE:
In Calibration mode, the compressor prepares itself for calibration. Any external demand will be blocked from the system, i.e., any external computer, PLC, building management system, or automatic control will *not* be able to write to the compressor.

5. From the menu bar, select “Advanced”→ “Bearing Calibration”. The “Startup Check Calibration Data” window should open, as shown in Figure 4-53.
6. Click on “Perform Calibration”. The message “Bearing Calibration in Progress” will appear. Observe if the compressor makes a distinctive clanking noise. This confirms the calibration is in progress. Do *not* click on “Save Calibration”.
7. In the “Startup Check Calibration Data” window, compare the values between the “Latest Check” and the “Stored Calibration” for the following parameters:
   - FRX Gain
   - FRY Gain
   - BRX Gain
   - BRY Gain
   - AX Gain
8. Open the “Compressor Event Log” window. Select “Window”→ “Event Log” from the menu bar, or click on the “Event Log” icon located below the menu bar.
9. Verify that the following message is displayed:
   - “Bearing Calibration Performed”

   Verify that the following error is *not* displayed:

   - “Bearing Error: Calibration Failed”

Calibration Data Interpretation

- **One or more of the gains are zero**

Interpretation: There is an electrical fault.

1. Measure the HV+, +17HV, and +5V test point voltages on the Backplane. Refer to 4.5.8 "Backplane Verification" - 4.5.8.1 "Test Point Voltage Measurement". If the measured test point voltages on the Backplane are as expected, then proceed with the next step. Otherwise, troubleshoot following the steps in 4.3.4 "No (Low) Backplane Voltage" on page 34.
2. Measure the PWM Amplifier output current to the bearings. Refer to section 4.5.13 "Current Output to Bearings Measurement" on page 76. If the output current from the PWM Amplifier is not as expected, then the PWM Amplifier is faulty and needs to be replaced. Otherwise, proceed with the next step.
3. If the bearings cannot be calibrated and the PWM Amplifier outputs 2.0-3.0A to the bearings, then the shaft is obstructed. Repeat the calibration procedure 3 more times. If the bearings still cannot be calibrated, ensure that the calibration procedure has been properly performed, then contact Turbocor technical support if the problem persists.

- **The difference between the “Latest Check” and “Stored Calibration” is less than 20% of the “Stored Calibration**

Interpretation: Bearing calibration was successful.

- **The difference between the “Latest Check” and “Stored Calibration” is greater than 20% of the “Stored Calibration”**

Interpretation: Excess carbon obstructing the shaft.

In an attempt to grind away any excess carbon obstructing the shaft, repeat the calibration procedure 3 more times. If the bearings still do not calibrate, contact Turbocor technical support.

4.5.13 Current Output to Bearings Measurement

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Set the multimeter for current measurement.
4. Turn ON the AC input power to the compressor.

NOTE:
All PWM current output measurements should be taken during compressor bearing calibration. Refer to 4.5.12 "Bearing Calibration". Also, one period (approximately 1 minute) must pass during calibration before taking the measurement, as it is required to wait for all the actuators to be activated beforehand.

Figure 4-54 Measuring the Bearing Current Output

Axial Bearing

5. From the left set of PWM current output cables, place the ammeter clamp around either the orange or blue cable. The meter should show a current reading of 2.0-3.0A.

Rear Bearing

6. From the left set of PWM current output cables, place the ammeter clamp around either the white or black cable. The meter should show a current reading of 2.0-3.0A.

7. From the left set of PWM current output cables, place the ammeter clamp around either the red or green cable. The meter should show a current reading of 2.0-3.0A.

Front Bearing

8. From the right set of PWM current output cables, place the ammeter clamp around either the white or black cable. The meter should show a current reading of 2.0-3.0A.
9. From the right set of PWM current output cables, place the ammeter clamp around either the red or green cable. The meter should show a current reading of 2.0-3.0A.

4.5.14 Motor-Cooling Solenoid Verification

Service Tools/Test Equipment:

- Screwdriver
- Multimeter

4.5.14.1 Resistance Measurement

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Disconnect the motor-cooling solenoid connector from the Backplane, as described in 5.6.2.1 "Disconnecting the Motor-Cooling Solenoids from the Backplane" on page 94.
4. Set the multimeter for resistance measurement.

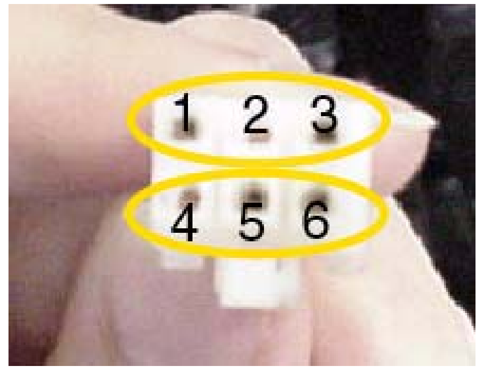


Figure 4-55 Motor Cooling Solenoid Cable Connector

5. Observe the voltage and power specification indicated on the side of the motor-cooling solenoids. From Table 4-13, find the expected resistance for the high and low motor-cooling solenoids.

Table 4-13 Expected Solenoid Resistance

Voltage (V)	Power (W)	Expected Resistance
15	3.6	62.5Ω±10%
24	4.8	120Ω±10%

6. Measure the resistance across the high motor-cooling solenoid. Place the meter probes at pins 1 and 3 of the cable connector.
7. Measure the resistance across the low motor-cooling solenoid. Place the meter probes at pins 5 and 6 of the cable connector.

If the measured resistance is not as expected, then the solenoid is faulty and need to be replaced.

4.5.15 Magnetic Field Verification

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Turn ON the AC input power to the compressor.
4. Place a screwdriver next to the motor-cooling solenoids, as shown in Figure 4-56. If the solenoids are working properly, then, due to the magnetic field, the screwdriver will be attracted to the solenoids.

If the screwdriver is not attracted to the solenoids, continue with the 4.5.16 "Input Voltage Verification".

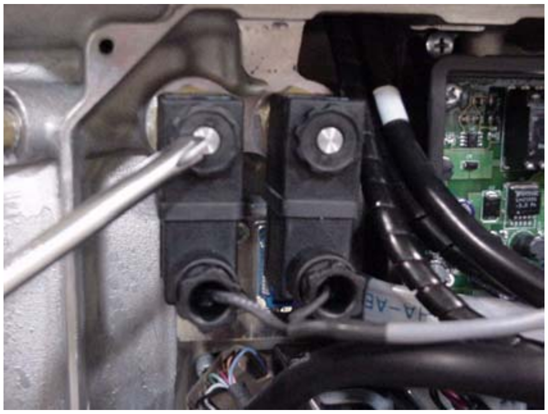


Figure 4-56 Verifying Solenoid Magnetic Field

4.5.16 Input Voltage Verification

1. Turn OFF the AC input power to the compressor.
2. Remove the service-side cover (refer to section 6.4.2).
3. Turn ON the AC input power to the compressor.
4. To verify if the Serial Driver is providing power to the solenoids, refer to 4.5.9 "Serial Driver Verification" - "Output Voltage Verification" on page 73.

If there is no power provided to the solenoids, measure the +15V and +24V test points on the Backplane. (Recall that the solenoids are powered by the Serial Driver, which in turn is powered by the Backplane. See Figure 3-17- "Compressor Energy and Control Flow Block Diagram" on page 21.) If no (low) voltage is measured from the Backplane test points, troubleshoot following the procedures outlined in 4.3.4 "No (Low) Backplane Voltage" on page 34.

4.5.17 Cooling Path Blockage Inspection

1. Remove the solenoids and motor-cooling valve. Refer to 6.8.7 "Motor-cooling Valve - Removal" on page 106.
2. Ensure that the cooling paths are clean, as shown in Figure 4-57.

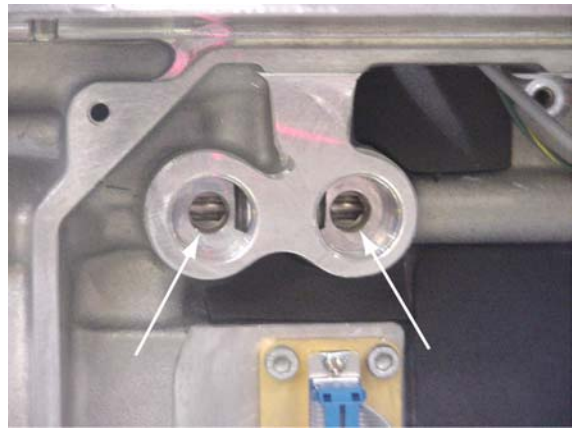


Figure 4-57 Solenoid Cooling Path

4.5.18 Inlet Guide Vane (IGV) Motor Verification

4.5.18.1 Resistance Measurement

Service Tools/Test Equipment:

- Multimeter

1. Turn OFF the AC input power to the compressor.
2. Disconnect the IGV feed-thru connector as described in 5.6.2.7 "Disconnecting Power to the IGV Motor" on page 96.
3. Set the multimeter for resistance measurement.
4. Measure the resistance across pins 1 and 2, as shown in Figure 4-58. The meter should show a reading of 52.4Ω±5%.

5. Measure the resistance across pins 3 and 4, as shown in Figure 4-59. The meter should show a reading of 52.4Ω±10%.

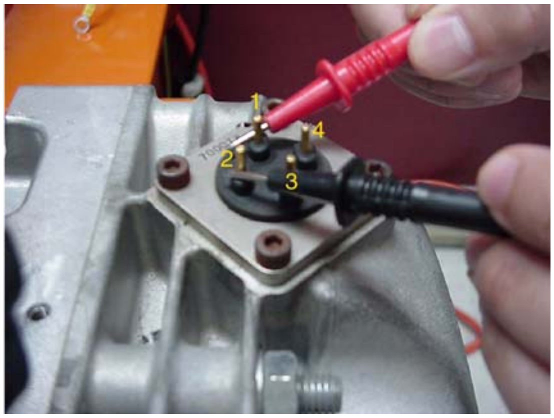


Figure 4-58 IGV Resistance Measurement (1 of 2)

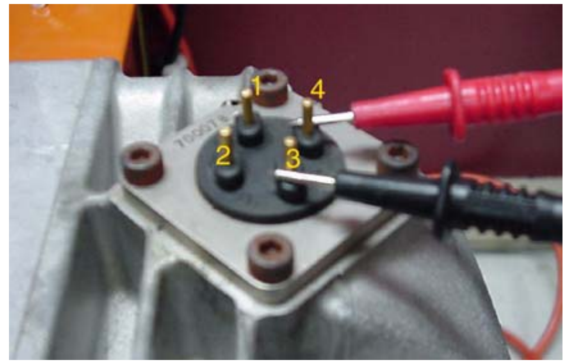


Figure 4-59 IGV Resistance Measurement (2 of 2)

4.5.18.2 Input Voltage Verification

To verify if +15VDC is provided to the IGV by the Serial Driver, refer to 4.5.9 "Serial Driver Verification" - "Output Voltage Verification" on page 73.

Ensure that the IGV cable is properly attached to output port J21 on the Backplane. Also verify that the cable is not broken. Refer to 3.2.3 "Backplane I/O" on page 9 for the port location.

4.5.19 Checking the Expansion Valve Drive

The EXV1 and EXV2 status-indicating LEDs (D1-D8) on the Compressor Interface module can be used for fault diagnosis; refer to Figure 4-60. Table 4-14 summarizes the status indications for the two electronic expansion valves.

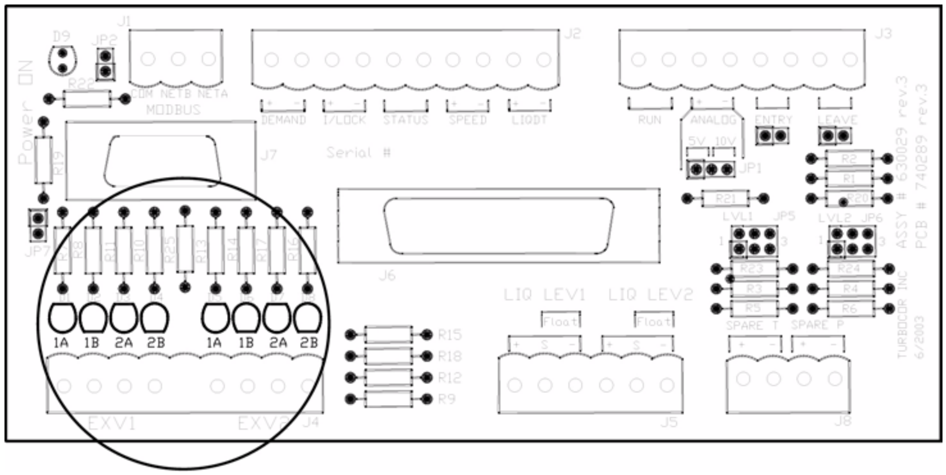


Figure 4-60 Interface Module LEDs

Table 4-14 Valve Driver Fault Diagnosis Chart

LED Status				Description
1A	**1B**	**2A**	**2B**	
ON	ON	ON	ON	Proper operation, i.e., wiring is correct. NOTE: If 1A and 1B, or 2A and 2B wiring is reversed, the LED indication will appear correct. The valve motor, however, will turn in the wrong direction.
ON	OFF	OFF	ON	1A and 2A wiring reversed. No valve motion.
ON	DIM	DIM	OFF	1B and 2A, or 1A and 2B wiring is reversed. No valve motion.
OFF	OFF	ON	ON	1A and 1B wiring open. No valve motion.
ON	ON	OFF	OFF	2A and 2B wiring open. No valve motion.

NOTE:
If one LED is off and the adjacent LED is brighter than normal, this may indicate that the valve motor wire, associated with the off LED, is shorted to ground. This condition will cause resistor overheating on the Compressor Interface module.

4.6 Compressor Module Draining Energy

4.6.1 Serial Driver Draining Energy

The following procedure is to determine if the Serial Driver is draining the compressor energy.

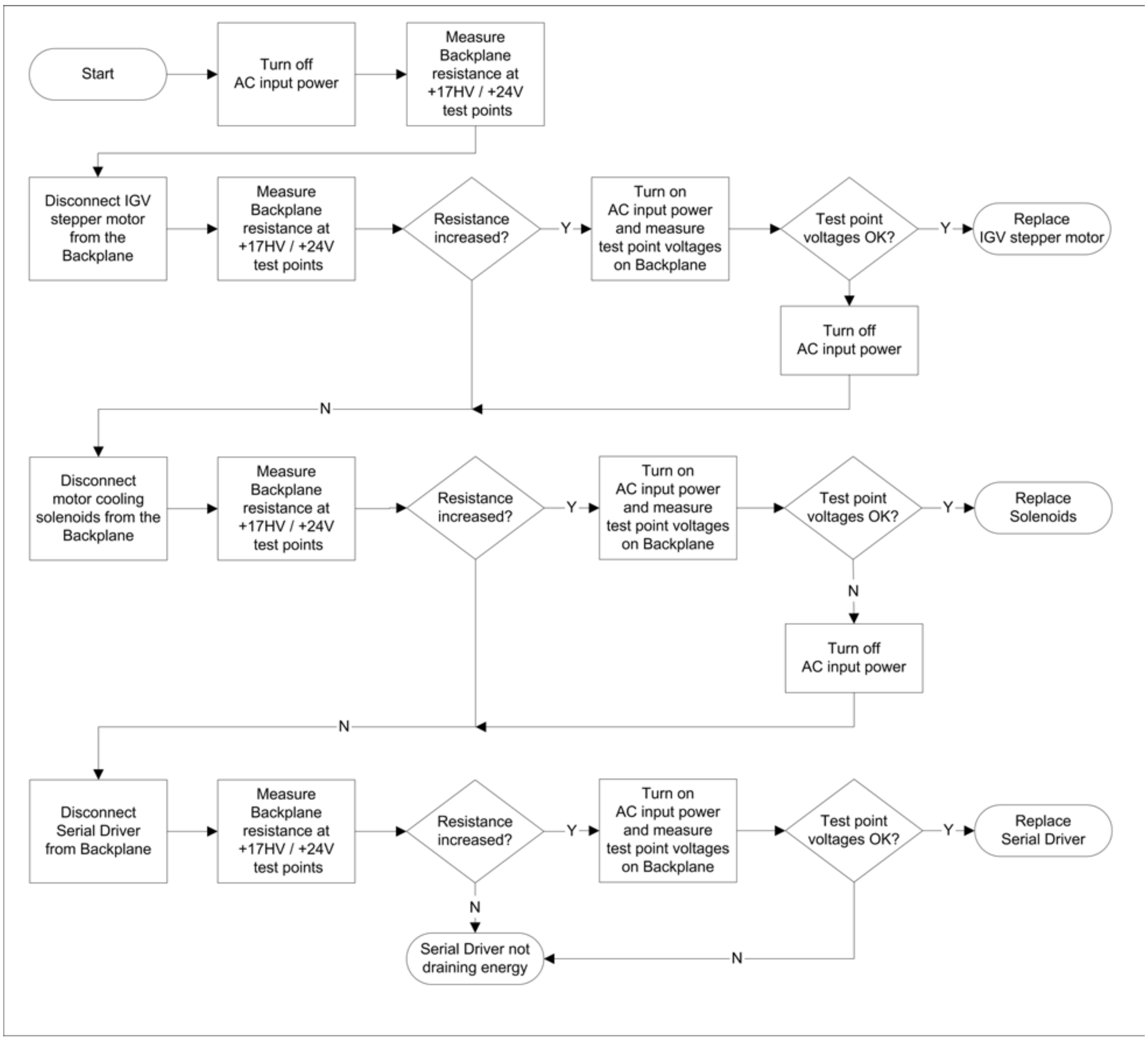


Figure 4-61 Flowchart to Determine if the Serial Driver is Draining Energy

1. Turn OFF the AC input power to the compressor.
2. Measure and record the resistance at the +17HV, +24V test points. Refer to 4.5.8.3 "Test Point Minimum Resistance Measurement" on page 72.
3. Disconnect the IGV stepper motor from the Backplane. Refer to section 5.6.2.2 "Disconnecting the IGV Stepper Motor from the Backplane".
4. Measure the resistance at the +17HV, +24V test points. Refer to 4.5.8.3 "Test Point Minimum Resistance Measurement" on page 72. If the measured resistance increases, continue with the next step; otherwise, continue with step 6.
5. Turn ON the AC input power and measure the voltages at the test points. Refer to 4.5.8.1 "Test Point Voltage Measurement" on page 71. If the test point voltages are as expected, the IGV stepper motor is faulty and need to be replaced; otherwise, turn OFF the AC input power and continue with the next step.
6. Disconnect the motor-cooling solenoids from the Backplane (see section “Disconnecting the Motor-Cooling Solenoids from the Backplane” on page 94).
7. Measure the resistance at the +17HV, +24V test points. Refer to section paragraph 4.5.8.3. If the measured resistance increases, continue with the next step; otherwise, continue with step 9.
8. Turn ON the AC input power and measure the voltages at the test points. Refer to section paragraph 4.5.8.1. If the test point voltages are as expected, the motor-cooling solenoids are faulty and need to be replaced; otherwise, turn OFF the AC input power and continue with the next step.
9. Remove the Serial Driver from the Backplane.
10. Measure the resistance at the +17HV, +24V test points. Refer to section paragraph 4.5.8.3. If the measured resistance increases, continue with the next step; otherwise, the Serial Driver is not (or not the only) source of energy drain.
11. Turn ON the AC input power and measure the voltages at the test points. Refer to section paragraph 4.5.8.1. If the test point voltages are as expected, the Serial Driver is faulty and needs to be replaced; otherwise, the Serial Driver is not the source (or not the only source) of energy drain.

4.6.2 BMCC Draining Energy

The following procedure is to determine if the BMCC is draining the compressor energy.

1. Ensure the AC input power to the compressor is turned OFF.

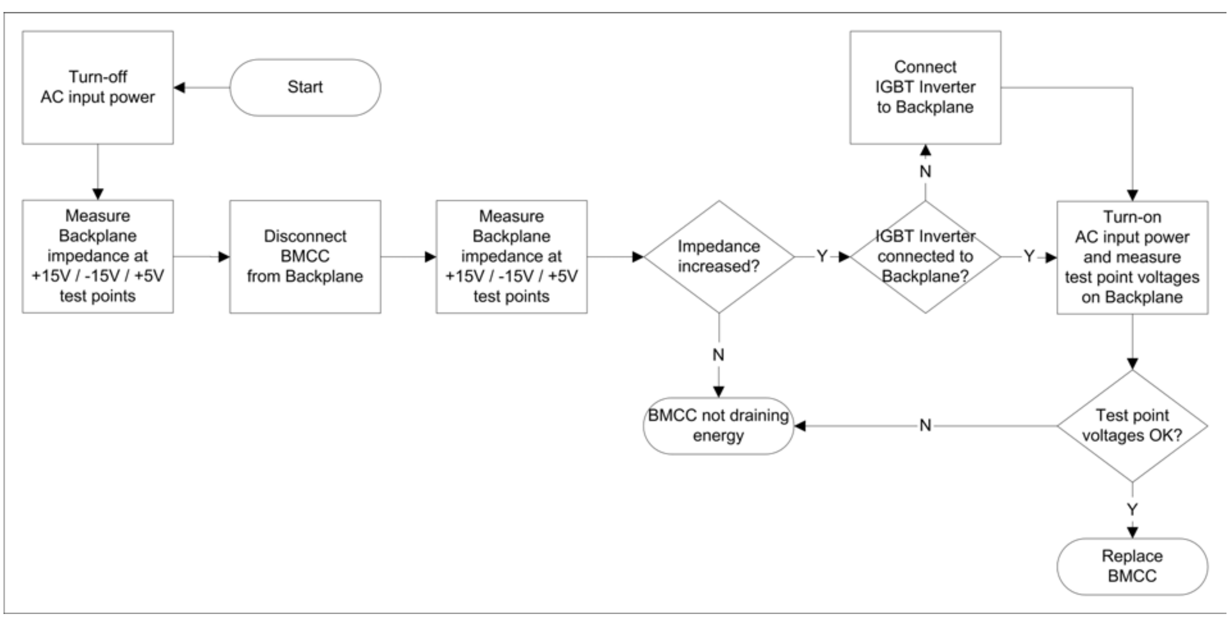


Figure 4-62 Flowchart to Determine if the BMCC Is Draining Energy

2. Measure and record the resistance at the +15V, -15V, +5V test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement".
3. Disconnect the BMCC from the Backplane.
4. Measure the resistance at the +15V, -15V, +5V test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance increases, continue with the next step; otherwise, the BMCC is not (or not the only) source of energy drain.
5. Verify if the IGBT Inverter is connected to the Backplane. If it is not, connect the IGBT Inverter to the Backplane before proceeding; to do so, reverse the procedure outlined in section “Disconnecting the IGBT Inverter from the Backplane” on page 94.

WARNING

Either the BMCC or IGBT is required to be connected to the Backplane before turning on the compressor.

When the BMCC is disconnected from the Backplane, it is important that the IGBT Inverter is connected!

6. Turn ON the AC input power and measure the voltages at the test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If the test point voltages are as expected, the BMCC is faulty and needs to be replaced; otherwise, the BMCC is not the source (or not the only source) of energy drain.

4.6.3 PWM Amplifier Draining Energy

The following procedure is to determine if the PWM Amplifier is draining the compressor energy.

1. Ensure the AC input power to the compressor is turned OFF.
2. Measure and record the resistance at the HV+, +17HV, +5V test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement".

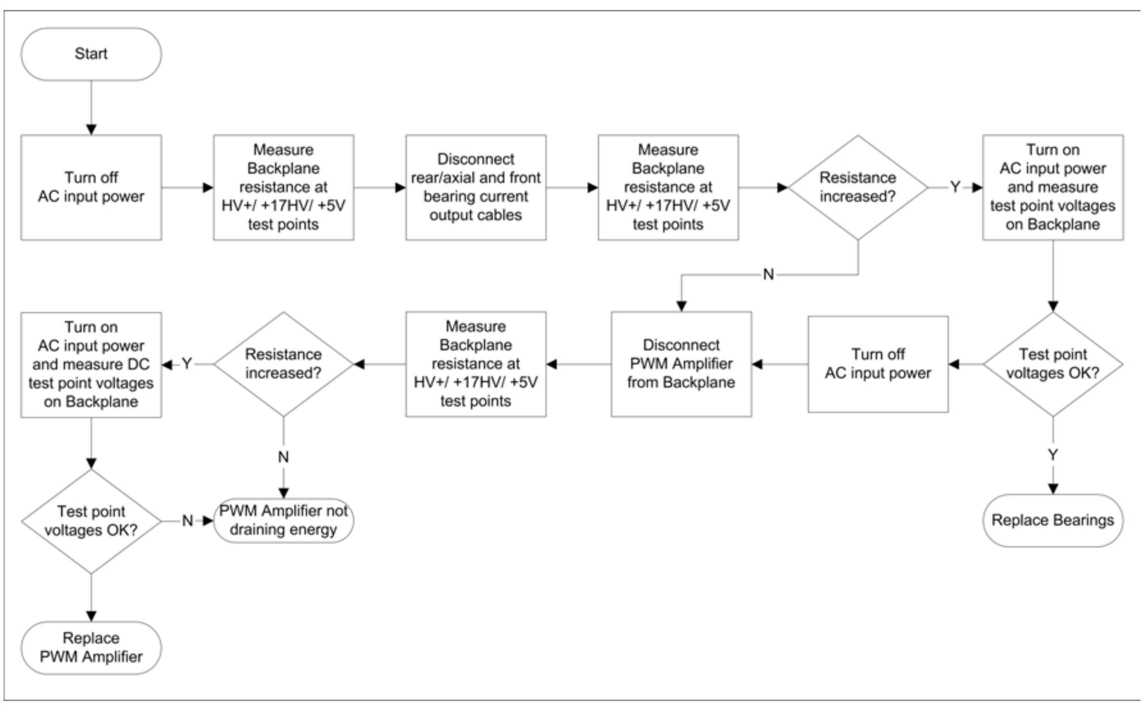


Figure 4-63 Flowchart to Determine if the PWM Amplifier is Draining Energy

3. Disconnect the rear/axial bearing current output cable and the front bearing current output cable (refer to section 5.6.2.4 "Disconnecting the Bearing Current Output Cables").
4. Measure the resistance at the HV+, +17HV, +5V test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance increases, continue with the next step; otherwise, continue with step 7.
5. Turn ON the AC input power and measure the voltages at the test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If the test point voltages are as expected, the bearings are faulty and need to be replaced; otherwise, continue with the next step.
6. Turn OFF the AC input power.
7. Disconnect the PWM Amplifier from the Backplane (see section “Bearing PWM Amplifier - Removal” on page 104).
8. Measure the resistance at the HV+, +17HV, +5V test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance increases, continue with the next step; otherwise, the PWM Amplifier is not the source (or not the only source) of energy drain.
9. Turn ON the AC input power and measure the voltages at the test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If the test point voltages are as expected, then the PWM Amplifier is faulty and needs to be replaced; otherwise, the PWM Amplifier is not the source (or not the only source) of energy drain.

4.6.4 Compressor Interface Module Draining Energy

The following procedure is to determine if the Compressor Interface is draining the compressor energy.

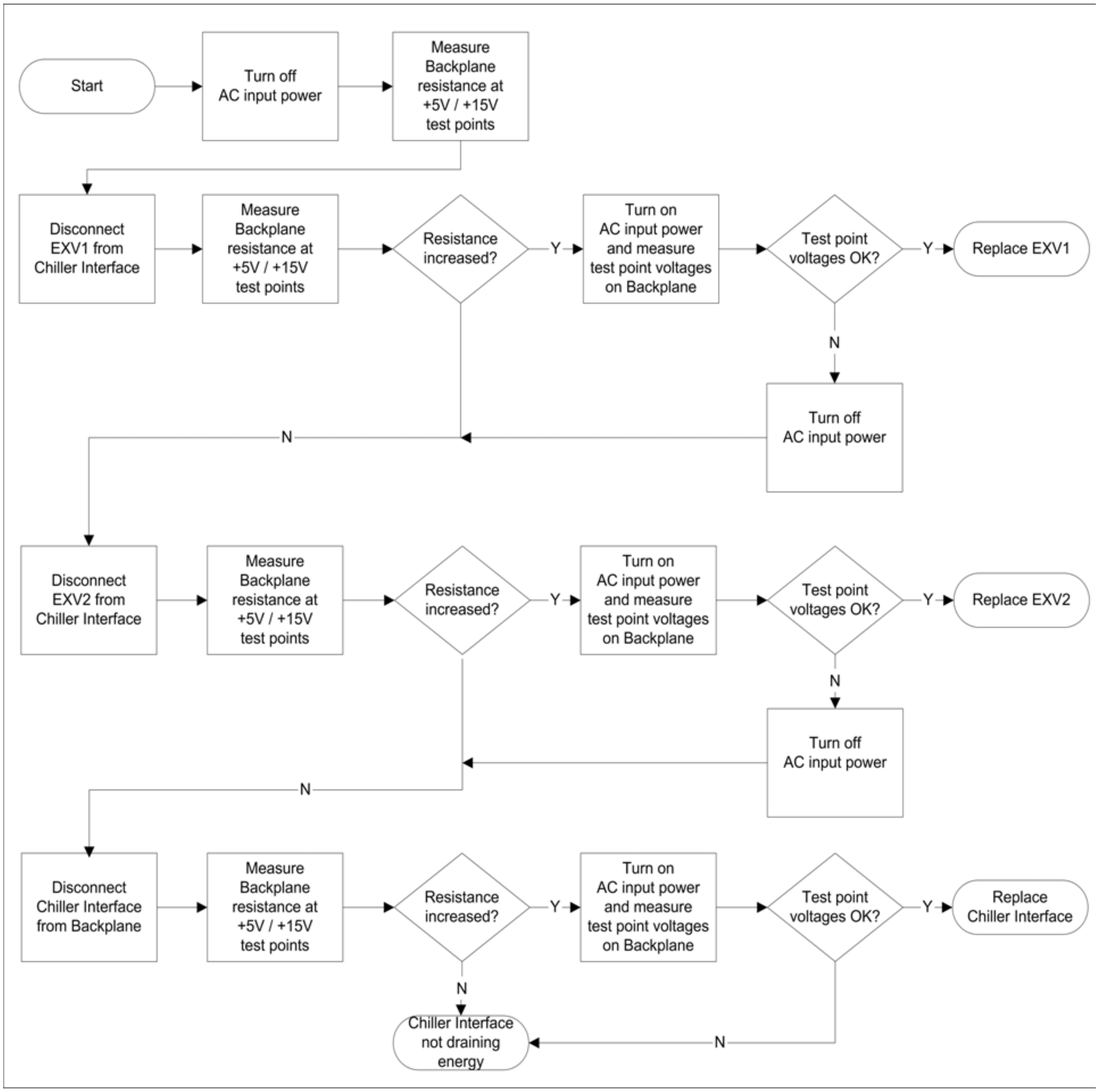


Figure 4-64 Flowchart to Determine if the Compressor Interface Module is Draining Energy

1. Turn OFF the AC input power to the compressor.
2. Measure and record the resistance at the +5V, +15V test points. Refer to 4.5.8.3 "Test Point Minimum Resistance Measurement" on page 72.
3. Disconnect the Electronic Expansion Valve 1 (EXV1) from the Compressor Interface. Refer to 5.6.2.5 "Disconnecting the Electronic Expansion Valves from the Compressor Interface" on page 95.
4. Measure the resistance at the +5V, +15V test points. Refer to 4.5.8.3 "Test Point Minimum Resistance Measurement" on page 72. If the measured resistance increases, continue with the next step; otherwise, continue with step 6.
5. Turn ON the AC input power and measure the Backplane test point voltages. Refer to 4.5.8.1 "Test Point Voltage Measurement" on page 71. If the test point voltages are as expected, EXV1 is faulty and needs to be replaced; otherwise, turn OFF the AC input power and continue with the next step.
6. Disconnect the Electronic Expansion Valve 2 (EXV2) from the Compressor Interface. See section "Disconnecting the Electronic Expansion Valves from the Compressor Interface" on page 95.
7. Measure the resistance at the +5V, +15V test points. Refer to section paragraph 4.5.8.3. If the measured resistance increases, continue with the next step; otherwise, continue with step 9.
8. Turn on the AC input power and measure the Backplane test point voltages. Refer to section paragraph 4.5.8.1. If the test point voltages are as expected, then EXV2 is faulty and needs to be replaced; otherwise, turn OFF the AC input power and continue with the next step.
9. Disconnect the Compressor Interface from the Backplane. Refer to "Disconnecting the Compressor Interface from the Backplane" on page 96.
10. Measure the resistance at the +5V, +15V test points. Refer to section paragraph 4.5.8.3. If the measured resistance increases, continue with the next step; otherwise, the Compressor Interface is not the source (or not the only source) of energy drain.
11. Turn ON the AC input power and measure the Backplane test point voltages. Refer to section paragraph 4.5.8.1. If the test point voltages are as expected, the Compressor Interface module is faulty and needs to be replaced; otherwise, the Compressor Interface module is not the source (or not the only source) of energy drain.

4.6.5 IGBT Inverter Draining Energy

The following procedure is to determine if the IGBT Inverter is draining the compressor energy.

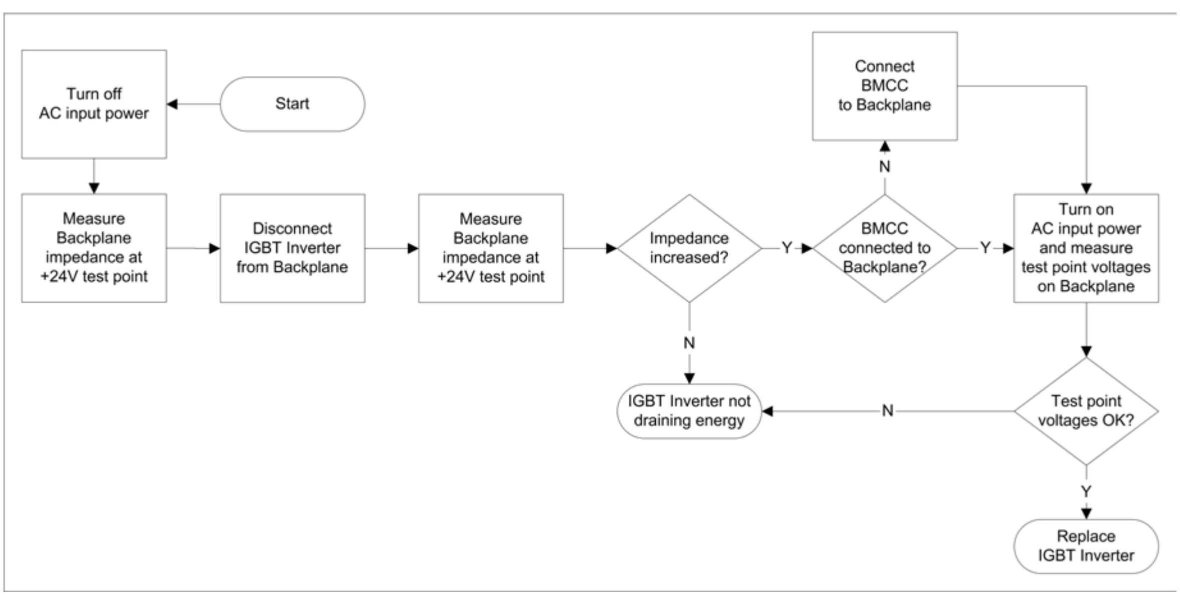


Figure 4-65 Flowchart to Determine if the IGBT Inverter is Draining Energy

1. Ensure the AC input power to the compressor is turned OFF.
2. Measure and record the resistance at the +24V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement".
3. Disconnect the IGBT Inverter from the Backplane (refer to section 5.6.2.3 "Disconnecting the IGBT Inverter from the Backplane").
4. Measure the resistance at the +24V test point. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Minimum Resistance Measurement". If the measured resistance increases, continue with the next step; otherwise, the IGBT Inverter is not the source (or not the only source) of energy drain.
5. Verify if the BMCC module is connected to the Backplane. If it is not, connect the BMCC module to the Backplane before proceeding.

⚠ WARNING

Either the BMCC or IGBT is required to be connected to the Backplane before turning on the compressor. When the IGBT Inverter is disconnected from the Backplane, it is important that the BMCC is connected.

6. Turn ON the AC input power and measure the voltages at the test points. Refer to the procedure outlined in 4.5.8 "Backplane Verification" - "Test Point Voltage Measurement". If the test point voltages are as expected, the IGBT Inverter is faulty and needs to be replaced; otherwise, the IGBT Inverter is not the source (or not the only source) of energy drain.

5 Service Procedures

5.1 Connecting Refrigerant Gauges

⚠ WARNING

It is extremely important that the manifold set is free of moisture and dust.

It is also important that the gauge set is calibrated and not contaminated with other refrigerants or oil.

When performing any service procedure that requires the addition of refrigerant, do not use reclaimed refrigerant unless it is of guaranteed quality and oil-free.

1. Connect the low pressure hose (blue hose) to the access valve (customer-supplied) in the suction piping.
2. Connect the high pressure hose (red hose) to the access valve (customer-supplied) in the discharge piping.
3. Purge both gauge lines ensuring that non-condensables, which can lead to false pressure readings, are not present in the line.

5.2 Soldering Procedure

When components in the refrigeration system require replacement, soldering or sweating will be required to either remove or replace the components.

To protect the internal pipe work, the use of industrial grade nitrogen must be used at all times during any procedure where a naked flame is applied to the pipe work.

The use of nitrogen prevents copper oxide formation in the internal pipe work during the soldering process. (This keeps the internal pipe work clean and free of contamination.)

1. Connect the gauge manifold set as per procedure paragraph 5.1.
2. Connect the common gauge line (yellow hose) to the nitrogen regulator.
3. Set the regulator to provide a positive pressure (< 5 psi).
4. Open the nitrogen cylinder and manifold set to purge the area to be soldered. (Nitrogen displaces any oxygen present in the pipe work.)

⚠ WARNING

During the soldering process, be sure that any component that may be affected by the addition of heat to the area be cooled by means of a wet rag wrapped around the component.

5. Once the soldering process is complete, cool down the pipe work and shut off the nitrogen supply. Once cool, the system can be re-assembled and tested for leaks.

5.3 Leak Testing

Service Tools/Consumables:

- Dry nitrogen
- Refrigerant
- Leak detector for refrigerant in use
- Soap bubbles
- Refrigerant manifold free of contaminants
- Nitrogen regulator

NOTE:
Refer to Industry/ASHRAE Standards when performing service on the refrigeration system.

⚠ CAUTION

Always wear proper safety equipment when handling refrigerants

There are commonly two types of systems that are encountered when leak checking:

- New systems that have never been in operation.
- Systems that have a standing charge of refrigerant in them

The system type will determine the course of action to be taken.

5.3.1 New System

NOTE:
Before you check for leaks in a new system, make sure that you have a drier and strainer installed to prevent damage to the compressor on start-up.

1. Connect a refrigerant manifold to the high and low sides of the system.
2. Make sure all system valves are open and any solenoids are open.
3. Add 1 pound of tracer refrigerant to the system. (Refer to EPA and S.C.A.Q.M.D. standards)
4. Connect a nitrogen bottle to the system. Slowly start to apply pressure to the system. Apply approximately 25 psi and perform a quick check for obvious leaks. (If any leaks are present at this time, remove the nitrogen from the system and repair the leak, then continue to the next step.)

WARNING
Do not pressurize the system over 150 psi; valve damage can occur.

5. If there are no apparent leaks, increase the system pressure to 100-125 psi. ()
6. Stop applying nitrogen to the system. Close the manifold and observe the pressure. Note the pressure when you start.
7. With the leak detector, start going over all soldered or mechanical connections in the refrigeration system.
8. If a leak is suspected with the leak detector, confirm with soap bubbles. If a leak is present when you apply the soap bubbles, large bubbles will start to appear.
9. If a leak has been detected, remove the nitrogen and repair the leak, and then recheck. If no leak is detected, observe the pressure on the manifold again. If there is no pressure loss, leave the pressure in the system for an extended period of time (usually 24 hours), and then recheck. If the system pressure did not change, remove the nitrogen charge and move onto the evacuation stage. If the system pressure did change, recheck that no leaks are present.

5.3.2 System with a Standing Charge

If a leak is suspected in a system that already has refrigerant, refer to the following.

1. With your leak detector, go over all soldered and mechanical connections in the system.
2. If a leak is suspected, confirm the leak with soap bubbles. If no leak is detected and you have done a thorough leak check, confirm that the system is not undercharged.
3. Once a leak has been detected, you need to recover the system's refrigerant charge or isolate the system's refrigerant from the affected area.
4. Once the system charge has been safely removed, continue onto the repair of the leak.
5. Once the repair has been made, confirm with tracer gas, nitrogen, and leak detector or just nitrogen that the leak is no longer present.

5.4 Refrigerant Recovery

NOTE:
Refer to Industry/ASHRAE Standards when performing service on the refrigeration system.

CAUTION
Always wear proper safety equipment when handling refrigerants

Service Tools/Test Equipment:

- Recovery machine
- Recovery bottle/s
- Refrigerant manifold free of contaminants
- Scale

When recovering refrigerant, try to remove the least amount of refrigerant from the system as possible. If you can isolate the charge and recover it at the low side of the system, or possibly even pump down, try that first. By doing this you are decreasing the risk of contaminating the refrigerant and the system.

Before proceeding, make sure that the system has been de-energized.

WARNING
For chiller applications, make sure that the circulating pumps are on and that you have flow. Failure to do so can result in significant tube damage to the chiller.

5.4.1 Removing Small Amounts of Charge

1. Identify the component you want to remove the charge from.

2. Isolate the area with the system's refrigerant valves.
3. Connect a refrigerant manifold system to the high and low parts of the area.
4. Connect the process line (yellow hose) to the inlet side of the recovery tank.
5. Take an additional hose from the outlet side of the recovery machine and connect it directly to the low side of the system.

NOTE:
Remember to purge the air from the lines so you do not contaminate the refrigerant.

6. Start the recovery machine. Allow the machine to run until the gauges show a couple inches of vacuum. Once this is done, close the manifold set off.
7. Close the recovery machine off and isolate those valves.
8. As long as the valves are holding, it is safe to perform work on the isolated area.

5.4.2 Removing Large Amounts of Charge

When removing large amounts of charge, it is always preferred to try and remove the liquid from the system first, and then the vapor. It is also generally a bit faster. A common method for doing this is the "push/pull method". This accomplished by pushing the liquid out of the system with the vapor in the system.

1. Connect a gauge hose to a "low" spot in the system where there is liquid (i.e. the liquid line).
2. Connect the process line (yellow hose) to the liquid side of the recovery bottle.
3. Take another hose from the vapor side of the bottle and attach it to the inlet side of the recovery machine.
4. Take the outlet side of the recovery machine and connect it to a "high point" (normally high in the condenser) in the system, which will cause the liquid to be forced out and into the recovery bottle.

NOTE:
Remember to purge the air from your lines so you do not contaminate the refrigerant.

5. Once you have removed the liquid from the system, isolate the valves and shut off the recovery machine.
6. Set up the recovery machine for normal vapor recovery.
7. Connect the manifold set to the high and low sides of the system.
8. Connect the process line (yellow hose) to the inlet side of the recovery machine.
9. Take an additional hose and connect it from the outlet side of the recovery machine to the vapor side of the bottle.
10. Once the gauges indicate a small vacuum (approximately 5 inches), isolate the gauges and the recovery machine. Work can now be performed on the system.

5.5 Charging the System

Service Tools/Consumables:

- Refrigerant manifold free of contaminants
- Refrigerant
- Thermometer
- Scale

NOTE:
Refer to Industry/ASHRAE Standards when performing service on the refrigeration system.

⚠ CAUTION

Always wear proper safety equipment when handling refrigerants

If a system is new or a repair is made, confirm the system has been properly evacuated before proceding with charging. General practice is to pull the system to 500 microns or less.

1. Connect a refrigerant manifold set to the low and high sides of the system.
2. Connect the refrigerant bottle to the process line (yellow hose).
3. Invert the refrigerant bottle and open the valve on the bottle. Confirm that there is liquid present in the hoses. Ensure that the air is purged out of the hoses before charging or the system will be contaminated.
4. Open the valves on the manifold set and begin charging the system with liquid refrigerant.
5. Once the static charge of liquid is complete, isolate the valves on the gauges. Remove the high-side line and connect it to the motor cooling port.
6. Try to start the system. As soon as the system starts, observe the inverter temperature on the compressor. It may be necessary to supply the compressor with liquid refrigerant at the motor cooling port until the system is properly charged. The system must have proper subcooling before the compressor can run without the supply from the refrigerant bottle.
7. Once the system is running and the charge is close, load the system to full load conditions. Check the subcooling; refer to the manufacturer’s recommendations. Generally, subcooling should be in the range of 10-15°F. If it is a chiller application, check the chilled water and condenser water approaches. If it is a DX air handling system, check the difference in the supply air vs return air.
8. Once the charge is correct, isolate the gauges and manifold set and remove them from the system.

5.6 Disconnecting and Reconnecting Electronic Circuits

⚠ CAUTION

Refer to 1 "Safety Considerations" prior to disconnecting or reconnecting electronic components.

⚠ DANGER

Disconnect and lockout incoming electrical power prior to disconnecting or reconnecting electronic components.

The following sections describe how to disconnect electronic circuits. To reconnect the electronic circuits, simply reverse the relevant procedure.

5.6.1 Top-Side Modules

The following procedures assume that the mains input cover and top cover have been removed. Refer to sections 6.4.1 and 6.4.3, respectively.

5.6.1.1 Disconnecting the AC Input Power Cables

Service Tools/Test Equipment:

- 14 mm socket driver

To disconnect the AC input power cables from the compressor, use a 14 mm socket driver to remove the three sets of nuts and washers that connect the AC input cables to the compressor. See Figure 5-1.

Figure 5-1 Disconnecting the AC Input Cables

5.6.1.2 Disconnecting Soft-Start Controller Input

To disconnect the AC/DC input voltage to the Soft-Start Controller, detach the cable at the Soft-Start input/output port J1. Refer to Figure 5-2.

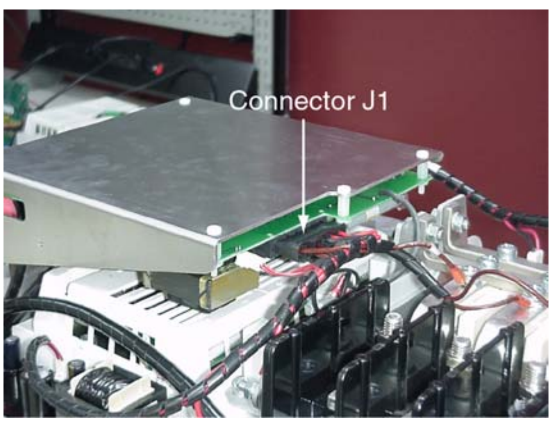


Figure 5-2 Disconnecting the Soft-Start Controller Input

5.6.1.3 Disconnecting the Rectifier from the Soft-Start Controller

To disconnect the Rectifier from the Soft-Start Controller, detach the cable from the Soft-Start output. The cable connection for the Soft-Start output to the Rectifier is located in the back of the compressor, as shown in Figure 5-3.

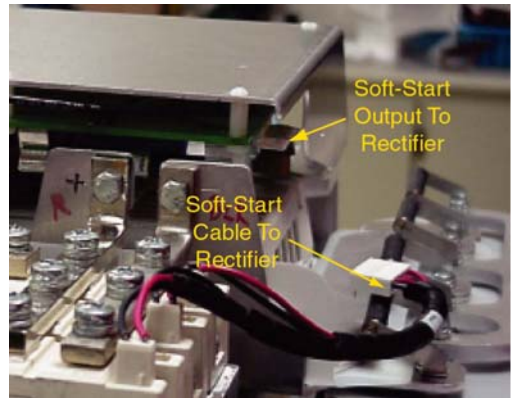


Figure 5-3 Disconnecting the Rectifier from the Soft-Start Controller

5.6.1.4 Disconnecting Soft-Start Controller from the DC-DC Converter

To disconnect the Soft-Start Controller from the DC-DC Converter, disconnect the input cables at ports J1 and J4 of the DC-DC Converter, as shown in Figure 5-4.

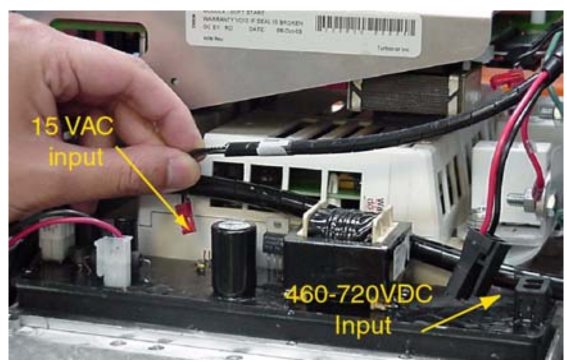


Figure 5-4 Disconnecting the Soft-Start Controller from the DC-DC Converter

5.6.1.5 Disconnecting the DC Bus from the IGBT Inverter

Service Tools/Test Equipment:

- 1.5”x 7” piece of insulating material (such as cardboard paper)

To disconnect the DC bus from the IGBT Inverter:

1. Remove the Soft-Start Controller (refer to section 6.10.1).
2. Remove the snubber capacitors (refer to section 6.10.3).
3. Insert a 1.5”x 7” piece of insulating material (such as cardboard paper) in between the (+) and (-) DC bus terminals, such that the (+) DC bus is not in contact with the (-) DC bus, as shown in Figure 5-5

WARNING

Check that the insulating material has not been damaged.

Figure 5-5 Disconnecting the DC Bus from the IGBT Inverter

5.6.1.6 Disconnecting the Motor from the IGBT Inverter

Service Tools/Test Equipment:

- Phillips #3 screwdriver

To disconnect the motor from the IGBT Inverter:

1. Remove the Soft-Start Controller (refer to section 6.10.1).
2. Remove the three Phillips-head screws, washers, and spacers that secure the blue, black, and red motor bus bars to the IGBT Inverter, as shown Figure 5-6.

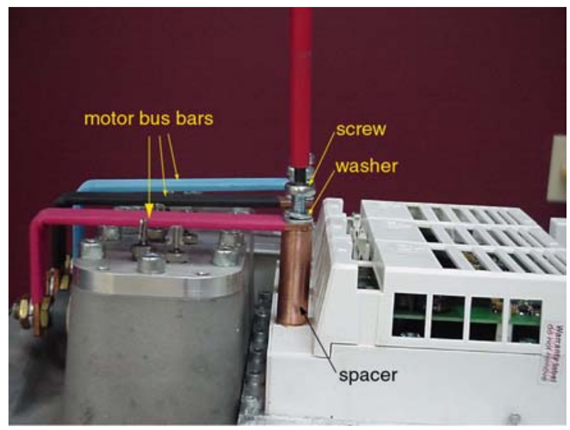


Figure 5-6 Disconnecting the Motor from the IGBT Inverter

5.6.1.7 Disconnecting the Backplane from the IGBT Inverter

To disconnect the Backplane from the IGBT Inverter:

1. Remove the Soft-Start Controller (refer to section 6.10.1)
2. Detach the cable located on the top of the IGBT Inverter, as shown in Figure 5-7

.

Figure 5-7 Disconnecting the Backplane from the IGBT Inverter

5.6.2 Service-Side Modules

The following procedures assume that the service-side cover (refer to section 6.4.2) has been removed.

5.6.2.1 Disconnecting the Motor-Cooling Solenoids from the Backplane

To disconnect the motor cooling solenoids from the Backplane, detach the cable, at the control output port J16, from the Backplane. See Figure 5-8.

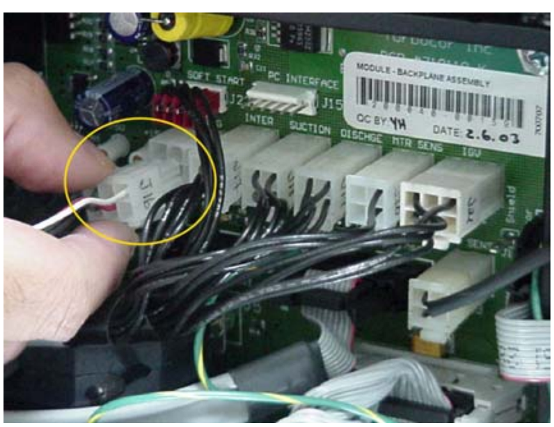


Figure 5-8 Disconnecting the Motor Cooling Solenoids from the Backplane

5.6.2.2 Disconnecting the IGV Stepper Motor from the Backplane

To disconnect the IGV stepper motor from the Backplane, detach the cable at the control output J21 on the Backplane. See Figure 5-9.

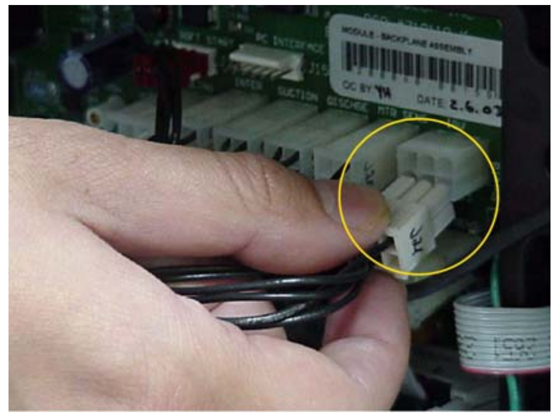


Figure 5-9 Disconnecting the IGV stepper Motor from the Backplane

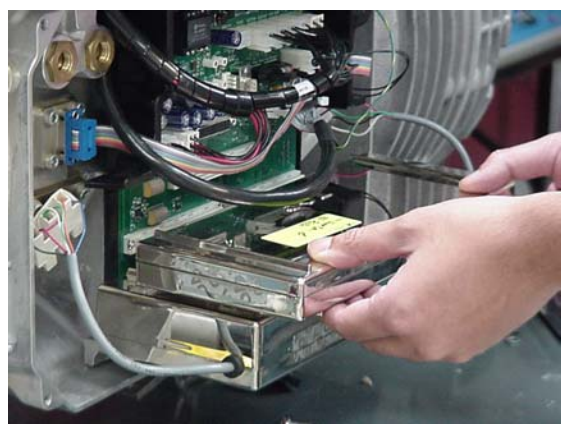


Figure 5-10 Disconnecting the BMCC from the Backplane

5.6.2.3 Disconnecting the IGBT Inverter from the Backplane

To disconnect the IGBT Inverter from the Backplane, disconnect the cable located at port J6 of the Backplane, as shown in Figure 5-11.

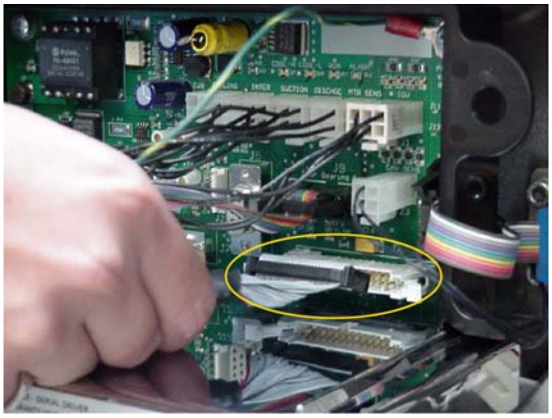


Figure 5-11 Disconnecting the IGBT Inverter from the Backplane

5.6.2.4 Disconnecting the Bearing Current Output Cables

Carefully withdraw the cluster block from the feed-thru connector on the rear/axial (left) and front (right) radial bearings. Remove the cluster blocks squarely by hand to prevent damage to the connector pins. Refer to Figure 6-3.

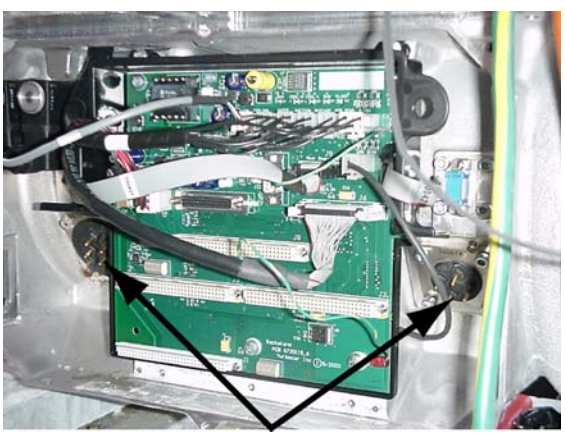


Figure 5-12 Bearing Power Connectors

5.6.2.5 Disconnecting the Electronic Expansion Valves from the Compressor Interface

Electronic Expansion Valve 1 (EXV1)

To disconnect EXV1 from the Compressor Interface, disconnect the left set of cables (1A, 1B, 2A, 2B) located at port J4 of the Compressor Interface. Refer to Figure 5-13.

Electronic Expansion Valve 2 (EXV2)

To disconnect EXV2 from the Compressor Interface, disconnect the right set of cables (1A, 1B, 2A, 2B) located at port J4 of the Compressor Interface. Refer to Figure 5-13.

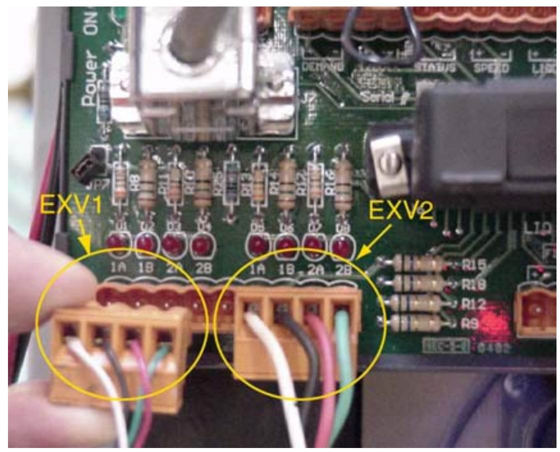


Figure 5-13 Disconnecting the Electronic Expansion Valves from the Compressor Interface

5.6.2.6 Disconnecting the Compressor Interface from the Backplane

To disconnect the Compressor Interface from the Backplane, detach the communication cable located at port J7 of the Backplane. Refer to Figure 5-14.

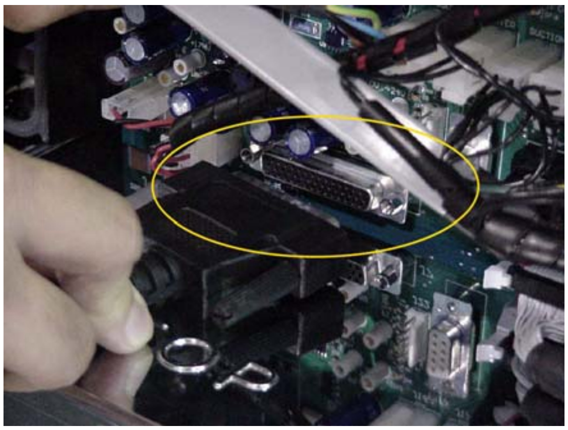


Figure 5-14 Disconnecting the Compressor Interface from the Backplane

5.6.2.7 Disconnecting Power to the IGV Motor

Service Tools/Test Equipment:

- 4 mm Allen key

To disconnect the power to the IGV motor, use a 4 mm Allen key to remove the clamp securing the connector, as shown in Figure 5-15. Then detach the connector on the IGV housing as shown in Figure 5-16.

Figure 5-15 Disconnecting Power to the IGV Motor (1 of 2)

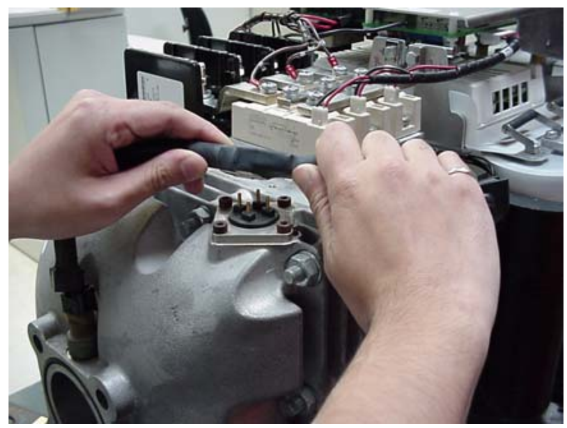


Figure 5-16 Disconnecting Power to the IGV Motor (2 of 2)

6 Removal and Installation

6.1 Preparation for Service

Before performing any service on the compressor, electrical power must be isolated. To ensure safe and clear access to the compressor, follow these procedures.

DANGER

This equipment contains hazardous voltages that can cause injury or death. Only a qualified electrician should work on high-voltage electronic 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 compressor access covers. Disconnect and lockout power and then wait 10 minutes for capacitors to de-energize before removing covers.

DANGER

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

Removing the top cover will expose you to a high voltage (460-720 VDC) hazard. Exercise care when working around energized circuits.

When proceeding to test the compressor, ensure the compressor access covers are replaced and securely fastened.

DANGER

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

6.2 Service Tools

The following table lists the tools required for servicing the compressor.

Table 6-1 List of Service Tools

Tools	Spec.
Allen key set	2.5, 4, 5, 8, 14 mm 7/64"
Torx screwdriver	#25
Phillips screwdriver	#2, #3
Assorted sockets and driver	14, 16, 17 mm 18 mm deep socket 15/16", 1'1/8"
Combination wrench set	5/16", 7/16", 5/8" 10, 24 mm
Adjustable 14" wrench	
Manifold set	
Multimeter (with clamp-type ammeter and diode setting)	1000V AC-DC
Torque wrench	55 ft-lbs (75 Nm)
Putty knife	1”
Grounding wrist strap	
Safety glasses	approved, impact-resistant

6.3 Handling Static Sensitive Devices

Active electronic components are susceptible to damage when exposed to static electrical charges. Damage to such components may lead to outright failure or reduction in service life. Since the presence of static charges is not always evident, it is essential that service personnel follow static control procedures at all times when handling sensitive electronic components.

This section outlines static control precautions that must be followed when providing service support in the field. Service support personnel should create a safe, static-free environment.

Service personnel should use a commercially available service kit for handling static-sensitive devices. The kit typically includes:

- static dissipative work surface
- ground cord Assembly
- alligator clip
- grounding wrist strap
- wrist strap tester

If a safe, static control environment cannot be created for a specific reason, the operator that handles the module has to discharge himself before touching the module and should never carry the module without its electrostatic discharge (ESD) protective bag.

The modules should be removed from the ESD protective bag at the last moment, just before installation when the operator is ready to do the replacement.

The operator should avoid touching any components or connectors on the module and should hold the module by its edge or enclosure, as applicable.

The following non-enclosed modules need to be handled with additional care:

- Soft Start Controller
- Backplane Module
- High-voltage DC-DC Converter

These modules should be handled as follows:

- Soft Start - by the aluminum bracket
- DC-DC Converter - by the aluminum heat sink plate or the plastic spacers
- Backplane - by the black plastic housing

For further information on ESD standards, refer to the following documentation:

JEDEC Standard - Requirements for Handling Electrostatic Discharge-Sensitive Devices
Website: www.JEDEC.org

ANSI/ESD S20.20 - Protection of Electrical and Electronic Parts, Assemblies, and Equipment
Website: www.ESDA.org

ANSI/ESD S541 - Protection of Electrostatic Discharge Susceptible Items, Packaging Materials for ESD Sensitive Items
Website: www.ESDA.org

6.4 Service Covers - Removal & Installation

To enable access for servicing, the compressor is equipped with three removable covers; refer to Figure 3-1. During normal operation, these covers must be securely fastened to the compressor to prevent accidental contact with hazardous voltages and to protect the electronic components from the environment.

The following paragraphs describe the cover removal procedures. To replace the covers, simply reverse the relevant procedure.

Service Tools/Test Equipment:

- T25 Torx bit and driver

6.4.1 Mains Input Cover

Release the four captive screws that secure the mains input cover. Lift away cover.

6.4.2 Service-Side Cover

Release the six captive screws that secure the service-side cover. Lift away cover.

6.4.3 Top Cover

1. Remove the mains input cover; refer to paragraph paragraph 6.4.1.
2. Release the nine captive screws that secure the top cover. Lift away cover.

6.5 Compressor - Removal

Refer to 6.1 "Preparation for Service" prior to commencing removal procedures.

Service Tools/Test Equipment:

- T25 Torx bit and driver
- 14 mm, 17 mm socket and driver
- Adjustable 14” wrench
- Hex key set (up to 14 mm)
- Phillips #3 screwdriver
- 5/16" combination wrench

6.5.1 Refrigerant Containment

CAUTION

Isolation and recovery of the refrigerant must be performed by a qualified service technician.

1. Close the suction, discharge, and economizer (if fitted) ball valves.
2. Close the motor cooling shut-off valve.
3. Connect the service gauge as per procedure paragraph 5.1.
4. Connect a refrigerant recovery system to the compressor as per industry-standard procedures and transfer the refrigerant into a clean cylinder.

6.5.2 Compressor Removal

Refer to 6.1 "Preparation for Service" prior to commencing the removal procedures.

1. Switch off the AC mains at the disconnect switch. Install a lock-out device or place a placard at the switch alerting others that compressor servicing is in progress.
2. Remove the mains input cover; refer to paragraph paragraph 6.4.1.
3. Using a 14 mm socket and driver, remove the terminal nuts from the terminal block. Refer to Figure 6-1.
4. Remove the AC mains cables from the terminals.

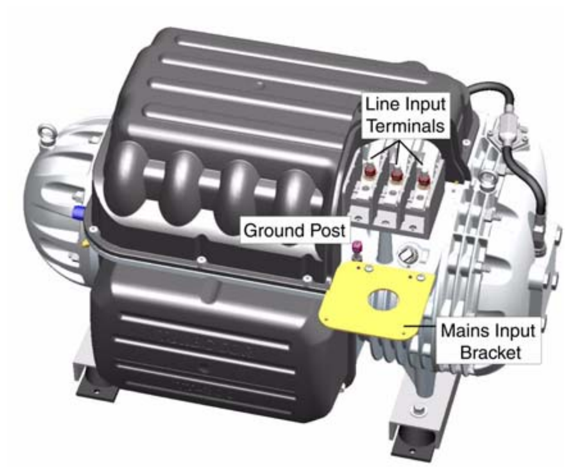


Figure 6-1 AC Mains Terminal Block

5. Using a 5/16" combination wrench, remove the nut that secures the mains input ground wire to the post. Remove the ground wire.

6. Remove the two Phillips-head screws that secure the mains input bracket to the main compressor housing.
7. Release the six captive screws that secure the service-side cover. Lift away cover.

WARNING
Make sure that there is no secondary power source connected to the Compressor Interface module before disconnecting the I/O cable.

8. Disconnect the I/O cable from the Backplane I/O connector.
9. Remove the two Phillips-head screws that secure the I/O cable grommet to the main compressor housing. Remove the I/O cable from the compressor.
10. Replace the service-side cover.

NOTE:
The following paragraphs describe the removal sequence for Turbocor-supplied service valves. For other valves, use the appropriate tools.

11. Once the transfer of refrigerant is complete, proceed to disconnect the service isolation valves. Using a 24 mm combination wrench, remove the suction ball valve bolts.
12. Using a 17 mm socket, remove the discharge ball valve bolts.
13. If an economizer ball valve is fitted, remove the valve bolts using a 17 mm socket.
14. Remove the motor cooling connection at the rear of the compressor.
15. Replace the mains input cover and secure it with the four captive screws.
16. Using a 16 mm socket, remove the four compressor mounting bolts.
17. Connect an approved lifting device, such as a mobile hydraulic lifter, to the eyebolts provided on each side of the compressor.
18. Remove the compressor.
19. Using the blanking plates provided with the new compressor, seal up the compressor in preparation for shipment to the supplier. (This will prevent moisture and foreign material from entering the compressor and possibly affecting the compressor strip-down and analysis procedures.)

6.6 Compressor - Installation

Service Tools/Test Equipment:

- T25 Torx bit and driver
- 14 mm, 17 mm socket and driver
- Adjustable 14” wrench
- Hex key set (up to 14 mm)
- Phillips #3 screwdriver
- 5/16", 24 mm combination wrench

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

1. Remove the blanking plates provided with the new compressor.
2. Position the compressor over the rubber mounts and align the four holes in the compressor base channel with the rubber mounts.
3. Assemble the four 3/8” screws with the spring washers. Insert the screws into the rubber mounts and tighten them.

4. Attach the motor cooling connection at the rear of the compressor.

⚠ WARNING

Install new gaskets only when reattaching the ball valves to the compressor.

NOTE:

The following paragraphs describe the installation sequence for Turbocor-supplied service valves. For other valves, use the appropriate tools.

5. Using a 17 mm socket, tighten the economizer valve bolts (if fitted) to 22 Nm.
6. Using a 17 mm socket, tighten the discharge service valve bolts to 22 Nm.
7. Using a 24 mm combination wrench, tighten the suction service valve bolts to 75 Nm.
8. Release the six captive screws that secure the service-side cover. Lift away cover.
9. Connect the I/O cable to the compressor I/O connector at the Backplane.
10. Attach the I/O cable grommet to the main compressor housing. Secure the grommet with two Phillips-head screws .
11. Replace the service-side cover.
12. Remove the four captive screws that secure the mains input cover. Lift away cover.

⚠ DANGER

Make sure that electrical power is isolated from the AC mains cables before handling them.

13. Secure the mains input bracket to the compressor housing using two Phillips-head screws.
14. Attach the AC mains cables to the terminals.
15. Using a 14 mm socket and driver, attach the terminal nuts to the terminal block . Tighten the terminal nuts to 192 in-lbs. Refer to Figure 6-1.
16. Attach the ground cable to the ground post on the compressor housing.
17. Attach the ground nut to the ground post and tighten it using a 5/16" combination wrench.
18. Replace the mains input cover and secure it with four captive screws.

6.7 Serviceable Components

The replaceable modules described in this manual are located behind the service-side and top covers. Table 6-2 lists the replaceable components that are available for servicing the compressor. Figure 6-2 shows the component locations.

In order to access the replaceable modules, the relevant service cover must be removed; refer to paragraph 6.4 "Service Covers - Removal & Installation" for details.

Table 6-2 Spare Parts List

Item	Description	Turbocor Part #
1	Housing Assembly - IGV (brass)	Contact DTCI
2	Module - Bearing PWM	310012
3	Module - DC-DC Converter- Hi Voltage (460V)	340029-1
4	Module - Backplane Assembly	200125
5	Sensor-Pressure/Temperature (150psi)	900576
6	Sensor-Pressure/Temperature (500psi)	900577
7	Buss Bar Assembly	213023
8	Kit - Regular Black Covers	880047
8	Kit - CE Coated Covers	880050
12	Module - Serial Driver	300047
13	Module - Soft Start	220039
14	Module - Bearing-Motor-Compressor Control (BMCC)	Contact DTCI

Table 6-2 Spare Parts List (Continued)

Item	Description	Turbocor Part #
15	Kit - Solenoid Valves (R134a)	901937
16	Kit - Mounting	100066
17	Diode - Rectifier	901425
18	Kit - Service Valve - Discharge	100413
19	Kit - Service Valve - Suction	100412
20	Kit - Service Valve - Economizer	100414
22	Kit - PCB Assembly Compressor Int. Connector	530010
23	Line Reactor - 3 Phase-140A-0.5mH	901453
23	Line Reactor - 3 Phase-180A-0.5mH	901454
24	Cable Harnesses - Compressor Controller & DC Supply (not shown) - see Note 1.	260029 200132
24	Cable Harness - Compressor Controller (not shown) - see Note 2.	200126
25	Cable Harness - Chiller (not shown)	230041
26	Cable Harness - Soft Start (not shown)	720358
27	Cavity Sensor (not shown)	200042
28	Bearing Feed-Through (4 pins) (not shown)	750078
29	Bearing Feed-Through (6 pins) (not shown)	750079
30	Manuals	TBD
31	Kit - O-ring - Compressor (excluding valves)	100129

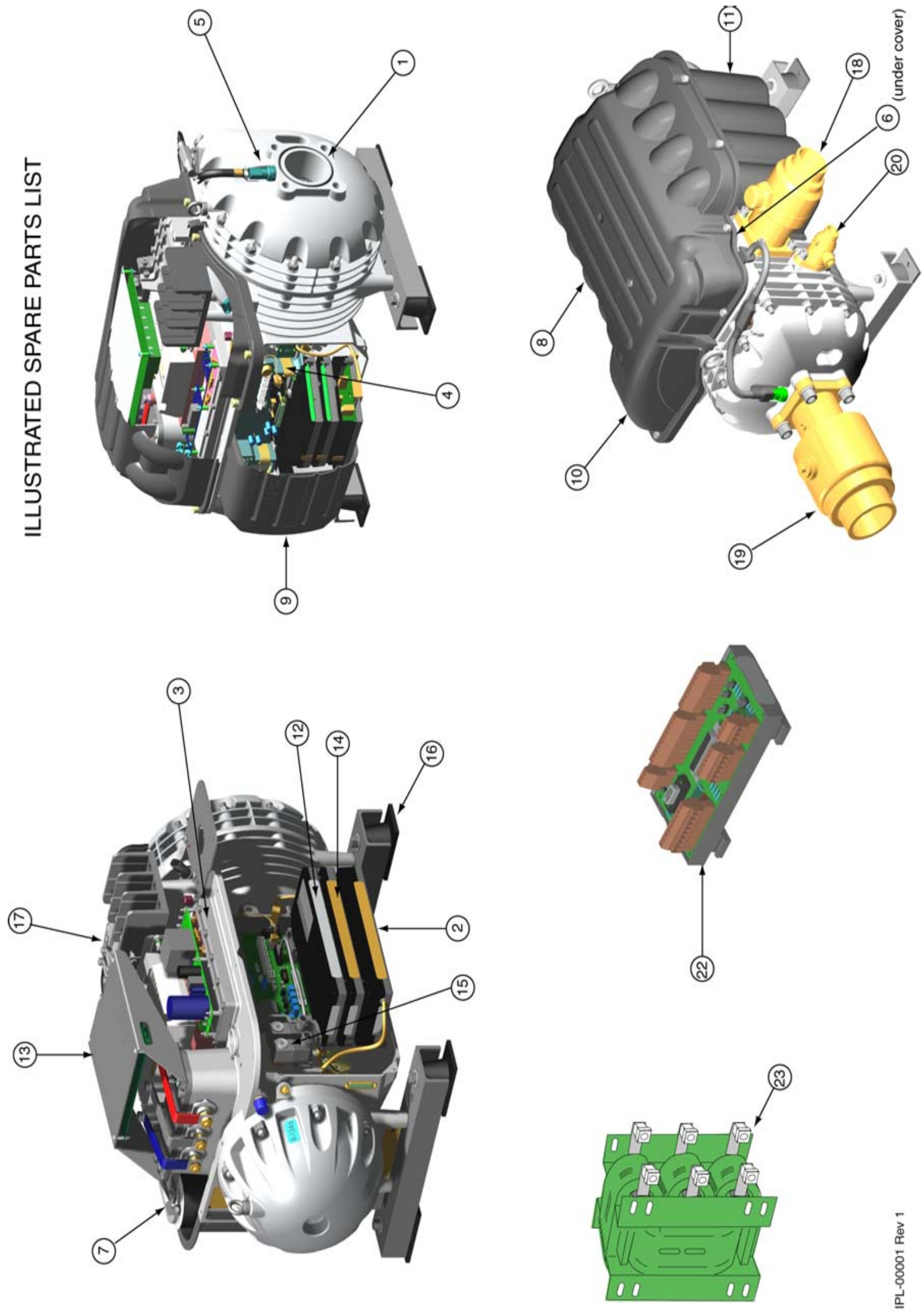


Figure 6-2 Spare Part Locations

6.8 Service-side Modules - Removal

The following procedures assume that the service-side cover has already been removed.

Refer to 6.1 "Preparation for Service" and 6.3 "Handling Static Sensitive Devices" prior to commencing removal procedures.

6.8.1 Serial Driver - Removal

Pull the Serial Driver module out of its slot and store it in the antistatic bag that was shipped with the replacement module.

6.8.2 BMCC - Removal

Pull the BMCC module out of its slot and store it in the antistatic bag that was shipped with the replacement module.

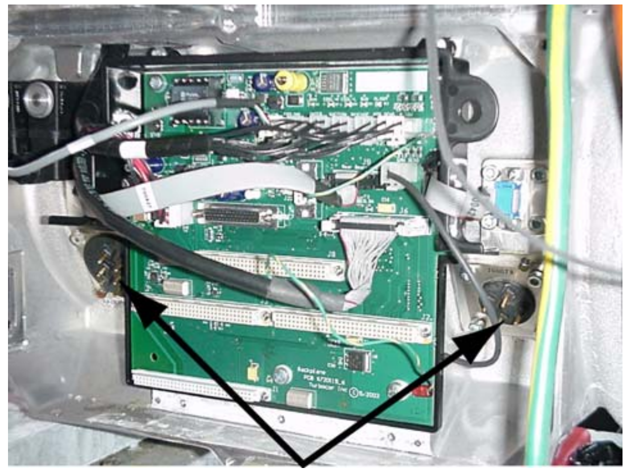


Figure 6-3 Bearing Power Connectors

6.8.3 Bearing PWM Amplifier - Removal

Service Tools/Test Equipment:
• Phillips #2 screwdriver

1. Remove the BMCC and Serial Driver modules; refer to paragraphs 6.8.2 "BMCC - Removal" and 6.8.1 "Serial Driver - Removal".
2. Carefully withdraw the cluster block from the feed-thru connector on the front and rear radial bearings. Remove the cluster blocks squarely by hand to prevent damage to the connector pins. Refer to Figure 6-3.
3. Remove the three Phillips-head screws that secure the heatsink of the PWM amplifier module to the main compressor housing. Refer to Figure 6-4.
4. Pull the PWM amplifier module out of its slot and store it in the antistatic bag that was shipped with the replacement module.

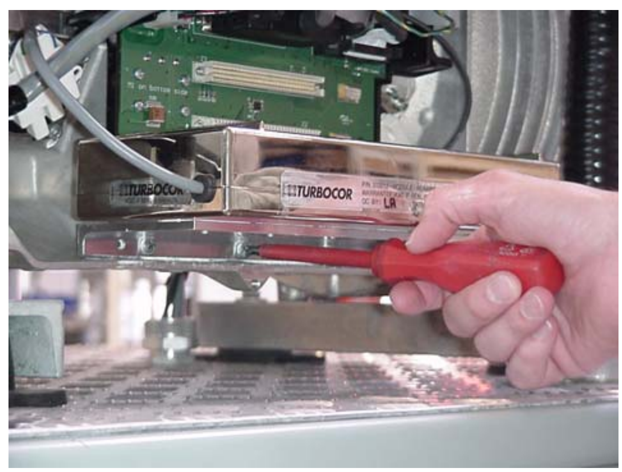


Figure 6-4 Removing the PWM Amplifier

6.8.4 Backplane - Removal

Service Tools/Test Equipment:
• Phillips #2 screwdriver

1. Remove the PWM Amplifier, BMCC module, and Serial Driver module as outlined in the previous sections.

2. Disconnect the 250V input connector (J4).
3. Disconnect the I/O cable harness connector (J5) and the ground lug from connector J5.
4. Disconnect the IGBT interface connector (J6). Remove the ring terminal (attached to the IGBT interface cable) from the ground screw at the top right of the Backplane.
5. Disconnect the Soft Start interface connector (J22).
6. Disconnect the motor cooling solenoid connector (J16).
7. Disconnect the pressure/temperature sensor connectors (J17, J18, and J19).
8. Disconnect the position sensor connectors (J9 and J10) and the ground lug from connector J9.
9. Disconnect the cavity temperature sensor connector (J23).
10. Disconnect the IGV motor drive connector (J21).
11. Disconnect the motor temperature sensor connector (J20).
12. Disconnect the +24VDC connector (J24).
13. Remove the three Phillips-head screws (including the frame ground screw) that secure the backplane to the service-side housing. Refer to Figure 6-5.
14. Withdraw the backplane from the service-side housing and store it in the antistatic bag that was shipped with the replacement backplane.

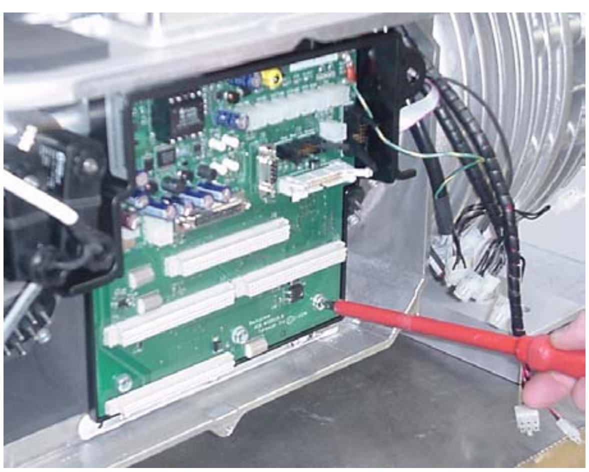


Figure 6-5 Removing the Backplane Mounting Screws

6.8.5 Motor Cavity Sensor - Removal

Service Tools/Test Equipment:

- 5/8" combination wrench

1. Remove the backplane; refer to paragraph paragraph 6.8.4.
2. Disconnect the sensor connector.
3. Using a 5/8" combination wrench, remove the motor cavity sensor. Refer to Figure 6-6.
4. Ensure threads are clean and free from residual sealant.

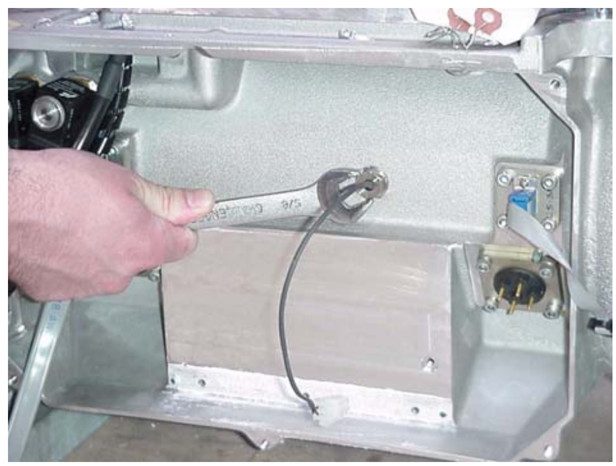


Figure 6-6 Motor Cavity Sensor Removal

6.8.6 Motor-cooling Solenoid - Removal

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Loosen and remove the knurled nut.
2. Remove the spring washer.
3. Remove the solenoid.
4. If the coil is faulty, disconnect the coil using a Phillips-head screwdriver. Replace the coil.

6.8.7 Motor-cooling Valve - Removal

Service Tools/Test Equipment:

- 18 mm deep socket and driver

1. Remove the motor-cooling solenoid; refer to paragraph paragraph 6.8.6.
2. Using a 18 mm socket and driver, remove the motor-cooling valve.

6.9 Service-side Modules- Installation

The following procedures assume that the service-side cover has already been removed.

Refer to 6.1 "Preparation for Service" and 6.3 "Handling Static Sensitive Devices" prior to commencing installation procedures.

6.9.1 Motor-cooling Valve - Installation

Service Tools/Test Equipment:

- 18 mm deep socket and driver

1. Lubricate a new o-ring with grease and install it on the valve.
2. Insert the valve in the opening and engage the first few threads by hand.
3. Tighten the valve using a 18 mm socket and driver.

6.9.2 Motor-cooling Solenoid - Installation

1. Slide the solenoid over the valve body.
2. Install the spring washer.
3. Install the knurled nut and tighten it by hand.

6.9.3 Motor Cavity Sensor - Installation

Service Tools/Test Equipment:

- 5/8" combination wrench

1. Apply a sealant to the sensor threads.
2. Insert the sensor into the opening and engage the first few threads by hand.
3. Using a 5/8" combination wrench, tighten the sensor to 10 Nm.
4. Reconnect the sensor connector.
5. Replace the backplane; refer to paragraph paragraph 6.9.4.

6.9.4 Backplane - Installation

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Position the plastic stand-offs in the recessed mounting holes in the main compressor housing.
2. Align the backplane with the mounting holes.
3. Attach the ring terminal from the IGBT interface cable to the frame ground screw. Insert and tighten the frame ground screw and the remaining two Phillips-head screws that secure the backplane to the service-side housing.
4. Connect the 250V input connector (J4).
5. Connect the I/O cable harness connector (J5) and the ground lug.
6. Connect the IGBT interface connector (J6).
7. Connect the Soft Start interface connector (J22).
8. Connect the motor-cooling solenoid connector (J16).
9. Connect the pressure/temperature sensor connectors (J17, J18, and J19).
10. Connect the position sensor connectors (J9 and J10).
11. Connect the cavity temperature sensor connector (J23).
12. Connect the IGV motor drive connector (J21).

13. Connect the motor temperature sensor connector (J20).
14. Connect the +24VDC connector (J24).

6.9.5 Bearing PWM Amplifier - Installation

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Align the Amplifier module's heatsink with the two guide pins in the main compressor housing.
2. Insert the Amplifier module into the connector.
3. Secure the Amplifier module's heatsink to the main compressor housing with three Phillips-head screws. **Verify that the module's heatsink is firmly seated against the main compressor housing**.
4. Connect the two cluster blocks to the feed-thru connectors on the front and rear radial bearings.

6.9.6 BMCC - Installation

1. Align the BMCC module's two lower guides so that they are aligned on the inside of the PWM Amplifier module's two upper guides. Note the insertion guides in Figure 6-7.
2. Slide the BMCC module into the connector until it is firmly seated.

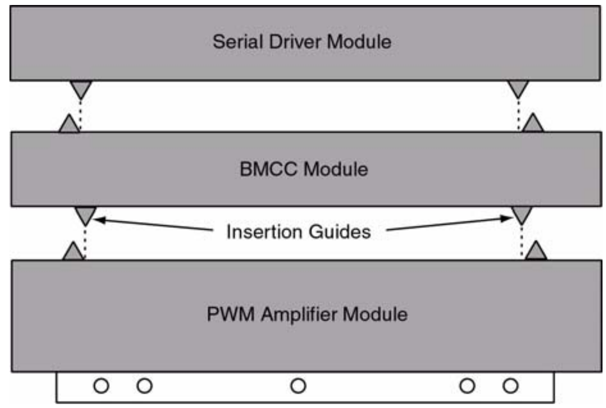


Figure 6-7 Module Insertion Guides

6.9.7 Serial Driver - Installation

1. Align the Serial Driver module's two lower guides so that they are aligned on the inside of the BMCC module's two upper guides.
2. Slide the Serial Driver module into the connector until it is firmly seated.

6.10 Top-side Modules - Removal

The following procedures assume that the top cover has already been removed.

Refer to 6.1 "Preparation for Service" and 6.3 "Handling Static Sensitive Devices" prior to commencing removal procedures.

6.10.1 Soft Start Module - Removal

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Disconnect the three cable connectors from the Soft Start module.
2. Disconnect the Soft Start ground wire by removing the nuts and mains input ground wire from the ground post on the compressor housing.
3. Remove the four Phillips-head screws that secure the mounting bracket. Refer to Figure 6-8.
4. Remove the module and store it in the antistatic bag that was shipped with the replacement module.

6.10.2 DC-DC Converter Fuse - Removal

NOTE:
The DC-DC Converter fuse is located on the Soft-Start module.

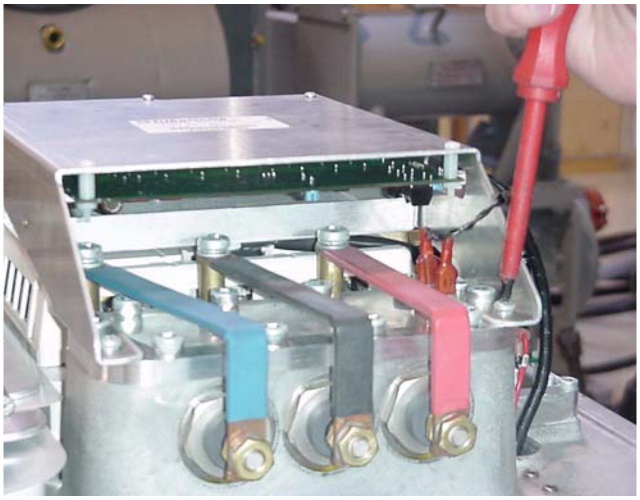


Figure 6-8 Soft Start Module Removal

1. Remove the Soft-Start Controller (refer to section 6.10.1).
2. Remove the fuse located on the Soft-Start Controller. See Figure 6-9.

Figure 6-9 DC-DC Converter Fuse Removal

6.10.3 Snubber Capacitors - Removal

Service Tools/Test Equipment:

- Phillips #3 screwdriver

1. Remove the Soft-Start Controller (refer to section 6.10.1).
2. Remove the six Phillips-head screws and washers that secure the three snubber capacitors (see Figure 6-10), and remove the snubber capacitors.

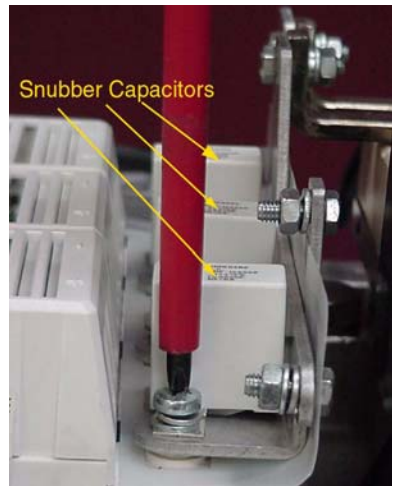


Figure 6-10 Snubber Capacitor Removal

6.10.4 High-voltage DC-DC Converter - Removal

Service Tools/Test Equipment:

- 2.5 mm Allen key

1. Remove the four connectors (800VDC (J1), 250VDC (J2), 24VDC(J3), and 15VAC (J4)) from the module.
2. Using a 2.5 mm Allen key, loosen the 4 hex-head screws that are located next to the IGBT Inverter. Remove the 4 hex-head screws that are located on the front side of the Converter. Refer to Figure 6-11.
3. Lift the module on the front side and slide it clear of the rear screws. Store the module in the antistatic bag that was shipped with the replacement module.

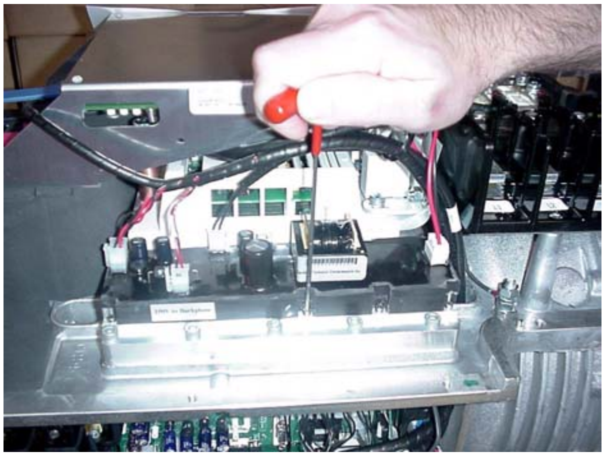


Figure 6-11 HV DC-DC Converter Removal

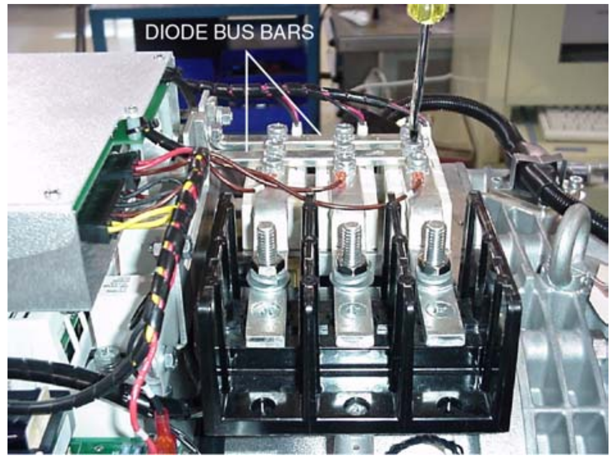


Figure 6-12 Removing the Diode Bus Bars

6.10.5 Rectifier Diodes - Removal

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- 10 mm combination wrench

1. Disconnect the mains input wires from the terminals; refer to 5.6.1.1 "Disconnecting the AC Input Power Cables" on page 91.
2. Remove the three Phillips-head screws that secure the AC bus bars to the rectifiers.
3. Remove the three Phillips flat-head screws that secure the AC bus bars to the terminal block. Lift away the AC bus bars.
4. Remove the six Phillips-head screws that secure the (+) and (-) diode bus bars to the rectifiers. Refer to Figure 6-12.
5. Using a 10 mm combination wrench, remove the attaching hardware that secures the (+) and (-) diode bus bars to the DC bus bars. Lift away the diode bus bars.
6. Disconnect the SCR gate connector from the rectifier.
7. Remove the two Phillips-head screws that secure the rectifier diode to the cooling manifold. Refer to Figure 6-13. Lift away rectifier diode.

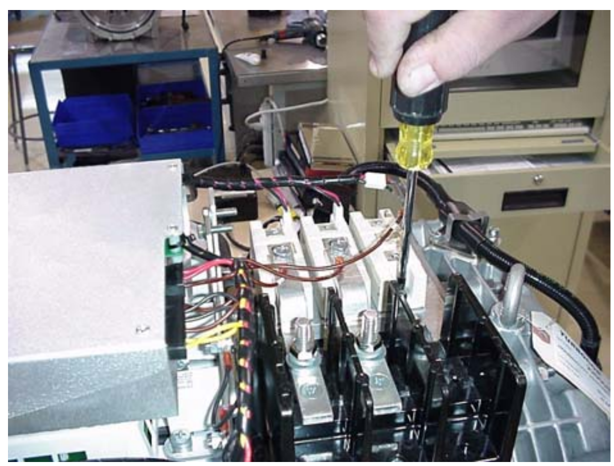


Figure 6-13 Removing the Rectifier Diode

6.10.6 Mains Terminal Block - Removal

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Disconnect the mains input wires from the terminals; refer 5.6.1.1 "Disconnecting the AC Input Power Cables" on page 91.
2. Remove the three Phillips-head screws that secure the AC bus bars to the rectifiers.
3. Remove the three Phillips flat-head screws that secure the AC bus bars to the terminal block. Lift away the AC bus bars.
4. Remove the three Phillips-head screws that secure the terminal block to the main housing; refer to Figure 6-14. Lift away terminal block.

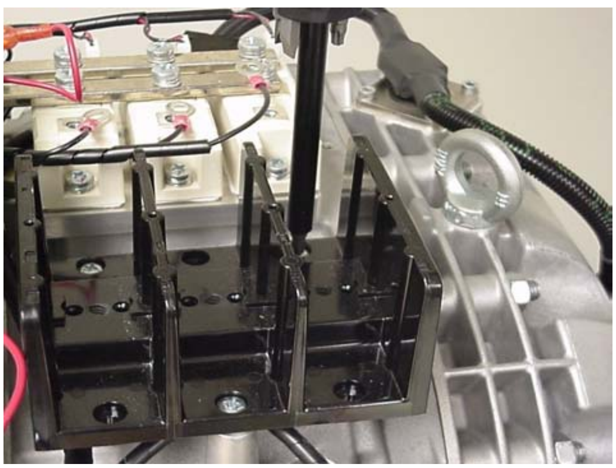


Figure 6-14 Removing the Terminal Block

6.10.7 DC Link Capacitors - Removal

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- 1-1/8" socket and driver
- 10 mm combination wrench

1. Remove the Soft Start module; 6.10.1 "Soft Start Module - Removal" on page 107.
2. Using a 10 mm combination wrench, remove the attaching hardware that secures the (+) and (-) diode bus bars to the DC bus bars. Refer to Figure 6-15.
3. Using a 10 mm combination wrench, remove the attaching hardware that secures the (+) and (-) ring terminals to the DC bus bars.
4. Remove the lug terminal that connects to the mid bus.
5. Remove the six Phillips-head screws and washers that secure the three snubber capacitors. Refer to Figure 6-16. Remove the capacitors and attaching hardware.
6. Using a 1-1/8" socket, remove the four nylon nuts that secure the DC link capacitors to the main compressor housing.
7. Lift out the DC link capacitors and DC buses as an assembly.

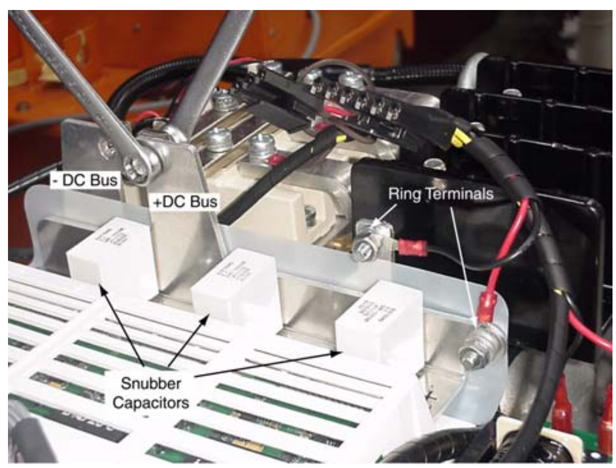


Figure 6-15 Removing Attaching Hardware from the DC Bus

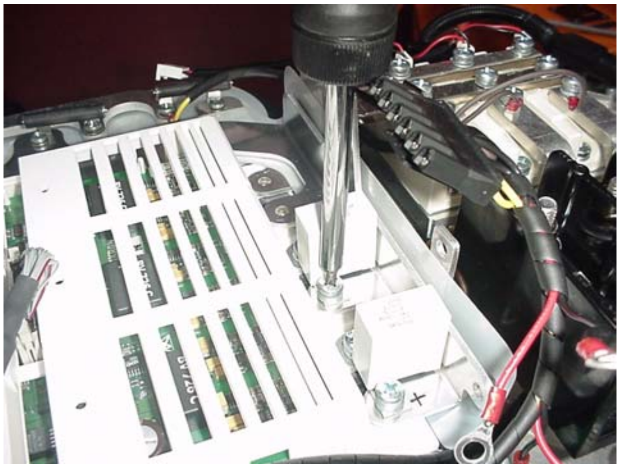


Figure 6-16 Removing the Snubber Capacitors

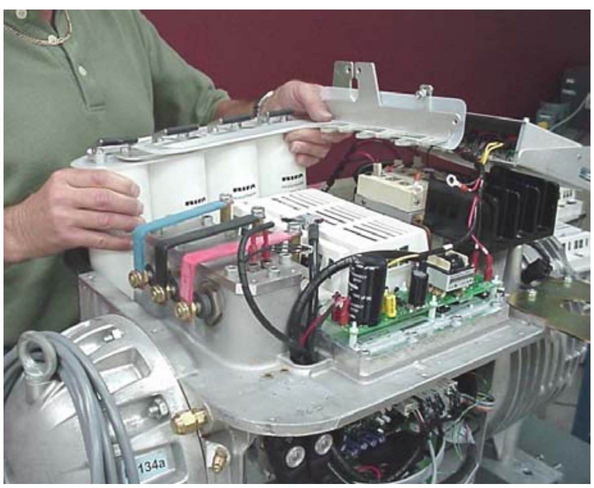


Figure 6-17 Removing the DC Link Capacitors and Bus Bars

6.10.8 IGBT Inverter - Removal

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- 5 mm Allen key

⚠ WARNING

Recover refrigerant from the compressor before removing the Inverter mounting screws. Removal of the mounting screws will break the seal under the Inverter heatsink and release refrigerant. Refer to paragraph 6.5.1 for refrigerant recovery procedure.

1. Remove the high-voltage DC-DC Converter. Refer to paragraph 6.10.4.
2. Remove the DC link capacitor and bus assembly. Refer to paragraph 6.10.7.
3. Disconnect the flat ribbon cable from the Inverter.
4. Remove the three Phillips-head screws, washers, and spacers that secure the bus bars to the Inverter.
5. Remove the bus bars from the rectifiers as outlined in 6.10.5 "Rectifier Diodes - Removal" on page 109.
6. Disconnect the SCR gate connectors from the rectifiers.
7. Using a 5 mm Allen key, remove the 14 screws and washers that secure the Inverter to the main housing. Refer to Figure 6-18. Remove Inverter and discard o-ring.

Figure 6-18 Removing the IGBT Inverter

6.10.9 Pressure/Temperature Sensors - Removal

Pressure/temperature sensors are installed at the suction and discharge ports. The following procedure applies to both locations.

Service Tools/Test Equipment:

- 15/16" deep socket and driver

1. Remove the compressor cover, if applicable.
2. Disconnect the sensor connector.
3. Using a 15/16" socket, remove the sensor.

6.11 Top-side Modules - Installation

The following procedures assume that the top-side cover has already been removed.

Refer to 6.1 "Preparation for Service" and 6.3 "Handling Static Sensitive Devices" prior to commencing installation procedures.

6.11.1 Soft Start Module - Installation

Service Tools/Test Equipment:

- Phillips #2 screwdriver

1. Align the Soft Start mounting bracket with the holes in the cover plate.
2. Insert and tighten the four Phillips-head screws to secure the mounting bracket.
3. Attach the three cable connectors to the Soft Start module.
4. Attach the Soft Start and mains input ground wires to the ground post on the compressor housing. Tighten the nuts.

6.11.2 High-voltage DC-DC Converter - Installation

Service Tools/Test Equipment:

- 2.5 mm Allen key
- 1” putty knife

1. Apply conductive paste to the underside of the DC-DC Converter heatsink.
2. Align the heatsink with the mounting holes on the IGBT base plate.
3. Insert and tighten the 8 hex-head screws that secure the DC-DC Converter heatsink to the IGBT base plate.
4. Attach the five connectors (800VDC (J1), 250VDC (J2), 24VDC(J3), and 15VAC (J4)) to the module.

6.11.3 IGBT Inverter- Installation

Service Tools/Test Equipment:

- Phillips #3 screwdriver
- 5 mm Allen key

1. Fit a new o-ring into the groove of the main compressor housing.
2. Align the Inverter over the mounting holes in the compressor main housing.
3. Insert the 14 screws with washers into the mounting holes. Tighten the screws using a 5 mm Allen key.
4. Insert the three spacers between the bus bars and the Inverter. Insert and tighten the three Phillips-head screws with washers to secure the bus bars to the Inverter.
5. Attach the bus bars to the rectifiers; refer to 6.11.4 "Rectifier Diodes - Installation" on page 113.
6. Re-connect the SCR gate connectors to the rectifiers.
7. Re-connect the flat ribbon cable to the Inverter.

8. Re-install the DC link capacitor and bus assembly. Refer to paragraph 6.11.6.
9. Re-install the high-voltage DC-DC Converter. Refer to paragraph 6.11.2.

6.11.4 Rectifier Diodes - Installation

Service Tools/Test Equipment:

- Phillips #2 screwdriver
- 10 mm combination wrench
- 1” putty knife

1. Apply conductive paste to the underside of the rectifier diode.
2. Align the rectifier diode with the mounting holes on the cooling manifold.
3. Insert and tighten the two Phillips-head screws that secure the rectifier diode to the cooling manifold.
4. Attach the SCR gate connector to the rectifier diode.
5. Align the AC bus bars with the mounting holes on the terminal block. Insert and tighten the Phillips flat-head screws.
6. Assemble the flat washer, spring washer and ring terminal (black wire) onto each of the three Phillips-head mounting screws. Insert each screw into the mounting hole in the AC bus bar. Tighten each screw to secure the AC bus bar and ring terminal to the rectifier diode.
7. Insert the screws through the (+) and (-) diode bus bars and DC bus bars. Slide the flat and spring washers over each screw. Attach and tighten the nuts.
8. Insert and tighten the six Phillips-head screws that secure the (+) and (-) diode bus bars to the rectifiers.
9. Attach the relevant mains input wire from the terminal block.

6.11.5 Mains Terminal Block - Installation

Service Tools/Test Equipment:

- Phillips #3 screwdriver

1. Align the terminal block over the mounting holes in the main housing.
2. Insert and tighten the three Phillips-head screws that secure the terminal block to the main housing;
3. Place the three AC bus bars over the terminal block and rectifier diodes. Insert and tighten the three Phillips flat-head screws that secure the AC bus bars to the terminal block.
4. For each of the three AC bus bars, assemble the flat washer, spring washer and ring terminal (black wire) onto the Phillips-head mounting screw. Insert the screws into the mounting holes in the AC bus bars. Tighten the screws to secure the AC bus bars and ring terminals to the rectifier diodes.
5. Attach the mains input wires to the terminals. Tighten the terminal nuts to 192 in-lbs.

6.11.6 DC Link Capacitors - Installation

Service Tools/Test Equipment:

- Phillips #2 screwdriver
- 1-1/8" socket and driver
- 10 mm combination wrench

1. Lower the DC link capacitors and bus bars as an assembly into position.
2. Attach the four nylon nuts that secure the capacitors to the main compressor housing. Tighten the nuts using a 1-1/8" socket.
3. Align the three snubber capacitors with the mounting holes on the Inverter. Insert and tighten the six Phillips-head screws with washers to secure the capacitors to the Inverter.
4. Insert and tighten the Phillips-head screw with washers that secures the ring terminal to the mid bus.
5. Re-connect the red and black ring terminals to the (+) and (-) DC buses, respectively, using attaching hardware. Tighten the connection using a 10 mm combination wrench.
6. Re-attach the (+) and (-) diode bus bars to the DC bus bars using attaching hardware. Tighten the connection using a 10 mm combination wrench.

6.11.7 Pressure/Temperature Sensors - Installation

Service Tools/Test Equipment:

- 15/16" deep socket and driver

1. Apply grease to the sensor o-ring.
2. Insert the sensor into the opening and engage the first few threads by hand.
3. Tighten the sensor to 10 Nm using a 15/16" socket.
4. Reconnect the sensor connector.
5. Replace compressor cover, if applicable.

6.12 Compressor Controller Cable Harness Replacement

Service Tools/Test Equipment:

- 4 mm Allen key

1. At the Backplane, disconnect the following connectors:
   - pressure/temperature sensor connectors (J17, J18, and J19)
   - IGV motor drive connector (J21)
2. Disconnect the rectifier heatsink sensor connector located under the terminal block.
3. Disconnect the suction and discharge temperature/ pressure sensor connectors; refer to Figure 6-20.
4. Remove the two screws that secure the connector clamp to the IGV housing using a 4 mm Allen key. Disconnect the IGV connector.
5. Remove the cable harness from the compressor.
6. Route the cable harness (part # 260029) through the hole in the main compressor housing at the service side. (The hole is located at the right-hand side of the compressor when viewing it from the service side.)
7. At the Backplane, attach the following connectors:
   - pressure/temperature sensor connectors (J17, J18, and J19)
   - IGV motor drive connector (J21)
8. Route the cable harness between the HV DC-DC Converter and the IGBT Inverter.
9. Feed a cable tie around the cable harnesses and the Soft Start mounting stud as shown in Figure 6-19.
10. Tighten the cable tie to pull the harnesses away from the DC-DC Converter module.
11. Bend the cable harness under the mains terminal block and route it toward the capacitor side of the compressor.

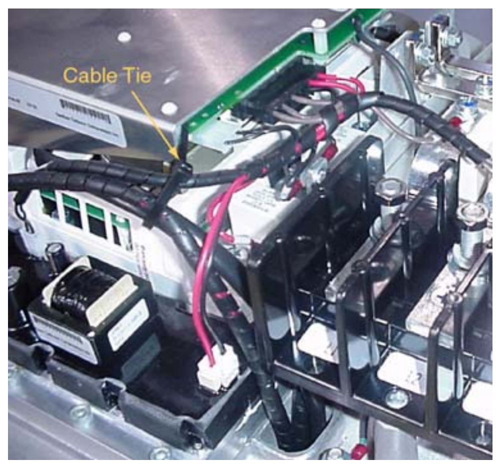


Figure 6-19 Cable Harnesses with Cable Tie

12. Attach the rectifier heatsink sensor connector located under the terminal block.
13. Attach the suction and discharge temperature/pressure sensor connectors; refer to Figure 6-20.
14. Attach the IGV connector. Replace the connector clamp and secure it with the two screws using a 4 mm Allen key.
15. Insert the molded rubber grommet in the notch in the main compressor housing.
16. Replace the service-side and top covers on the compressor.

Figure 6-20 Cable Connection at the Suction Temperature/Pressure Sensor

6.13 DC Supply Cable Harness Replacement

1. At the Backplane, disconnect the following connectors:
   - 250V input connector (J4)
   - motor temperature sensor connector (J20)
   - +24VDC connector (J24)
2. Disconnect the 250VDC and 24VDC connectors (J2 and J3 respectively) from the HV DC-DC Converter module.
3. Disconnect the two lug connectors from the two thermistor terminals next to the motor bus bars.
4. Remove the cable harness from the compressor.
5. Route the new cable harness (part # 200132) through the hole in the main housing located on the right-hand side of the compressor. (The hole is on the right-hand side when viewing the compressor from the service side.)
6. At the Backplane, attach the following connectors:
   - 250V input connector (J4)
   - motor temperature sensor connector (J20)
   - +24VDC connector (J24)
7. Attach the 250VDC and 24VDC connectors (J2 and J3 respectively) to the HV DC-DC Converter module.
8. Attach the two lug connectors to the two thermistor terminals next to the motor bus bars.

6.14 Soft Start Cable Harness (part # 720358) Replacement

1. Disconnect the DC Bus and 15 VAC connectors (J1 and J4 respectively) from the DC-DC Converter module.
2. Disconnect the ring terminals labelled L1, L2, and L3 from the AC bus bars.
3. Disconnect the two -DC ring terminals from the -DC bus bar by removing the attaching hardware. Refer to Figure 6-21.

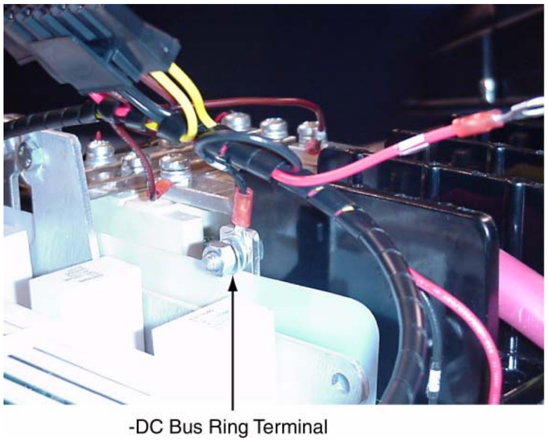


Figure 6-21 Ring Terminal at the Negative DC Bus

4. Disconnect the +DC ring terminal from the +DC bus bar by removing the attaching hardware. Refer to Figure 6-22.
5. Disconnect the two connectors (J1 and J7) from the Soft Start module.
6. Place the new wiring harness on top of the compressor.
7. Connect the DC Bus and 15 VAC connectors (J1 and J4 respectively) to the DC-DC Converter module.
8. Connect the ring terminals labelled L1, L2, and L3 to the AC bus bars. (Phase order is left to right when facing the terminal block.)

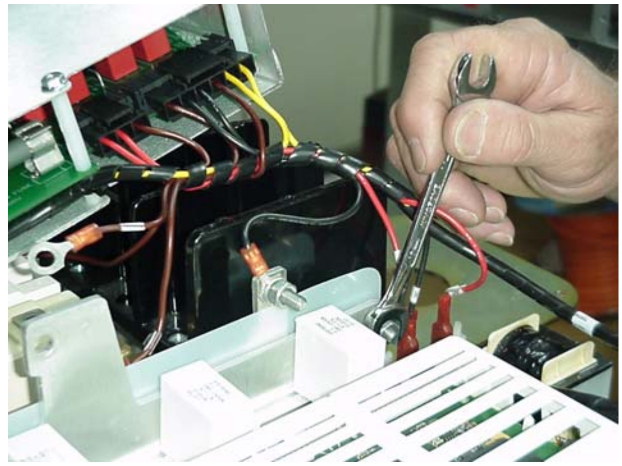


Figure 6-22 Removing the Ring Terminal from the Positive DC Bus Bar

9. Connect the two -DC ring terminals to the -DC bus bar. Secure the ring terminals with attaching hardware. Refer to Figure 6-21.
10. Connect the +DC ring terminal to the +DC bus bar. Secure the ring terminal with attaching hardware. Refer to Figure 6-22.
11. Attach the two connectors (J1 and J7) to the Soft Start module.

6.15 IGV Housing - Removal

Service Tools/Test Equipment:

- 10 mm socket and driver
- 4 mm Allen key

1. Remove the two scews that secure the cable clamp to the IGV housing using a 4 mm Allen key.
2. Disconnect the cable at the feed-thru connector on the IGV housing.
3. Disconnect the cable at the suction sensor.
4. Using a 10 mm socket, remove the twelve nuts that secure the IGV housing. Pull the IGV housing away from the compressor housing.

6.16 IGV Stepper Motor - Removal

Service Tools/Test Equipment:

- 2.5 mm, 4 mm, and 7/64" Allen keys

1. Remove the IGV housing; refer to paragraph 6.15. IGV stepper motor details are shown in Figure 6-23.
2. Using a 4 mm Allen key, remove the four screws that secure the feed-thru connector to the IGV housing. Refer to Figure 6-24.

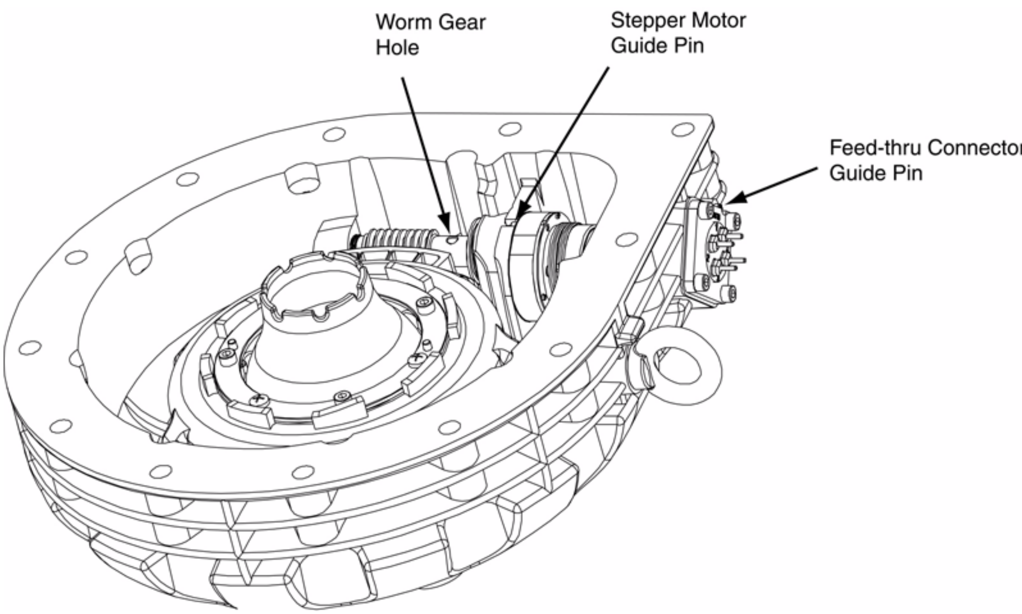


Figure 6-23 IGV Stepper Motor Details

3. Disconnect the lugs from the connector.
4. Using a 2.5 mm Allen key, loosen the setscrew that secures the stepper motor to the worm gear; refer to Figure 6-25. If necessary, rotate the worm gear (using an Allen key in the worm gear hole) to expose the setscrew.
5. Withdraw the stepper motor.
6. Using a 7/64" Allen key, remove the guide screw from the motor.
7. Withdraw the sleeve and anti-vibration pad. Save the guide screw, sleeve, and pad for installation in the new motor.

Figure 6-24 IGV Feed-thru Connector Removal

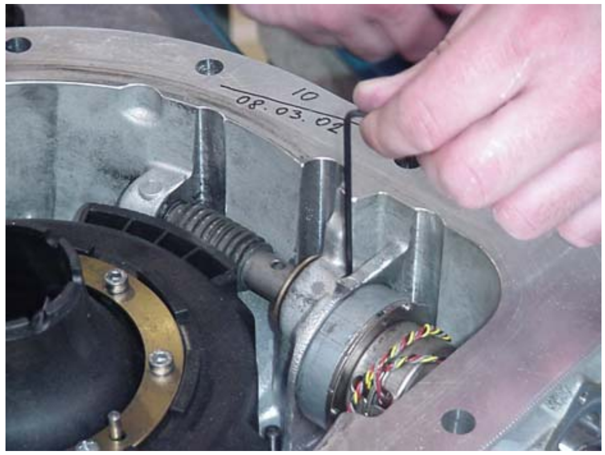


Figure 6-25 Loosening the Setscrew

6.17 IGV Stepper Motor - Installation

Service Tools/Test Equipment:

- 7/64”, 2.5 mm, and 4 mm Allen keys

1. Install the anti-vibration pad and sleeve onto the new motor. Insert the guide screw into the motor and tighten it using a 7/64" Allen key.
2. Align the motor guide screw with the notch in the IGV housing; refer to Figure 6-23. Ensure that the setscrew is in line with the flat side of the motor shaft. If not, rotate the motor shaft to the correct position.
3. Using a 2.5 mm Allen key, tighten the setscrew that secures the motor to the worm gear. (Rotate the worm gear, if necessary, to expose the setscrew.)
4. Insert a new o-ring on the feed-thru connector.
5. Connect the four lugs to the feed-thru connector according to the colour coding in Table 6-3.

Table 6-3 Colour Code for IGV Feed-thru Wiring

Pin No.	Wire Colour
1	Grey
2	Red
3	Yellow
4	Black

6. Install the feed-thru connector ensuring that the notch in the connector aligns with the guide pin on the IGV housing; refer to Figure 6-23.
7. Insert the four connector mounting screws. Using a 4 mm Allen key, tighten the screws to 4.75 Nm.
8. Install the IGV housing; refer to paragraph 6.18.

6.18 IGV Housing - Installation

Service Tools/Test Equipment:

- 10 mm socket and driver
- 4 mm Allen key

1. Fit a new o-ring into the groove of the main compressor housing.
2. Position the IGV housing over the compressor studs. Install the washers and nuts onto the twelve studs. Using a 10 mm socket, tighten the nuts, in a diagonal pattern, to 25 Nm.
3. Reconnect the cable at the feed-thru connector on the IGV housing. Secure the connector clamp with two screws using a 4 mm Allen key.
4. Reconnect the suction sensor connector.

6.19 Compressor Interface Module Replacement

1. Disconnect the terminal blocks from the Compressor Interface module.
2. Using a screwdriver, apply leverage towards the left (see Figure 6-26) while lifting the right side of the module. Repeat the procedure for the other mounting foot to disengage the module from the DIN rail.
3. Install the left foot of the replacement module into the rail and press the right side of the module down until it engages the rail.
4. Reconnect the terminal blocks on the module and make control wiring changes, if necessary.

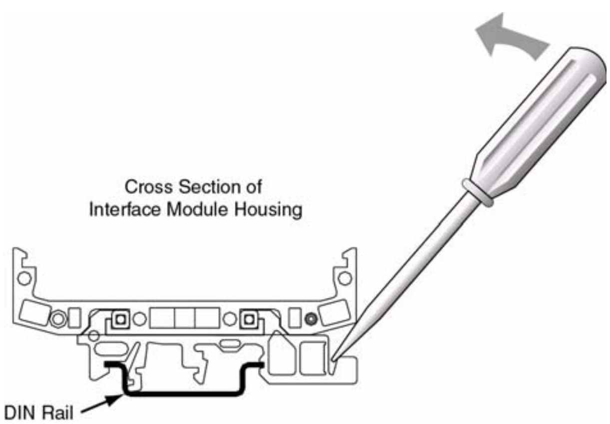


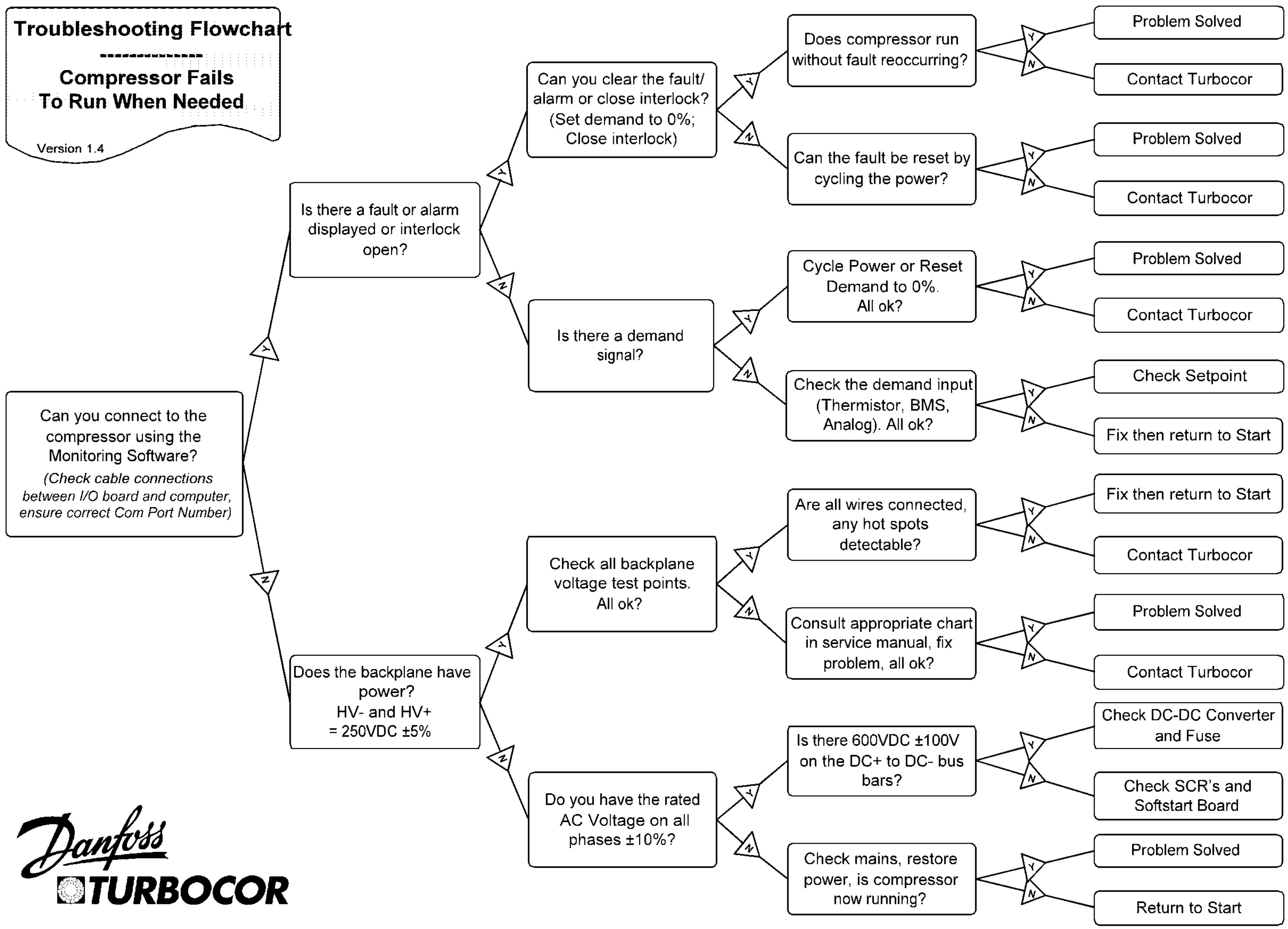
Figure 6-26 Removing the Interface Module from the Rail

Appendix A: General Troubleshooting Flowchart

The following flowchart can be utilized in combination with the other troubleshooting flowcharts in this manual to provide assistance in locating the problem within a compressor. It is intended to be used simply as a guide to applying logical steps in the troubleshooting of the compressor. Any procedure detailed in this chart should then be continued in its full form within the Service manual along with all the necessary safety precautions. The purpose of the flowchart is to enable one, by following the logical steps and the correct procedure section, to more quickly identify why the compressor is not running, and as such be able to rectify that problem.

⚠ WARNING

For any of the procedures found within this chart, please follow the correct procedure as specified in the manual. Any procedures involving verifying either DC or AC power can be hazardous, and as such, proper precautions need to be taken.



Troubleshooting Flowchart
Compressor Fails To Run When Needed
Version 1.4
Can you connect to the compressor using the Monitoring Software?
(Check cable connections between I/O board and computer, ensure correct Com Port Number)
Y
N
Is there a fault or alarm displayed or interlock open?
Does the backplane have power? HV- and HV+ = 250VDC ±5%
Can you clear the fault/ alarm or close interlock? (Set demand to 0%; Close interlock)
Is there a demand signal?
Check all backplane voltage test points. All ok?
Do you have the rated AC Voltage on all phases ±10%?
Does compressor run without fault reoccurring?
Can the fault be reset by cycling the power?
Cycle Power or Reset Demand to 0%. All ok?
Check the demand input (Thermistor, BMS, Analog). All ok?
Are all wires connected, any hot spots detectable?
Consult appropriate chart in service manual, fix problem, all ok?
Is there 600VDC ±100V on the DC+ to DC- bus bars?
Check mains, restore power, is compressor now running?
Problem Solved
Contact Turbocor
Problem Solved
Contact Turbocor
Problem Solved
Contact Turbocor
Check Setpoint
Fix then return to Start
Fix then return to Start
Contact Turbocor
Problem Solved
Contact Turbocor
Check DC-DC Converter and Fuse
Check SCR's and Softstart Board
Problem Solved
Return to Start

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