

CORESENSE™ DIAGNOSTICS FOR STREAM REFRIGERATION COMPRESSORS

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1 Introduction

CoreSense™ is an ingredient brand name for compressor electronics associated with Emerson's Copeland® brand products. CoreSense™ technology uses compressor as a sensor to unlock information from within the compressor providing value added features such as advanced motor protection, diagnostics, communication.

With active protection, advanced algorithms, and features like fault history and LED indicators, CoreSense™ Diagnostics for Copeland compressors enable technicians to diagnose the past and recent state of the system, allowing for quicker, more accurate diagnostics and less down time. The CoreSense™ Diagnostics is initially available as standard with the 4- and 6-cylinder Stream compressors.



Figure 1: Stream compressor with CoreSense™ Diagnostic

2 Specifications

Power supply for control module (in front of the compressor) is 120VAC or 240VAC.

Operating temperature	-32°C to 66°C	Steady load current for relay	3A
Voltage requirements	120 VAC or 240 VAC	Power rating for the module	3VA
Inrush current for relay	19A	Storage temperature	-40°C to 85°C
Voltage sensor module	24 VAC	Protection class	IP54

Table 1

3 Emerson CoreSense™ Diagnostics – Features

Nr	Feature	Nr	Feature
1	Motor Overheat Protection	8	Alarm History and Compressor Operating Conditions
2	Oil Pressure Protection	9	Crankcase Heater Control
3	Discharge Temperature Protection	10	Local and Remote Reset Capability
4	Locked Rotor Protection	11	Modbus® Communication
5	Single Phase/Missing Phase Protection	12	Power Consumption Monitoring (Voltage, Current, Power Factor)
6	Voltage Imbalance Protection	13	Crankcase Heater Control
7	Low Voltage Protection	14	Compressor Run Status (Proofing)

Table 2

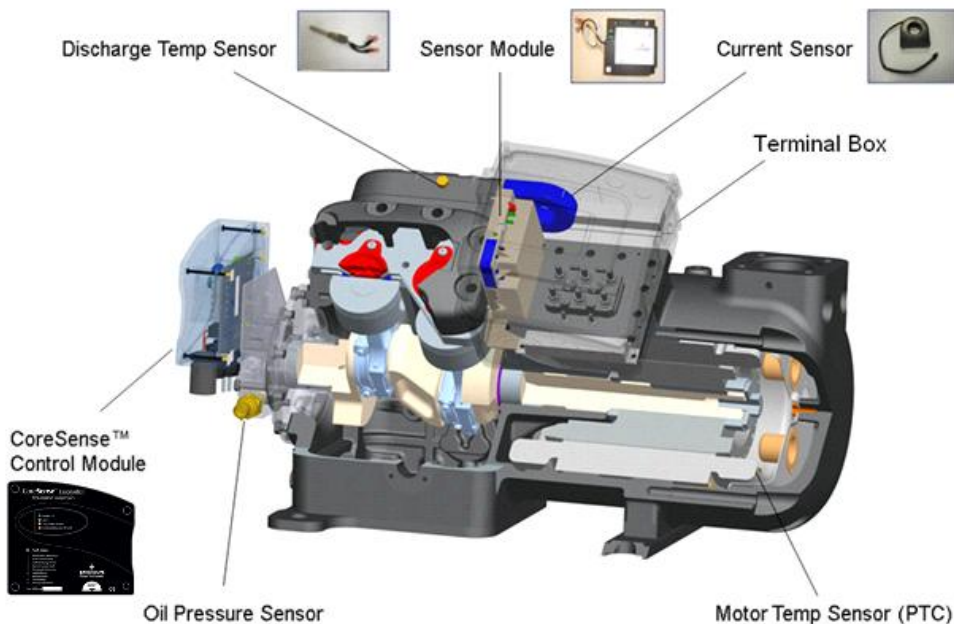
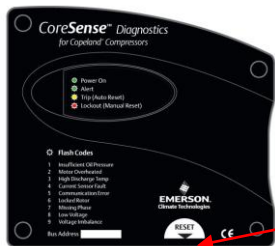


Figure 2

3.1 “Jog” feature



The reset button below the control module may be used as an emergency shutdown, such as for clearing liquid during a start-up. After the module re-boots (approximately 3 seconds) the compressor will run again. The reset button may be pushed as necessary to stop the compressor.

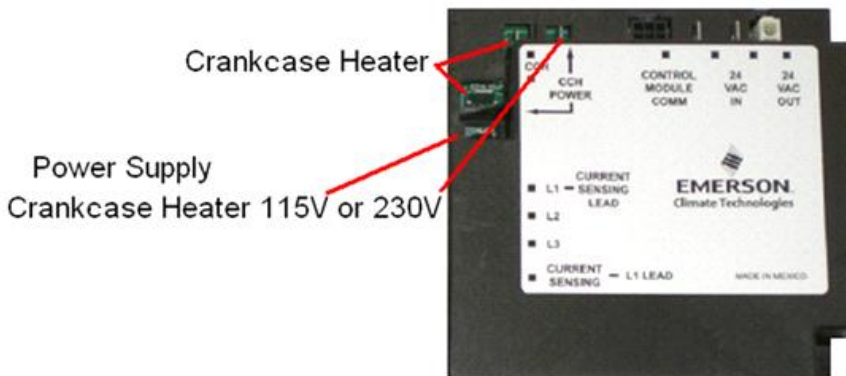
Reset button

Figure 3

3.2 Crankcase heater (CCH) control

The sensor module contains an on-board CCH control relay. An auxiliary contactor is no longer required to turn the heater on when the compressor turns off.

The appropriate voltage supply to the CCH power input terminals (115V/230V) is required.



3.3 Insufficient oil pressure protection

The CoreSense™ Diagnostics module replaces the mechanical oil pressure switch. Furthermore, it provides the added value of communication for insufficient oil pressure warning and lockouts via LED flash codes and/or a supervisory pack controller. Total insufficient oil pressure time for the compressor is stored and accumulated in the module memory.

CoreSense™ Diagnostics will issue a warning when oil pressure differential falls below 0.48-0.62 bar for 4 seconds.

Once the oil pressure differential falls below 0.48-0.62 bar for 2 minutes (120 sec), the module will shut the compressor off and a “low oil pressure lockout” will be reported. Before using the reset button, troubleshooting needs to be done to understand the failure. The compressor will switch back on once the reset has been activated either manually or remotely through the communication network, or when power has been cycled to the CoreSense™ module. This feature is not applicable to Copeland compressor models 4MTL (Stream CO2 compressors) as these have no positive oil pump fitted and are “splash” lubricated.

3.4 Motor overheat protection

Using Positive Temperature Coefficient (PTC) sensors on 4M* and 6M* Stream compressor models, the CoreSense™ Diagnostics module provides motor overheating protection. The CoreSense™ Diagnostic module replaces the Kriwan module INT69TM.

Alarm condition:

- Trip condition: PTC Resistance > 4.5 kΩ;
- Reset condition: PTC Resistance < 2.5 kΩ; 5 min time delay.

3.5 High discharge temperature protection

Discharge temperature protection is provided using a NTC sensor in the compressor cylinder head. The sensor is pre-installed at the factory and connected to the module. CoreSense™ will protect the compressor from high discharge temperature conditions. If the temperature sensor detects a discharge temperature higher than 154°C, the CoreSense™ will shut off the compressor until the temperature cools down to an acceptable level (about 130°C).

Either trip or lockout alarm can be selected by user. Default is trip alarm.

- Trip/lockout value $\geq 154^{\circ}\text{C}$ for 2 sec.
- Trip alarm: Automatic reset after 2 minutes; discharge temp < 130°C.
- Lockout alarm: Manual reset is necessary.

3.6 Locked rotor protection

Appears when the rotor is mechanically seized. Locked rotor current is expected to decrease within 4 seconds after the motor comes up to speed.

3.7 Missing phase protection

If any one of the 3 power phases is missing immediately after the compressor contactor is energized, a single-phasing condition exists.

The maximum response time shall be 1.2 seconds from the time of contactor energization.

Alarm condition: If any phase voltage < 84% of max of 3 input voltages for a period of 1 second.

- Trip time: 5 minutes with automatic reset.
- Lockout condition: Appears after the 10 consecutive trip alarms. Manual reset (using reset button below the module or using remote reset by pack controller).

In the case of a part winding motor this feature is detectable for primary winding only. Missing phase, voltage imbalance and low voltage are not detectable for the secondary winding. A missing phase can be detected during start-up, but not while the motor is running.

3.8 Low voltage protection

Appears when there is a low supply voltage.

Alarm condition: Motor compressor voltage < low voltage setting at compressor running state. The default low voltage setting is 75% of the nominal line voltage stored in the module for 2 sec.

- Trip Time: 5 minutes.

The module determines the operating frequency of the compressor. The compressor low voltage setting shall be lowered by the same percentage as the operating frequency if less than the nominal frequency. For example if a 60 Hz nominal frequency compressor is running at 57 Hz (5% less), then the low voltage setting shall be reduced by 5%.

3.9 Voltage imbalance protection

The purpose of this protection feature is to protect the compressor against a voltage imbalance condition that leads to motor overheating.

A configurable setting (default = 5%) for voltage imbalance is used to determine the operating limit of the compressor.

Alarm condition:

- Trip: When the voltage imbalance > 5% (configurable).
- Reset: Automatic reset after 5 min; voltage imbalance < 5%.

3.10 Flash memory information

Emerson Climate Technologies can provide a software to access EEPROM information.

3.10.1 The following asset information will be saved in the flash memory (EEPROM);

- Compressor model number
- Compressor serial number
- Compressor model number modified
- Compressor serial number modified
- Sensor module firmware revision

3.10.2 Compressor running status information will be saved in the flash memory (EEPROM):

- Number of compressor running hours
- Number of compressor starts
- Number of resets and type of reset
- Accumulated runtime without good oil pressure
- Number of relay cycles

3.10.3 Compressor Operating Parameters

- Current
- Voltage
- Power factor
- Power consumption
- Discharge temperature values

3.11 Modbus[®] communication

CoreSense™ Diagnostics has communication capability via a Modbus[®] network connection. With communication enabled, CoreSense™ warnings, trips and lockouts can be displayed and recorded in a pack controller such as the iPro Rack Controller from Dixell.

The CoreSense™ Diagnostics module is compatible with any other pack controller that has Modbus[®] protocol.

3.12 Local and remote reset

The CoreSense™ Diagnostics module is equipped with a reset button placed below the control module. The reset button may be pushed as necessary to stop the compressor.

The CoreSense™ Diagnostics module is equipped with a remote reset capability, such that if a compressor is off in a lockout condition, the user can remotely restart the compressor through their rack controller or compatible remote access software.

NOTE: Service contractor and end user policies need to be considered when deciding whether or not to use the remote reset feature in the pack controller.

3.13 Alarm history and running conditions

Operating information	Alarm history
Number of compressor running hours -	8 days alarm history
Accumulated running time without good oil pressure	Most recent 10 alarms
Number of switching cycles	Total number of alarms since the compressor first operation
Compressor power consumption*	
Current, voltage, power factor*	

*This data is not stored in CoreSense™ EEPROM memory. These values can be stored in a laptop using CoreSense™ PC Interface Software or Modbus® communication.

Table 3

3.14 Compressor status codes

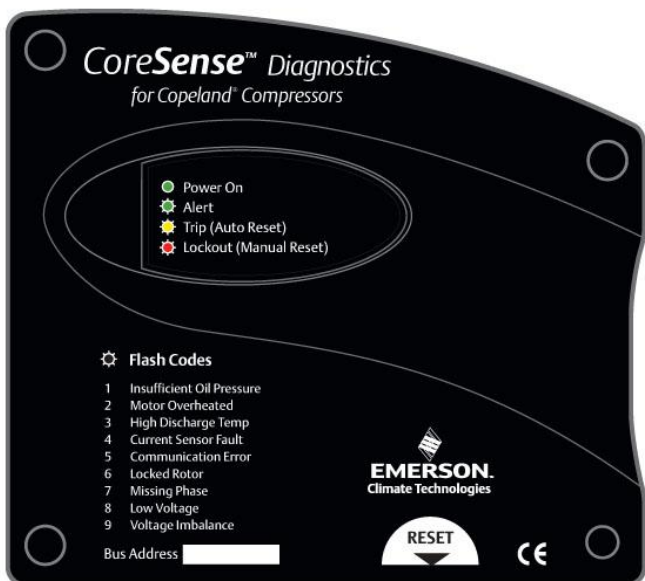
- Steady **green**: An indication of normal operation. There are no faults or issues with the compressor.
- Flashing **green**: An indication that there is an alert (warning) condition. The compressor can still be running.
- Flashing **orange**: An indication that the compressor has tripped with auto reset.
- Flashing **red**: An indication that the compressor is in lockout state.
- Solid **red**: An indication that the control module has failed.

3.15 LEDs on the module to display the failure alarms

For warning/alert (green), trip and lockout (red), the flash count is defined as 0.1 second 'on' and 0.4 second 'off' with a 2-second pause before the flash count repeats (timings are +/- 50 ms).

Definitions:

- Trip**: The module has shut off the compressor due to a fault condition. The compressor will be available to run when the fault condition no longer exists, and the minimum off time has been satisfied.
- Lockout**: The module has shut off the compressor due to a fault condition. The compressor will be available to run again when the fault condition has been cleared and manual or remote reset is done.



Alert alarms Compressor will not turn off.
Trip alarms Compressor turns off for some time with automatic reset.
Lockout alarms Compressor turns off. Manual reset necessary.

Figure 4

LED flashes count	Status LED description			Auto reset time	Lockout condition	Status LED troubleshooting information
1	Low Oil Pressure	NA	Low Oil Pressure	N/A	Without sufficient oil pressure for 2 minutes	If flashing green , compressor has been without sufficient oil pressure for 4 seconds. If flashing red , compressor has been without sufficient oil pressure for 2 minutes.
2	NA	Motor Protection Trip	NA	2 min	NA	If flashing orange , compressor is turned off because motor temperature has exceeded set point. (3 series PTCs; 1 input) (Trips at 4.5K Ohms, and will reset when below 2.75K Ohms.)
3	Discharge Temp.	Discharge Temp.	Discharge Temp.	2 min	Exceeds max set point (configured in EEPROM from iPRO)	If flashing green , the discharge temperature probe is open or disconnected. If flashing orange , discharge temperature has exceeded set point; compressor is turned off for 2 minutes before resetting. If flashing red , discharge temperature has exceeded set point and the compressor is locked out. (The customer has configured the module to lock out when the DLT temperature exceeds the maximum set point.) DLT probe is FACTORY INSTALLED
4	Current Sensor Fault	NA	NA	NA	NA	If flashing green , current sensor is disconnected from the module. Compressor run state is not known by module.
5	Communication Error	NA	NA	NA	NA	Communication between Control module and iPro (/System) Controller has been lost. Communication between Control module and Sensor module has been lost. Configuration miss-match between SW configuration from iPro and HW (network mode)
6	NA	Locked Rotor	Locked Rotor	5 min	10 consecutive events	If flashing orange , compressor failed to start, and excessive current may be present in the compressor. The compressor is turned off and will remain off for 5 minutes. If flashing red , compressor failed to start, and excessive current may be present in the compressor. The compressor is locked out after 10 consecutive events.
7	NA	Missing Phase	Missing Phase	5 min	10 consecutive events	If flashing orange , compressor is turned off due to missing phase. If flashing red , the compressor is locked out after 10 consecutive missing phase alarms.
8	N/A	Low Voltage	Low Voltage	5 min	10 consecutive events	If flashing orange , compressor is turned off due to low compressor voltage. If flashing red , the compressor is locked out after 10 consecutive low voltage alarms.
9	N/A	Voltage Imbalance	Voltage Imbalance	5 min	10 consecutive events	If flashing orange , compressor is turned off due to voltage imbalance. If flashing red , the compressor is locked out after 10 consecutive voltage imbalance.

Table 4

4 Electrical connections

4.1 System wiring diagram

Fuses and wire cable sizing must be done in accordance with all applicable electrical code standards. **Figure 5** below shows the recommended basic system wiring for a compressor with CoreSense™.

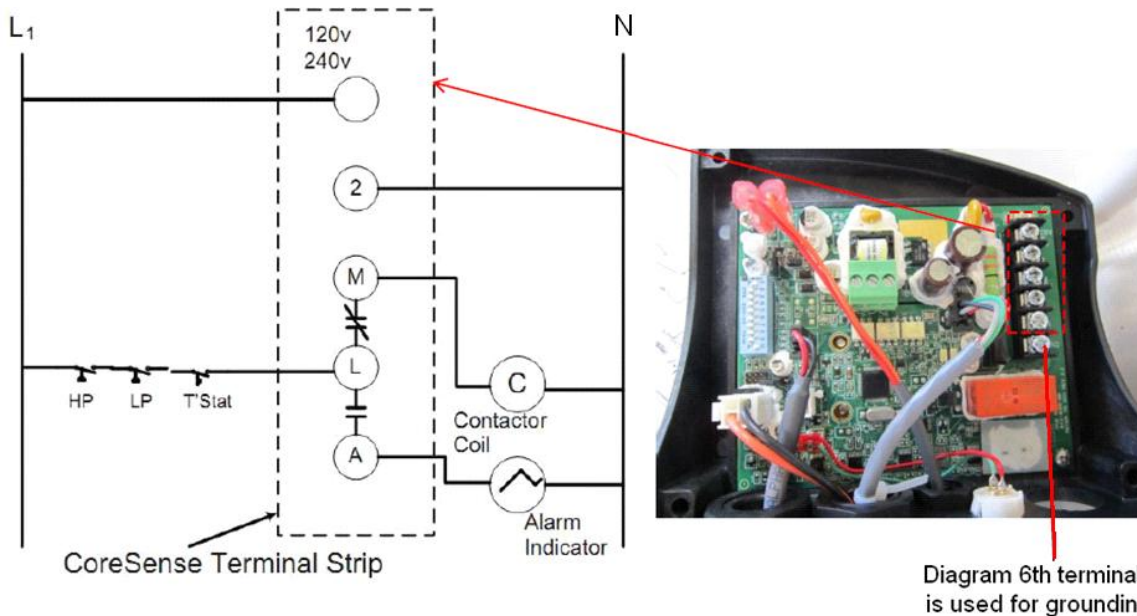


Figure 5: Wiring diagram

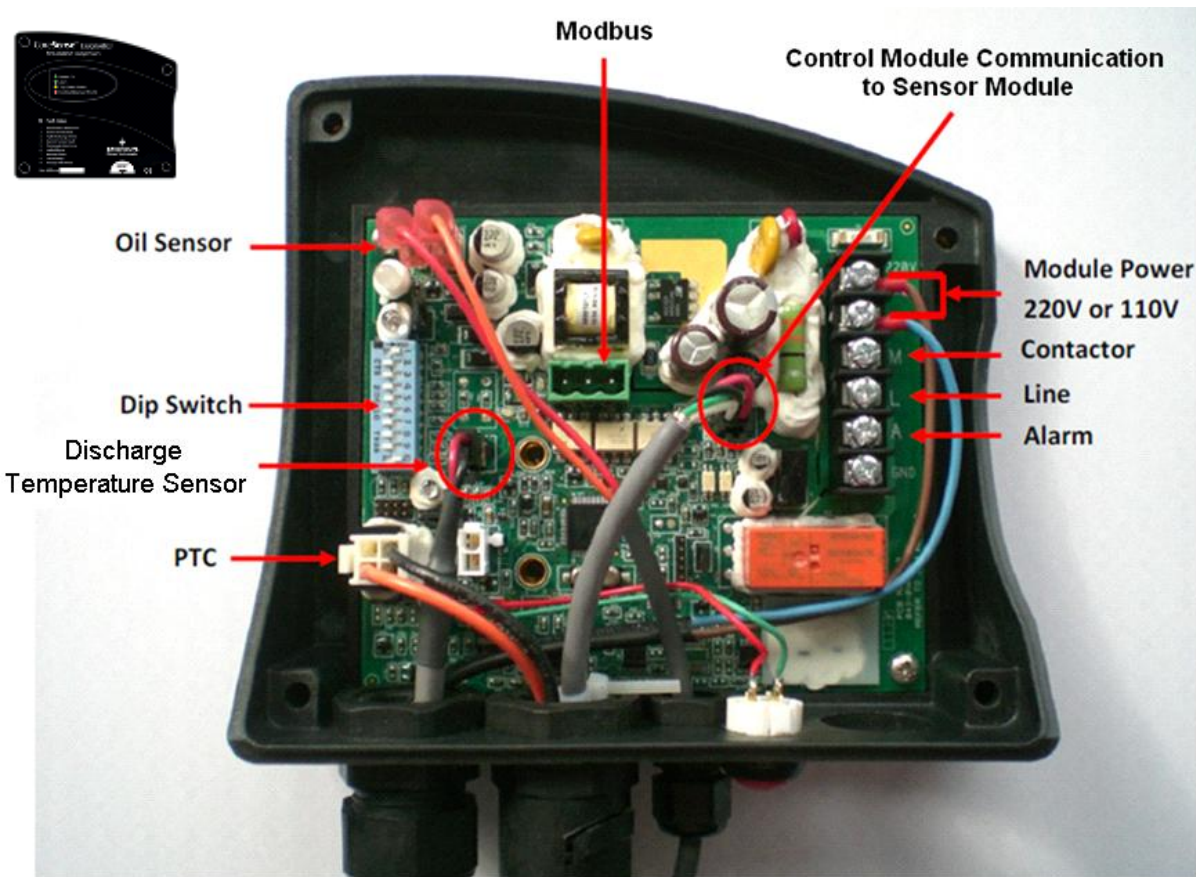


Figure 6: CoreSense™ wiring terminals description

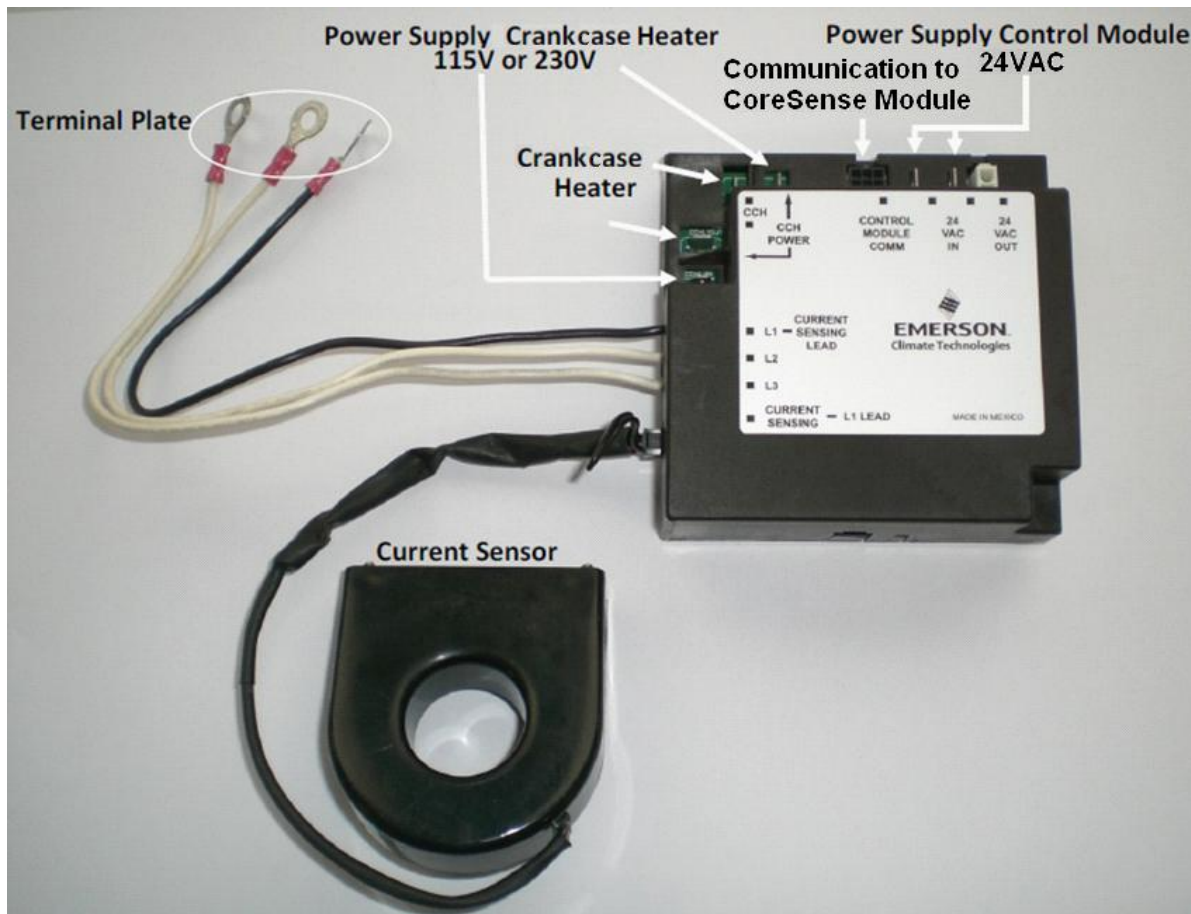


Figure 7: CoreSense™ module with current sensor

4.2 Terminal box and current sensing transformer connections

For space reasons inside the compressor terminal box wires L1 and L2 connected to the sensor module need to be exchanged in such a way that the black wire is connected to terminal 2 (V) and the white wire goes to terminal 1 (U) on the terminal plate as shown on the drawing. This results in that the current of L2 is sensed instead of L1.

4.2.1 Installation of current sensing module

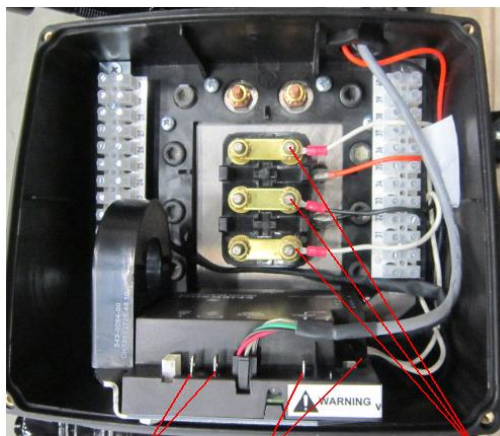
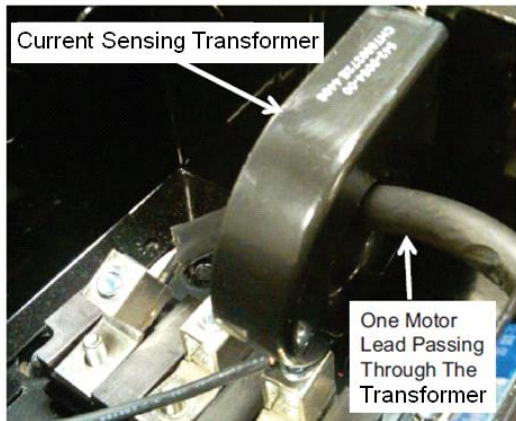


Figure 8: Current sensing module and T-Box wiring

One of the motor power leads passes through the “toroid” (current sensing module). Information from the current sensing module is used to determine running amps, power consumption and locked rotor conditions. There are 3 voltage sensing leads attached to the motor terminals and connected to the sensor module. Two of the leads are white, and one is black. For proper calculation of power factor and motor power it is necessary for the black voltage sensing lead and the power lead through the current sensing module to be connected to the same motor terminal.

Class II transformers have a maximum VA (Volt-Ampere) rating of less than 100 and a maximum secondary output of 30 VAC.

4.2.2 CoreSense™ Diagnostics with Y/Δ motors



Terminal box and the current sensing “toroid” connections are factory-installed. One of the motor power leads must be routed through Current Sensing Transformer (see **Figures 9 & 10** below).

Figure 9: Current sensing transformer

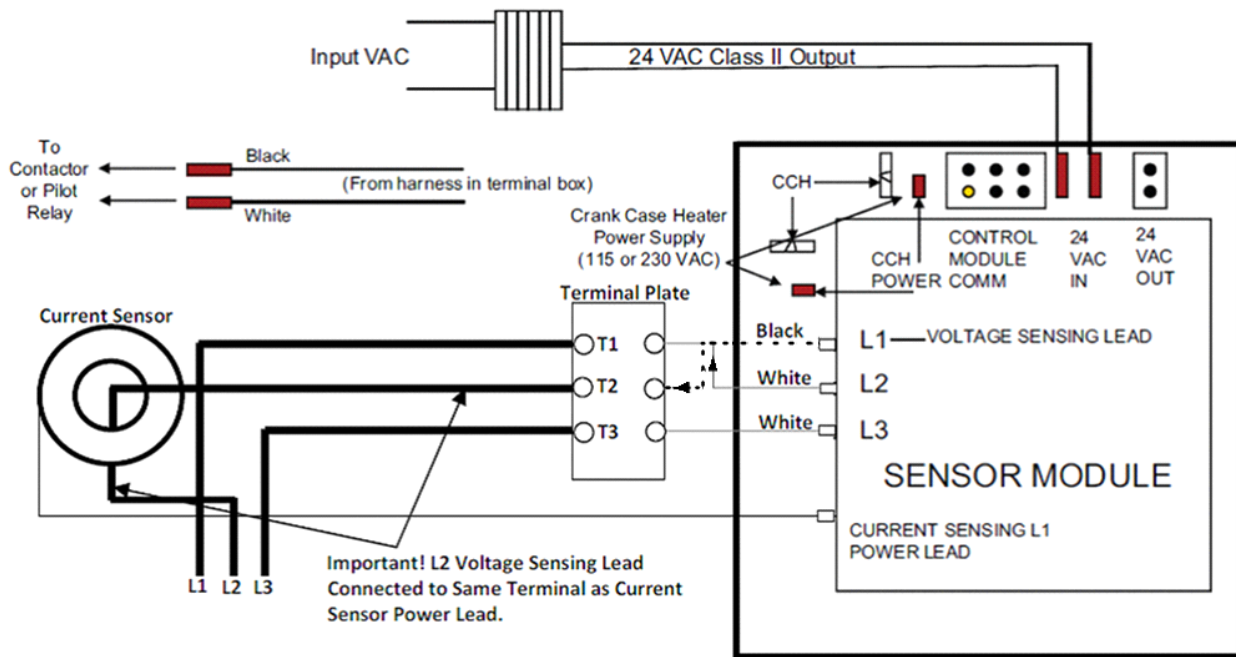


Figure 10: Wiring sensor module and leads routed through the current sensor

One motor lead must be routed through the centre opening of the current sensing transformer.

4.2.3 CoreSense™ Diagnostics with part winding

If using the CoreSense™ Diagnostics module with a part-winding start motor, one power lead of each of the windings should be passed through the current sensing transformer in the same direction (see **Figures 10 and 11**) to provide accurate compressor proofing. If the leads (L2 and L8 in picture below) are not routed in the same direction, the running current may indicate close to zero.

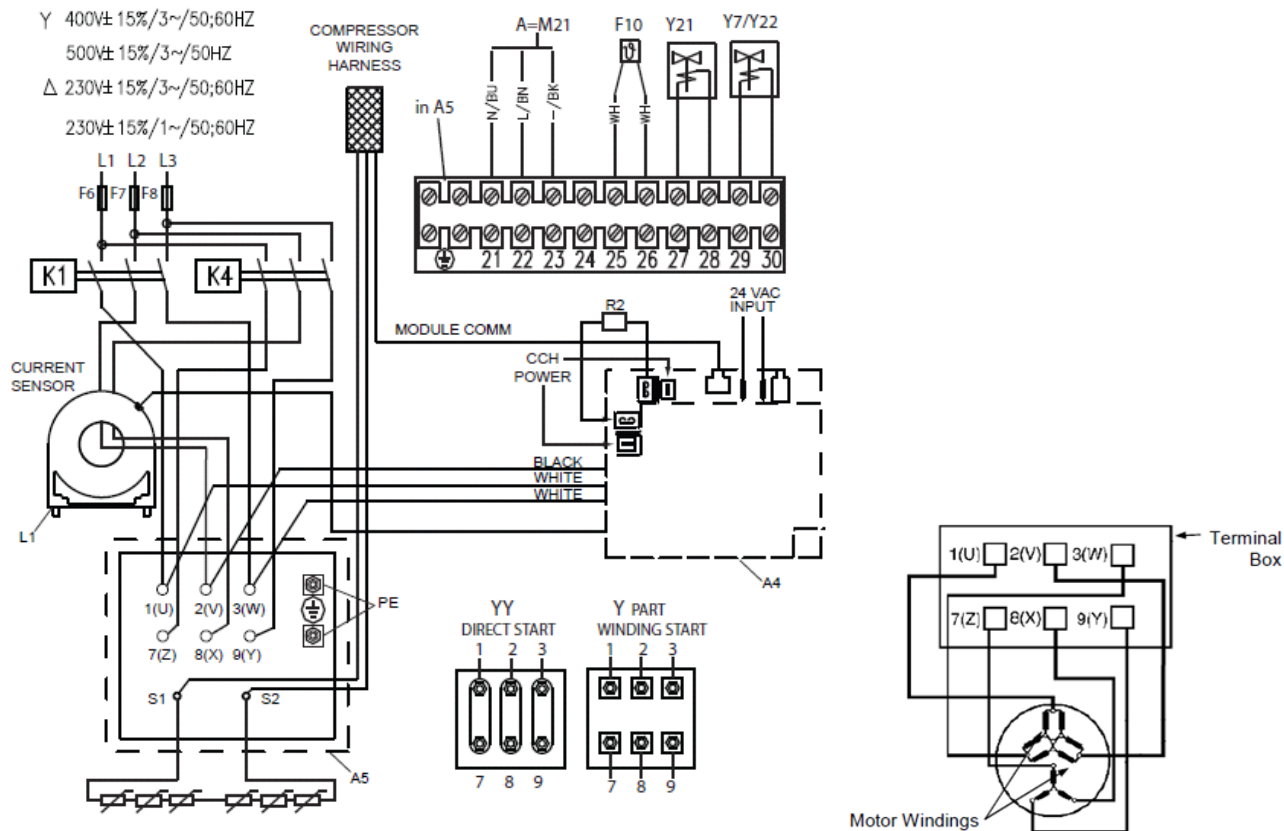


Figure 11: Wiring part winding

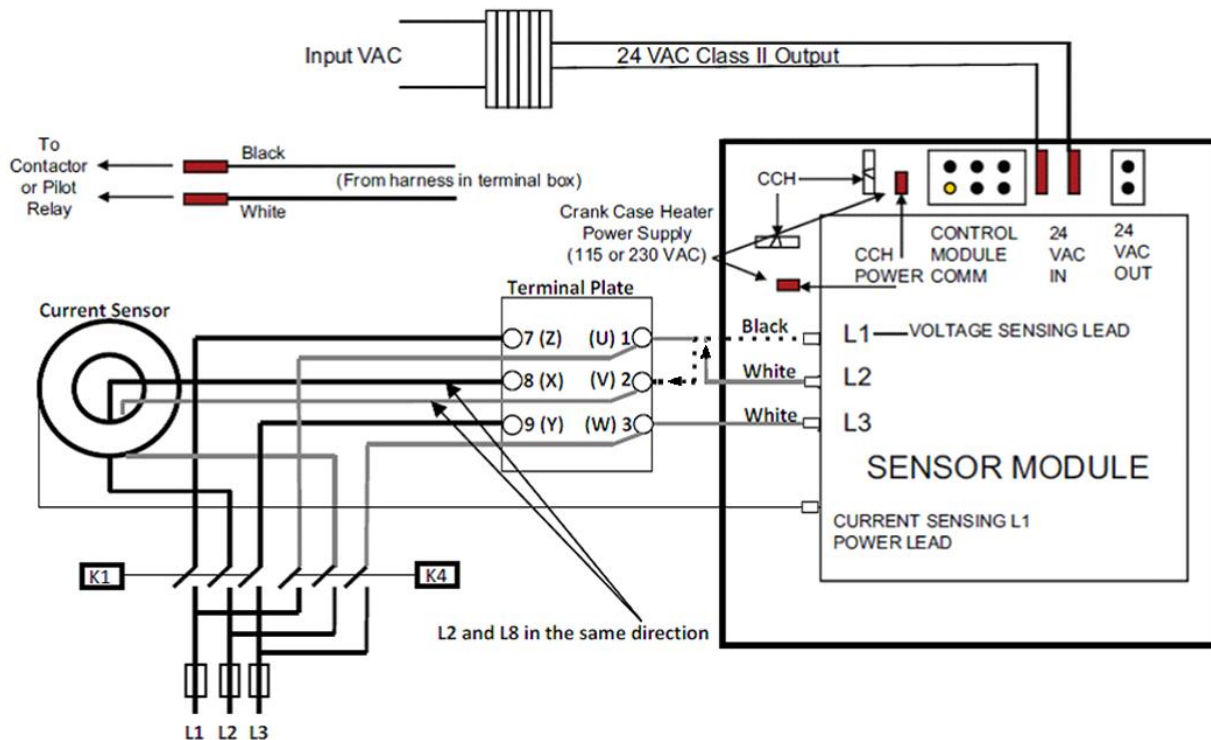


Figure 12: Wiring Sensor module and leads routed through the current sensor

5 CoreSense™ Diagnostics jumper settings

The last compressor in the daisy-chain must be “terminated” by moving the jumper from JP5 to JP3. For all other compressors the jumper should remain in the default JP5 position.

JP4 should be set “1-2” if connected to an iPro rack controller. Set JP4 to “2-3” for other pack controllers.

Do not remove JP1. This is reserved for future use.

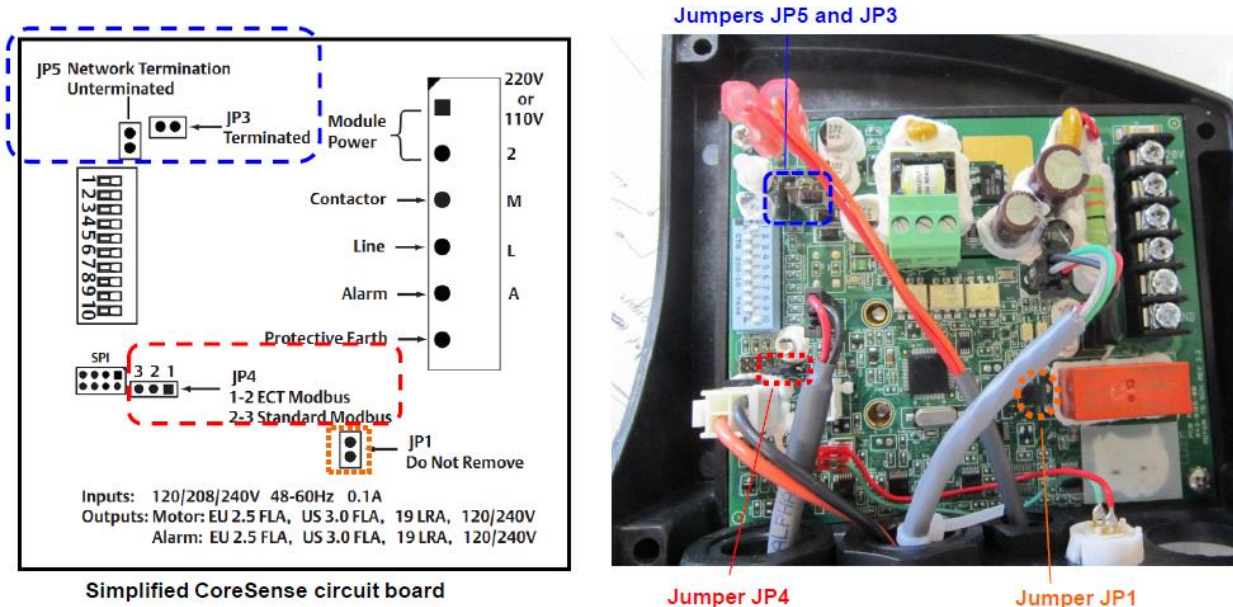


Figure 13

6 CoreSense™ Diagnostics DIP-Switch setting

DIP Switch	Factory Setting	DIP Switch Function
1	ON	Node Address for Communication
2	OFF	Node Address for Communication
3	OFF	Node Address for Communication
4	OFF	Node Address for Communication
5	OFF	Node Address for Communication
6	OFF	ON: VFD Application OFF: Non VFD Application
7	OFF	Communications Baud Rate OFF: 19200 Baud ON: 9600 Baud
8	OFF	OFF: No Parity ON: Even Parity
9	OFF	OFF: Stand-alone mode ON: Network Mode
10	ON	ON: DLT enabled OFF: DLT disabled

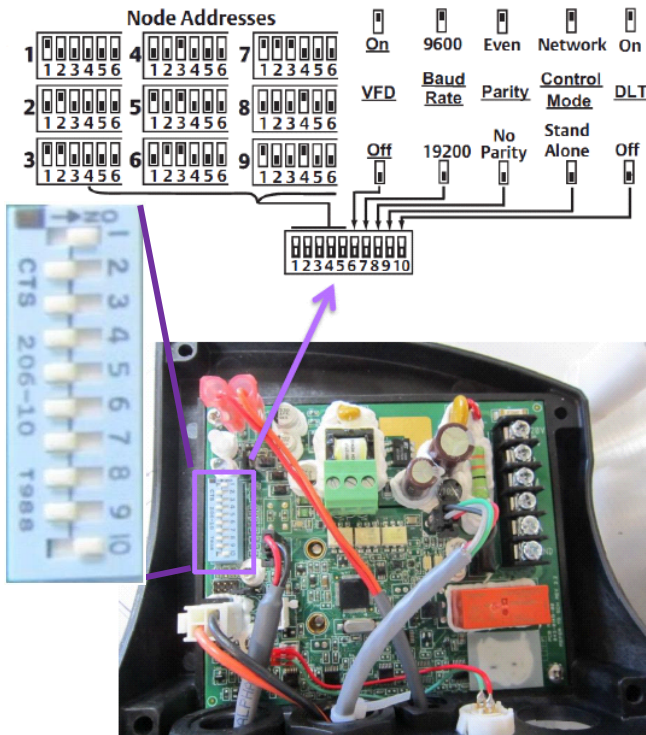


Figure 14: CoreSense™ Diagnostics DIP-Switch setting

Assign a unique node address to each CoreSense™ diagnostics module using switches 1 through 5.

- a. Set the communications baud rate for the module using switch 7. “Off” = 19200 baud, “On” = 9600 baud. The baud rate for each module should be set to match the rack controller.
- b. Set switch 8 to “Off” for no parity, to “On” for even parity.
- c. Set switch 9 to “Off” for stand-alone mode, to “On” for network mode. Network mode will generate a communications error if the rack controller fails to communicate with the device. For stand-alone mode, no communications are expected so the communication error is blocked.
- d. Factory default setting is “On” for dip-switch 10, ie, discharge temperature protection. If you want to disconnect the discharge temperature sensor, turn off dip-switch 10.

Push the reset button after changing the switch settings.

Ensure that the dip-switch settings on each module match the settings for the selected controller communication port.

Information in this document is subject to change without notification.

7 Troubleshooting

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
1 Insufficient oil pressure	<p>Warning: Appears when the differential oil pressure is less than 0.48 – 0.62 bar for 4 seconds.</p> <p>Lockout: Appears when the differential oil pressure is less than 0.48 – 0.62 bar for 2 minutes continuous, or intermittent but determined to be unsafe.</p>	<p>Loose wiring connections between CoreSense™ module and oil sensor.</p> <p>Faulty oil sensor (missing O-ring or clogged sensor screen).</p> <p>Faulty oil pump.</p> <p>Clogged strainer screen or worn bearings.</p>	<p>Verify the oil level present in the sight glass. If the oil is not present, resolve reservoir oil supply problem or oil level control setting issues.</p> <p>Verify that the harness is fully engaged to the sensor.</p> <p>Measure oil pump differential pressure. If less than 7 to 9 psi, inspect for clogged oil screen, faulty oil pump, liquid floodback or worn bearings.</p> <p>If good oil pressure exists, measure resistance across the oil sensor while the compressor runs. If the sensor resistance is "open" inspect for clogged sensor screen or missing O-ring.</p> <p>If sensor resistance is "closed", temporarily jumper across the harness connector pins (do not damage the pins!) while the compressor runs. If the oil warning does not go away, verify harness connector engagement at the module circuit board.</p>
2 Motor overheat	<p>Trip: Appears when the PTC Thermistor resistance is > 4.5 kΩ.</p> <p>Lockout: Appears when 10 consecutive motor overheat trip alarms occur.</p>	<p>Motor rotor is mechanically seized.</p> <p>Open circuit in harness.</p> <p>Connector pin not engaging at connector on control module</p> <p>Faulty CoreSense™ module.</p>	<p>In case of trip alarm, allow the motor to cool down for a minimum of 2 minutes (it may take longer) and the compressor will start automatically.</p> <p>In case of lockout alarm or multiple trips, check PTC resistance when the motor is cold (off for at least an hour). If resistance is high, inspect for faulty sensor or loose connection under terminal plate.</p> <p>If resistance is low, inspect for loose terminal strip connections, harness connection failure at circuit board, open harness circuit or high motor temp due to return gas temperature, motor voltage or load condition.</p>
3 Discharge temp protection	<p>Warning: When the discharge temperature sensor is defective or disconnected.</p> <p>Trip/Lockout: When the discharge temperature is > 154°C for 2 seconds.</p>	<p>Open discharge probe (faulty).</p> <p>The probe connection has not been made to the harness connector.</p> <p>The connector is not plugged into the CoreSense™ circuit board.</p> <p>The Discharge temperature has exceeded the maximum limit 154°C.</p> <p>Blocked condenser.</p> <p>Possible loss of refrigerant.</p>	<p>If there is a warning, verify proper probe connection to the harness and proper harness connection into the circuit board.</p> <p>If there is a warning, unplug the discharge temp probe and verify if the resistance of the probe is as specified vs its approximate ambient temperature.</p> <p>If the probe resistance is correct inspect the harness connector receptacle for damage and apply NyoGel 760G connector lubricant.</p> <p>Trip or Lockout: resolve system issues (high superheat, high head pressure), inspect for mechanical damage that can lead to high temps (valve plate gasket, suction or discharge valve failure).</p>

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
4 Connection lost CT to sensor	Warning: Appears when the signal from current sensor is not communicated to the sensor module.	The current sensor is not connected to the sensor module. Faulty current sensor. Faulty sensor module.	Verify if the CT connector is connected to the sensor module. If not connect the 4-pin current sensor connector into the sensor module. Verify if there is continuity between pin 3 & 4 (closest to the latch) of the current sensing connector. The resistance should be less than 1 Ω. If the resistance is greater than 1 Ω, replace the current sensing module. Be certain that the receptacles are fully engaged in the connector block. Verify if the Amp and Volts values are correctly displayed. If not, inspect the wire harness connector to ensure that the pins are fully engaged. If the above-mentioned trouble shooting measures didn't give the positive results, the reason is faulty sensor module or mis-installed connector. Replace the faulty sensor module with new one.
5 Communication Error	Warning: Appears when there is no communication between control module and sensor module or rack controller	Communication between CoreSense™ control module and rack controller has been lost. Communication between the CoreSense™ control module and the sensor module has been lost.	Is there a communication network? If not, set the network dip-switch to "stand-alone" and press reset. Is there a communication network? If not, verify that the communication harness is engaged at both the CoreSense™ module and the sensor module. If the LED on the top edge of the sensor module is dark, verify 24VAC power to the sensor module, or replace the sensor module. If communication network amber light is continuously on, reverse the communication wire polarity. If voltage between centre pin and the right or left pin isn't 2.3-2.6VDC, inspect for communication wire failure or wire strands that are "shorting" between the wires or to ground.
6 Locked rotor	Trip: Appears when the excessive current is present in the compressor. Refer AE bulletin for more details. Lockout: Appears when 10 consecutive locked rotor trip alarms occur.	Motor rotor is mechanically seized. Excessive current present in the compressor. Damaged valve plates in cylinder head.	Verify that motor voltage is adequate (+/- 10% of nominal rated voltage), especially during the starting event. Start compressor with no load. If it does start with no load, inspect the valve plate(s) for damage or look for other causes of leak-back.
7 Missing phase	Trip: Appears when there is a missing phase / single phasing. Lockout: Appears when 10 consecutive missing phase trip alarms occur.	Loose wiring connections at the terminals inside compressor T-Box. Worn out contactors. Line break in one of the phases.	Verify voltage supply from the main power buss. Verify voltage into and out of contactor (Repair or replace contactor if necessary). Verify that motor electrical connections are tight at the compressor motor terminals.

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
8 Low voltage	Trip: Appears when there is a low compressor voltage.	Supply voltage is not in the specified range. Loose wiring connections at the terminal plate. Worn out contactors. Faults with other peripheral electrical loads.	Verify voltage supply from the main buss. Verify voltage into and out of contactor (repair or replace contactor if necessary). Measure voltage at the compressor terminal (refer to AE10-1244, Recommended Contactor Selection for 3-Phase Motor Control – Power Supply Problems). Verify that motor electrical connections are tight at the compressor. Verify that there are not any faults with other peripheral electrical loads (for example fan motors).
9 Voltage imbalance	Trip: Appears when the voltage imbalance value exceeds the set value (default 5%).	Loose wiring connections at the compressor terminal plate inside T-Box. Worn out contactors. Faults with other peripheral electrical loads. Single phasing conditions.	Verify voltage supply from the main buss. Verify voltage into and out of contactor (repair or replace contactor if necessary). Measure voltage at the compressor terminal (refer to AE10-1244, Recommended Contactor Selection for 3-Phase Motor Control– Power Supply Problems). Verify that motor electrical connections are tight at the compressor. Verify that there are not any faults with other peripheral electrical loads (for example fan motors).