Diagnostic Manual

Packaged Rooftop Air Conditioners
Variable Speed Voyager™ and Precedent™
3 to 5 Tons and 12.5 to 17.5 Tons, 60 Hz

Models Numbers:

T/YZC036E3/4
T/YZC048F3/4
T/YZC060E4
T/YZ*150F3/4
T/YZ*180F3/4
T/YZ*210F3/4

⚠ SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, observe all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

February 2018

RT-SVD05C-EN

Ingersoll Rand

Introduction

Read this manual thoroughly before operating or servicing this unit.

Warnings, Cautions, and Notices

Safety advisories appear throughout this manual as required. Your personal safety and the proper operation of this machine depend upon the strict observance of these precautions.

The three types of advisories are defined as follows:

⚠WARNING Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It could also be used to alert against unsafe practices.

NOTICE Indicates a situation that could result in equipment or property-damage only accidents.

Important Environmental Concerns

Scientific research has shown that certain man-made chemicals can affect the earth's naturally occurring stratospheric ozone layer when released to the atmosphere. In particular, several of the identified chemicals that may affect the ozone layer are refrigerants that contain Chlorine, Fluorine and Carbon (CFCs) and those containing Hydrogen, Chlorine, Fluorine and Carbon (HCFCs). Not all refrigerants containing these compounds have the same potential impact to the environment. Trane advocates the responsible handling of all refrigerants-including industry replacements for CFCs such as HCFCs and HFCs.

Important Responsible Refrigerant Practices

Trane believes that responsible refrigerant practices are important to the environment, our customers, and the air conditioning industry. All technicians who handle refrigerants must be certified. The Federal Clean Air Act (Section 608) sets forth the requirements for handling, reclaiming, recovering and recycling of certain refrigerants and the equipment that is used in these service procedures. In addition, some states or municipalities may have additional requirements that must also be adhered to for responsible management of refrigerants. Know the applicable laws and follow them.

⚠WARNING

Proper Field Wiring and Grounding Required!

Failure to follow code could result in death or serious injury. All field wiring MUST be performed by qualified personnel. Improperly installed and grounded field wiring poses FIRE and ELECTROCUTION hazards. To avoid these hazards, you MUST follow requirements for field wiring installation and grounding as described in NEC and your local/state electrical codes.

⚠WARNING

Personal Protective Equipment (PPE) Required!

Installing/servicing this unit could result in exposure to electrical, mechanical and chemical hazards.

- **Before installing/servicing this unit, technicians MUST put on all PPE required for the work being undertaken (Examples; cut resistant gloves/sleeves, butyl gloves, safety glasses, hard hat/bump cap, fall protection, electrical PPE and arc flash clothing). ALWAYS refer to appropriate Material Safety Data Sheets (MSDS)/Safety Data Sheets (SDS) and OSHA guidelines for proper PPE.**
- **When working with or around hazardous chemicals, ALWAYS refer to the appropriate MSDS/SDS and OSHA/GHS (Global Harmonized System of Classification and Labelling of Chemicals) guidelines for information on allowable personal exposure levels, proper respiratory protection and handling instructions.**
- **If there is a risk of energized electrical contact, arc, or flash, technicians MUST put on all PPE in accordance with OSHA, NFPA 70E, or other country-specific requirements for arc flash protection, PRIOR to servicing the unit. NEVER PERFORM ANY SWITCHING, DISCONNECTING, OR VOLTAGE TESTING WITHOUT PROPER ELECTRICAL PPE AND ARC FLASH CLOTHING. ENSURE ELECTRICAL METERS AND EQUIPMENT ARE PROPERLY RATED FOR INTENDED VOLTAGE.**

Failure to follow instructions could result in death or serious injury.

⚠ WARNING

Follow EHS Policies!

Failure to follow instructions below could result in death or serious injury.

- **All Ingersoll Rand personnel must follow Ingersoll Rand Environmental, Health and Safety (EHS) policies when performing work such as hot work, electrical, fall protection, lockout/tagout, refrigerant handling, etc. All policies can be found on the BOS site. Where local regulations are more stringent than these policies, those regulations supersede these policies.**
- **Non-Ingersoll Rand personnel should always follow local regulations.**

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Revision History

- Updated electrical block diagram for control & power circuitry of 230VAC 3-phase drive.

Table of Contents

General Information

Variable speed compressor drive

Each variable speed system is equipped with an electric drive primarily focused at controlling variable speed compressors. The inverter modules in these electric drives are cooled using refrigerant cooled heat sinks. The electric drive platform can be divided into two separate functional areas: control circuitry and electric power circuitry. The control circuitry consists of a printed circuit board referred to as "interface module" and it's utilized with both 230VAC 3-phase and 460VAC 3-phase voltage drives. The electric power circuitry is different for 230VAC and 460VAC 3-phase drives and it consists of the Power Factor Correction "PFC" box and main drive box.

Control circuitry

The core control circuitry is the same for both 230VAC & 460VAC 3-phase voltage drives. This core consists of a PCB module referred to as the interface module and it is located in the main control box of the unit. Control circuitry for the electric drive consist of 24VAC "Compressor Command Signal", 0-10VDC "Compressor Speed Signal" and "5VDC" alarm signals. These signals are applied to/received directly from the interface module of the electric drive.

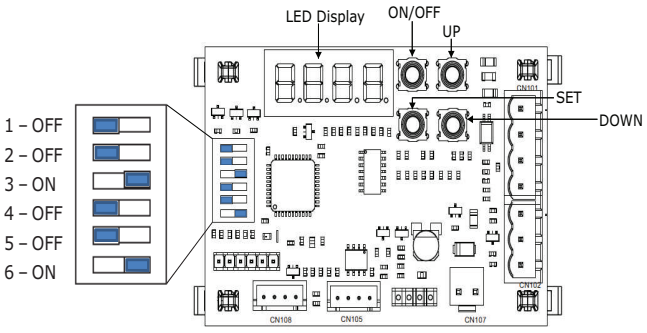
Interface module

Interface module PCB board is used to receive and transmit commands from the Trane® unit controller to the electric drive inverter module. It serves as the main connection hub for nearly all of the control circuitry wiring for the variable speed compressor drive. It includes an LED display that shows the drive status both during standby and operation mode. The dip switch settings on the interface module are unique to each compressor model and should be already preset from the factory. Please refer to the table below for dip switch settings per each compressor model:

SW1	SW2	SW3	SW4	SW5	SW6	Compressor model	LED display at power up
OFF	OFF	ON	OFF	OFF	OFF	VRJ028	J028
OFF	OFF	ON	OFF	OFF	ON	VRJ035/044	J035
OFF	OFF	ON	OFF	ON	OFF	VRJ035/044	J044

Please refer to the following graphic for location of LED display & dip switch settings on the interface module:

Figure 1. Dip switch settings for VRJ035 compressor model



The interface module also features a query mode display which allows the end user to look at key information about electric drive status. Query mode can be accessed anytime power is applied to the electric drive. In order to enter query mode display, press SET button and press UP or DOWN buttons to scroll through the IDs shown per table below. Press SET button again to enter normal status mode which displays the requested compressor frequency command. If UP/DOWN buttons are not pressed for 30 seconds, it will also return to the normal status.

During query mode, the LED screen will display active feedback from the drive board.

LED Display	Description
1.***	Compressor running mechanical frequency (value: 15-100 means 15-100 Hz). For example: 1.080 means the compressor is running at 80 Hz speed.
2.***	N/A
3.***	N/A
4.***	Drive output current Arms (value: 0-500 means 0-50 Arms
5.***	DC bus voltage (value: 0-800 means 0-800 VDC)
6.***	Heat sink temp (value: 0-200 means 0 to 200°C)

Note: * can be any value from 0 to 9

Power circuitry

The power circuitry is the high voltage portion of the electric drive that controls the current and voltage output to the compressor motor. It is controlled via the connections to the interface module in the control circuitry. The power circuitry consists of a Power Factor Correction (PFC) solution, EMI filter, DC bus board, and the inverter module. The rectifier section is designed into the Inverter Module PCB board. The power circuitry designs are different between 3-phase 230VAC & 460VAC drives.

PFC solution

Power Factor Correction (PFC) solution mainly consists of an AC line inductor and in the case of 230VAC drives, it also includes 3 capacitors. Purpose of the AC line inductors is to improve input power factor and reduce line harmonic emissions.These solutions are packaged separately inside a sheet metal box and are mounted in the indoor section of the unit. Specific location of these solutions could vary depending on the unit model type. Please refer to "Drive mounting locations in applications," p. 9, for more details on the location of these boxes inside the units. Phase power is applied directly to the PFC box which is connected in series to the main drive box.

EMI filter

Each voltage drive comes with a unique EMI filter specifically designed to provide AC line filtering to the inverter module as well as reduce conducted and radiated emissions from the electric drive. These components are located inside the main drive box.

Rectifier section

The rectifier section converts the incoming AC power from the utility to DC power. The rectifier is a three-phase rectifier, typical of most power systems. The rectifier section is located on the inverter module and is connected to the line filter module.

DC bus board

The DC bus is the intermediary power stage of the electric drive. The film capacitors on the DC bus PCB board form a DC power portion of the electric drive. The DC bus board is also located inside the main drive box.

Inverter section

The inverter section takes the DC power from the DC bus and creates the AC output which drives the compressor motor. It consists of an Integrated Power Module (IPM) which contains the insolated gate bipolar transistors (IGBTs), the gate drive modules, and current sensing circuit. The IGBTs are semiconductor devices which pulse at the switching frequency to synthesize a voltage waveform. Current sensing circuit provides feedback to the drive of the motor current. This is used both for control and protection of the drive.

Electrical block diagrams

Figure 2. Electrical block diagram - 230VAC 3-phase drive

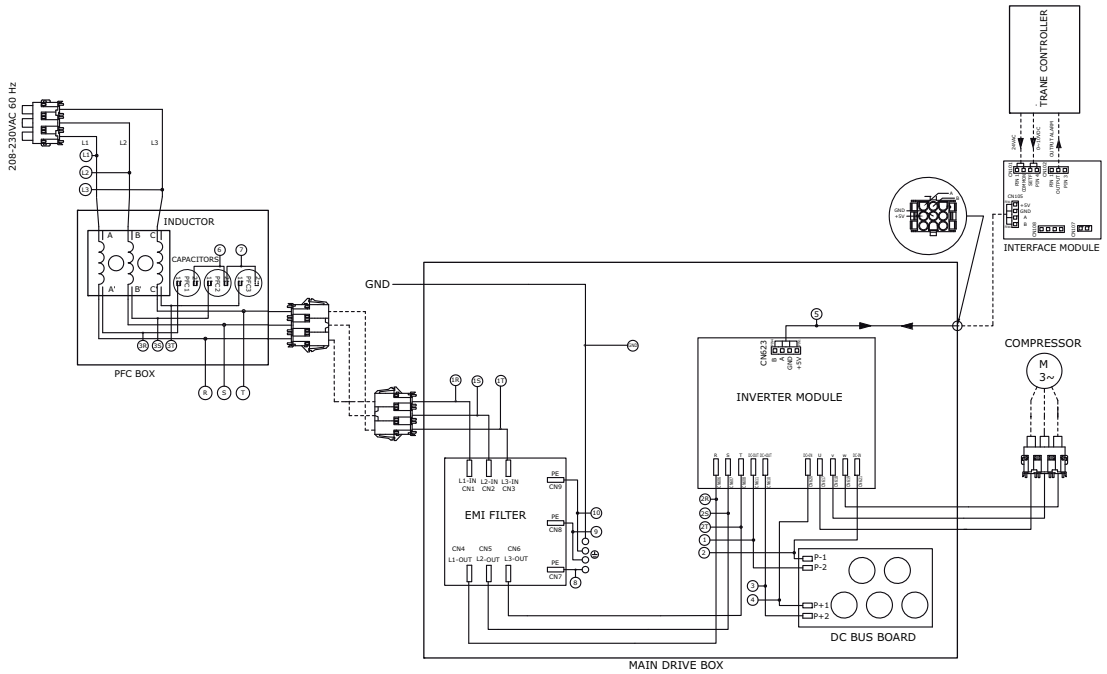
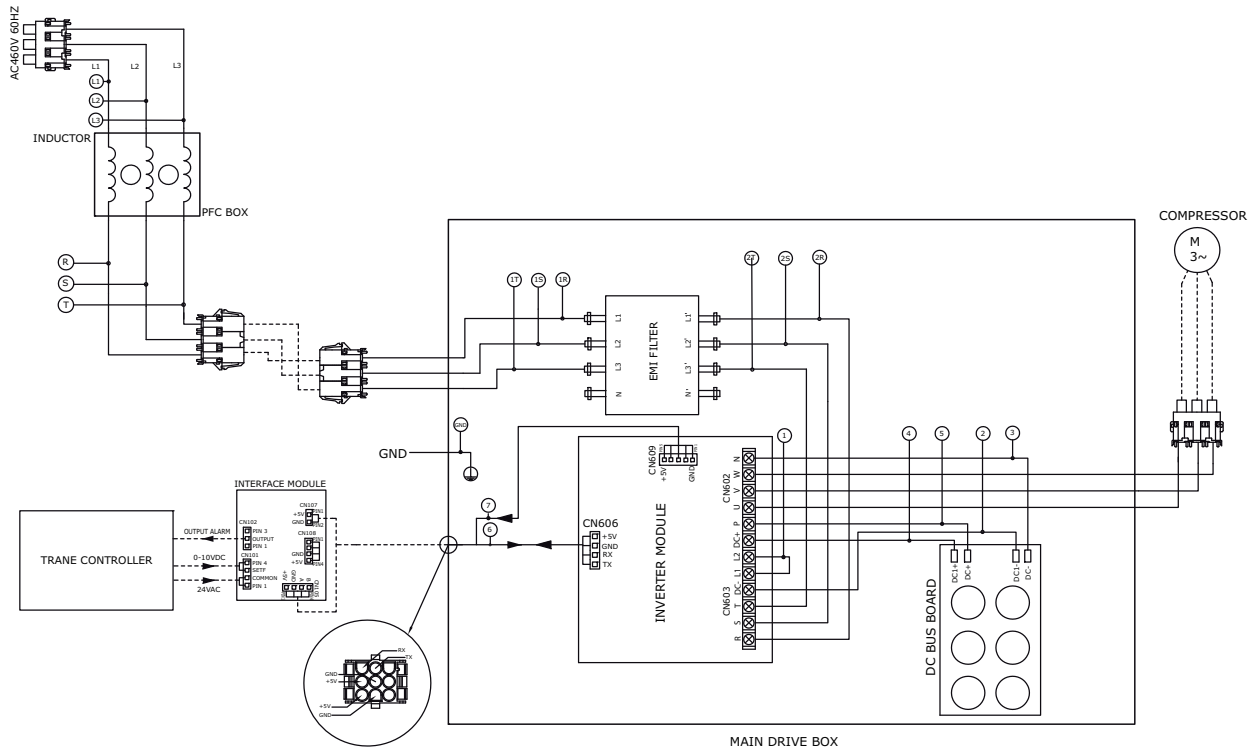


Figure 3. Electrical block diagram - 230VAC 3-phase drive



Drive pictures

Figure 4. Interface module

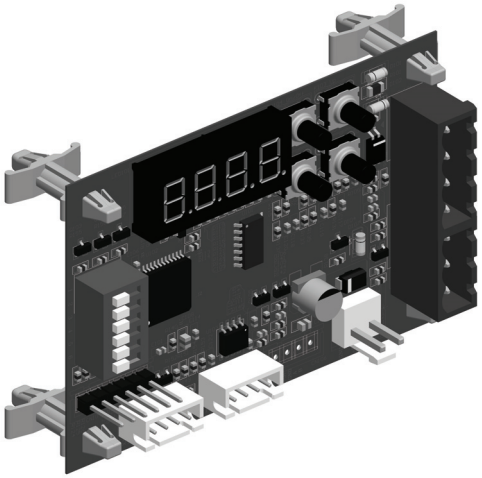


Figure 5. PFC box

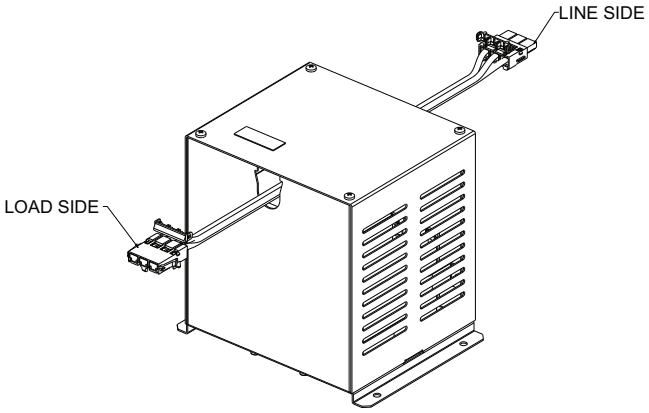


Figure 6. 230VAC 3-phase main drive box with front cover removed

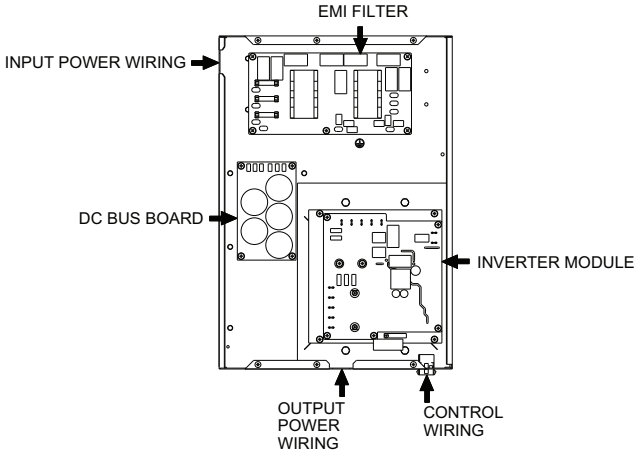
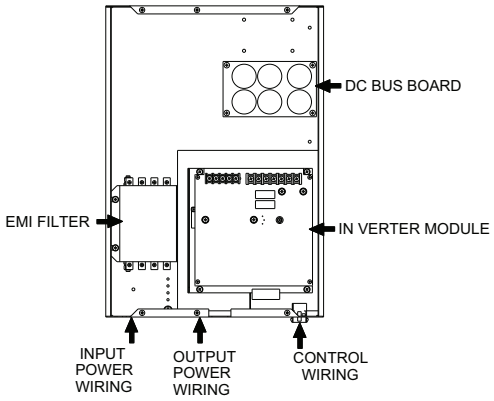


Figure 7. 460VAC 3-phase main drive box with front cover removed



Main drive box

Drive mounting locations in applications

Figure 8. Voyager™, 12.5 to 17.5 tons, 60 Hz, horizontal flow

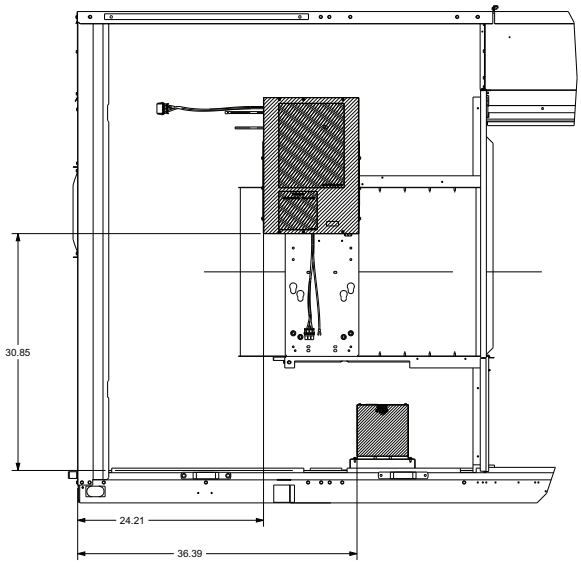


Figure 9. Voyager™, 12.5 to 17.5 tons, 60 Hz, downflow

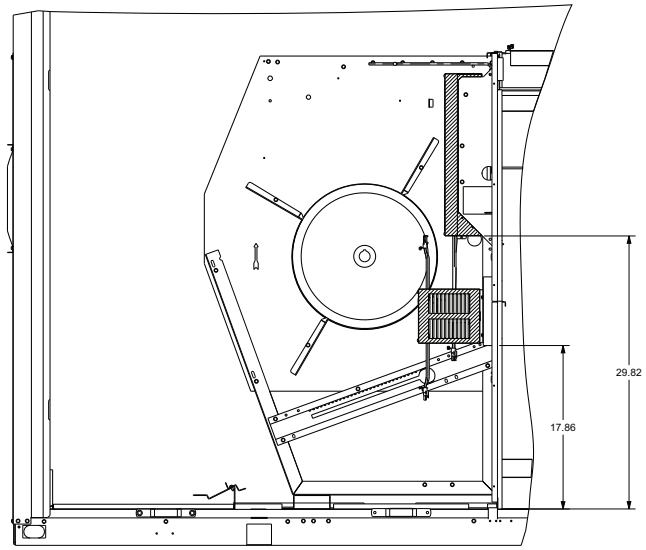


Figure 10. Precedent™ 3 tons, 60 Hz

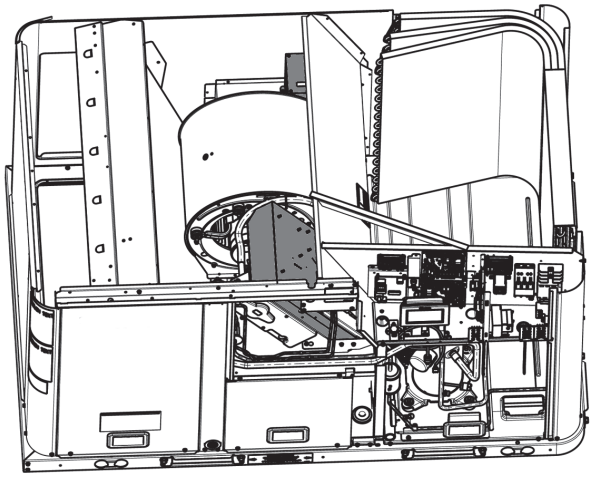
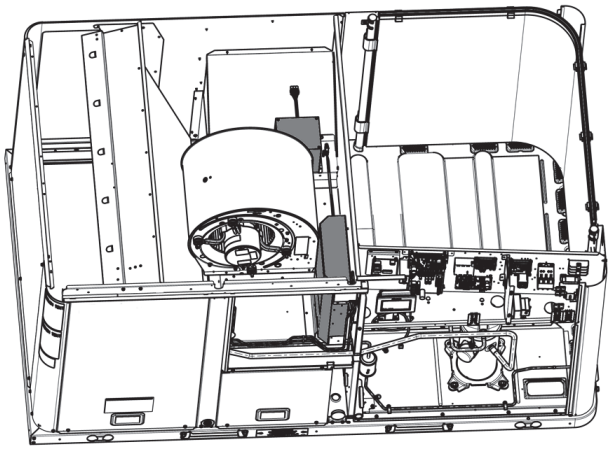


Figure 11. Precedent™ 4 & 5 tons, 60 Hz



Key drive components

Table 1. 230VAC 3-phase drive

Description	Part Number
Interface Module	X13651608010
Main Drive Box	X13610006020
PFC Box	X13610007020

Table 2. 460VAC 3-phase drive

Description	Part Number
Interface Module	X13651608010
Main Drive Box	X13610009020
PFC Box	X13610007030

Sequence of operation

In case of a cooling demand and presence of no alarm signal, 24VAC compressor command signal is sent to the interface module. A speed signal of 0-10VDC is also applied to the interface module. This would enable the electric drive to run the compressor at requested speed. In case of a fault or an error, an error code is displayed on the interface module LED display and a 5VDC alarm signal should be present on the interface module.

Normal operation

During normal operation mode, the interface module LED will display the requested frequency command at all times. For example; if the LED displays “F060” then it means that the requested compressor speed is 60Hz. In the absence of compressor speed request, the LED display should display “F000” which indicates that the compressor should be at “0” Hz speed or Off.

Abnormal operation

During abnormal operation mode, the interface module LED could be either off or display an error or protection code. Error codes are identified with letter “E” followed by a dash and two digits whereas protection codes are identified with letter “P” followed by a dash and two digits. For examples; E-04 or P-01. For complete list of Error and protection modes, please refer to “Variable speed compressor drive troubleshooting,” p. 12. When there are more than one error or protection modes active, the LED will display both error or protection codes with a delay of 0.5 seconds in between.

Variable speed compressor drive troubleshooting

This section details the error and protection codes as shown through the LED display of the interface module. It includes detailed descriptions and troubleshooting methods for each error or protection code. During all error "E" codes, the compressor is shut down by the drive and 5Vdc alarm output is present on the interface module.

Error & protection codes list

Incorrect dip switch settings—Error code: E-01

Criteria. Dip switches on the interface module are not set according to the table on p. 5 for appropriate compressor model.

Troubleshooting. Verify the compressor model from compressor nameplate and check if the dip switches are set correctly on the interface module for that compressor model.

Reset Criteria. Set the dip switches on the interface module to correct settings and re-apply power to the drive.

Communication Failure—Error code: E-02

Criteria. Loss of communication between interface module and the inverter module

Troubleshooting. Verify the wiring connections between the interface module and the inverter module.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated when communication is re-established between interface board and the inverter module.

Hardware Over-current limit—Error code: E-03

Criteria. Output current of the drive is higher than the specified limit for hardware over-current protection. During normal operation mode, the drive output current should not reach this value.

Troubleshooting. Verify there are no loose connections in input power wiring to the drive and output wiring from the electric drive to the compressor. Check compressor windings for any ground faults.

Check for abnormal conditions such as airflow blockage, improper condenser fan operation, compressor locked rotor situation, system charge or other conditions that could cause the system to be overloaded.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated and drive will operate normally as long as the overload condition is no longer present.

Drive Operation Failure —Error code: E-04

Criteria. Compressor doesn't start properly after five tries with 15 second intervals between each try.This could be caused by either loss of phase in drive output current to the compressor, compressor motor locked rotor situation, or damaged drive hardware.

Troubleshooting. Verify there are no loose connections in input power wiring to the drive and output wiring from the electric drive to the compressor. Check compressor windings for any ground faults.

Check if LED 602 is flashing On or completely Off. If Off, then inverter module is defective and needs to be replaced.

Cut off power to the drive and disconnect the output power (U, V, W) from the inverter module. By using the Diode settings on the multimeter, check the following 6 pairs of diodes: (DC+,U), (DC+,V), (DC+, W), (U,DC-), (V,DC-), (W,DC-). Perform a continuity check between the following pairs of terminals: (U, V), (V, W), (U, W). If any of the above pairs are shorted, then Integrated Power Module "IPM" is defective, and inverter module needs to be replaced.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated and drive will operate normally as long as the overload condition is no longer present.

Software over-current limits —Protection code: P-01 & Error code: E-05

Criteria. Output current of the drive is higher than the specified limit for software over-current protection.

Over-current limits associated with P-01 code are lower than the limits associated with E-05. During P-01, the compressor speed is either reduced or held constant whereas during E-05, the compressor is requested to shut down to protect the drive.

During normal operation mode, the drive output current should not reach the limits associated with E-05.

Troubleshooting. Verify there are no loose connections in input power wiring to the drive and output wiring from the electric drive to the compressor. Check compressor windings for any ground faults.

Check for abnormal conditions such as airflow blockage, improper condenser fan operation, compressor locked rotor situation, system charge or other conditions that could cause the system to be overloaded.

Reset Criteria. The protection or error code will remain active for at least 2 minutes. After 2 minutes, protection or error mode will be deactivated and drive will operate normally as long as the overload conditions are no longer present.

Output Current Sampling error —Error code: E-06

Criteria. At power up when the compressor is in Off state, if the inverter module doesn't properly detect the output current then the compressor would not be allowed to start.

Troubleshooting. Verify input power wiring to the drive and output power wiring from the drive to the compressor.

Reset Criteria. Error code can be de-activated by removing power to the drive and re-applying power.

Heat sink over heat —Protection code P-02 & Error code: E-07

Criteria. Temp sensor on the inverter module detects the temperature to be exceeding the limits defined in the inverter module software. Temp limits associated with P-02 are lower than the temp limits for E-07. During P-02, the compressor speed is either reduced or held constant whereas during E-07, the compressor is requested to shut down to protect the drive.

Troubleshooting. Verify refrigerant is flowing through the copper tubes used to cool the heat sink. Check for abnormal conditions such as airflow blockage, improper condenser fan operation, system over or under charge or other conditions that could result in higher Amp draw on the drive and cause overheating.

Reset Criteria. The protection or error code will remain active for at least 2 minutes regardless of changes in temperature. After 2 minutes, if the temp is below the specified limits in the drive software, the protection or error mode will be deactivated.

DC bus over voltage & under voltage—Error code: E-08

Criteria. DC bus voltage of the drive is above or below the specified limits for the drive.

230VAC Drive limits: Above 370Vdc or below 170Vdc.

460VAC Drive limits: Above 800Vdc or below 300Vdc

Troubleshooting. Verify input voltage to the R, S, T terminals on the inverter module is within +/-10% of the rated unit voltage. Inspect DC bus board for any damaged capacitors.

Reset Criteria. The protection will remain active for at least 2 minutes regardless of DC bus voltage. After 2 minutes, Protection mode will be deactivated when DC bus voltage is below or above the specified limits for the drive.

Incorrect Compressor Code—Error code: E-09

Criteria. Interface module sends the compressor code that is not supported by the inverter module.

Troubleshooting. Verify dip switch settings on the interface module are set correctly for appropriate compressor model and re-apply power to the drive.

Reset Criteria. Error mode can be de-activated by removing power to the drive board and re-applying power.

Heat sink temperature sensor error—Error code: E-12

Criteria. Heat sink temp sensor on the inverter module is reporting temperature readings outside the spec limit.

Troubleshooting. Verify heat sink temp sensor connector is plugged into the drive board and the sensor itself is not shorted/open.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated when sensor reading is within the allowed spec.

Drive board internal communication error—Error code: E-13

Criteria. Internal communication loss between the inverter module chips for at least 15 sec.

Troubleshooting. Verify connections between the interface module and the inverter module.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated when communication is re-established between the inverter chips.

3-phase AC input power phase-loss —Error code: E-15

Criteria. Loss of any of three phases of AC input power for longer than 30 msec when the drive has been powered for at least 8 sec.

Troubleshooting. Verify all three phases of AC input power to the R, S, T terminals on the inverter module.

Reset Criteria. The protection will remain active for at least 2 minutes. After 2 minutes, protection mode will be deactivated and drive will operate normally.

Magnetic Field Weakening Control—Protection code: P-05

Criteria. When the magnetic field angle between the compressor rotor and stator is below the specified value in the software, protection mode will be activated and compressor speed will be reduced gradually.

Troubleshooting. Check for abnormal conditions such as airflow blockage, improper condenser fan operation, system over or under charge or other conditions that could result in overload conditions on the compressor and cause this situation.

Reset Criteria. The protection mode will remain active until the angle value is smaller than specified value in the software.

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