

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 the compressor as a sensor to unlock information from within the compressor providing value added features such as advanced motor protection, diagnostics, power consumption measurement and communication.

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



Figure 1: Stream compressor with CoreSense Diagnostics

2 Specifications

Power supply for control module (in front of the compressor) is 120 VAC or 240 VAC. The sensor module needs 24 VAC power supply.

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

Table 1

3 CoreSense Diagnostics features

Nr	Feature	Nr	Feature
1	Motor overheat protection	8	Alarm history and compressor operating conditions
2	Insufficient oil pressure protection	9	Crankcase heater control
3	High discharge temperature protection	10	Reset
4	Locked rotor protection	11	Modbus® communication
5	Missing phase protection	12	Power consumption measurement (voltage, current, power factor)
6	Voltage imbalance protection	13	LEDs on the front module to display the failures
7	Low voltage protection	14	Compressor run status (proofing)

Table 2

CoreSense is compatible with VFD applications by turning on the DIP-Switch 6 in the front module. The features available for VFD are limited: motor overheat protection, insufficient oil pressure protection and high discharge temperature protection. Other features are available in Control Techniques frequency inverters.

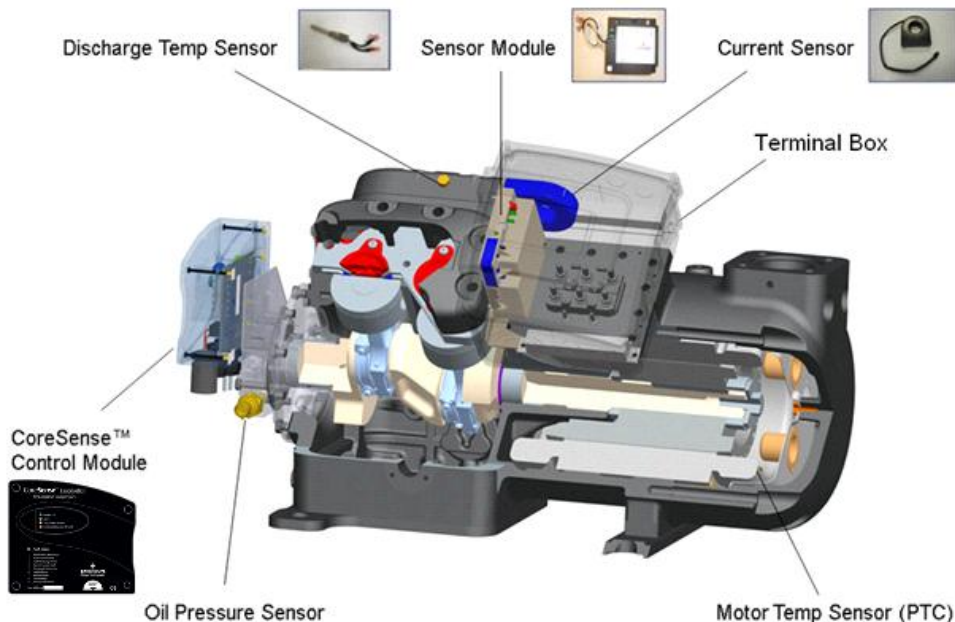


Figure 2

3.1 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 the 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 manually activated or when power has been cycled to the CoreSense module.

This feature is not applicable to compressor models 4MTL (Stream CO₂ compressors) as these have no positive oil pump fitted and are "splash" lubricated.

3.2 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 Diagnostics module replaces the Kriwan module INT69TM.

Alarm conditions:

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

3.3 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 using the PC interface software. Default is trip alarm. Trip and reset settings are configurable using PC interface software. The configurable range of trip settings is 108°C to 154°C and the reset value is 83°C to 130°C.

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

3.4 Locked rotor protection

CoreSense detects the locked rotor condition of the compressor. It has trip and lockout alarms. Initial alarm will be "Trip" alarm with autoreset and 10 consecutive trip alarms will result in "Lockout" alarm which requires manual reset.

3.5 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 conditions: Appears in case of missing phase conditions.

- 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 by cycling the power to the module).

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.

3.6 Low voltage protection

Appears when there is a low supply voltage.

Alarm conditions: 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 seconds.

- 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%.

3.7 Voltage imbalance protection

The purpose of this 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. The voltage imbalance setting is configurable in the range of 2 to 8 % using the PC interface software.

Alarm conditions:

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

3.8 "Jog" feature



The reset button below the control module may be used as an emergency shutdown, such as for clearing liquid during 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

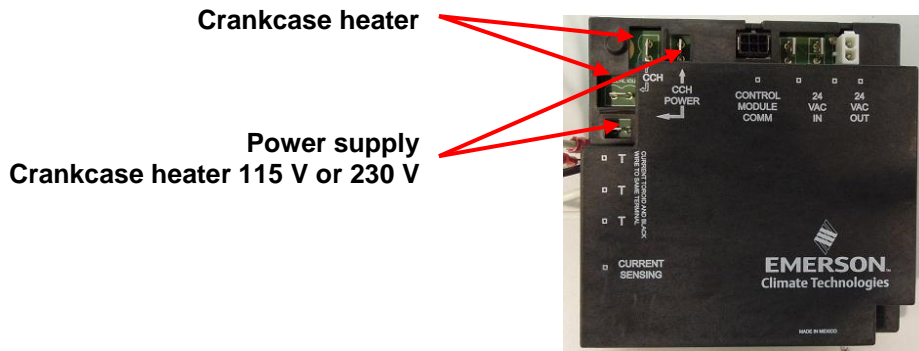
Figure 3

3.9 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 (115 V / 230 V) is required.

The control of a 480 V crankcase heater is not supported by CoreSense Diagnostics.



3.10 Flash memory information

Emerson Climate Technologies can provide software to access EEPROM information.

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
- Compressor nominal voltage and frequency
- Sensor module firmware revision

For dual voltage motors the lower value is saved in EEPROM memory. It is advised to change the nominal voltage setting values to the correct operating voltage in the EEPROM memory using PC interface software. Even if the nominal voltage is not changed, there is no effect on the compressor functionality due to this setting.

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

- Number of compressor running hours
- Number of compressor starts
- Accumulated runtime without good oil pressure
- Number of short cycles (compressor starts with a less than 3-minute runtime)

Compressor operating parameters:

- Current
- Voltage
- Power consumption
- Discharge temperature values

3.11 Modbus® communication

CoreSense Diagnostics has communication capability via a Modbus network connection. With communication enabled CoreSense warnings, trip and lockout alarms can be displayed and recorded in a pack controller with Modbus such as the iPro Rack Controller from Dixell.

Two types of Modbus are used with Stream compressors. The only possibility to identify which one is fitted in a CoreSense module is to open the module lid, and to look at the circuit board and label.

Most of the features are the same; the main differences are explained in Technical information D7.8.6 “CoreSense™ Diagnostics for Stream Compressors - Modbus® Specification”.

All the pictures and information hereafter deal with the more recent version.

The communication cable is wired from the pack controller to the first compressor. Additional compressors are wired in a daisy-chained configuration. The last compressor in the daisy chain should be terminated by jumper JP3 in the front module. Please refer to **Figures 4 and 5**.

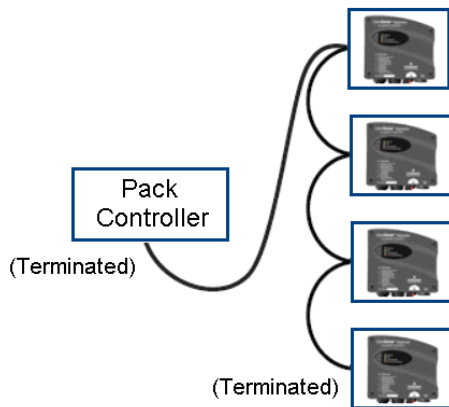


Figure 4: RS485 daisy-chain connection

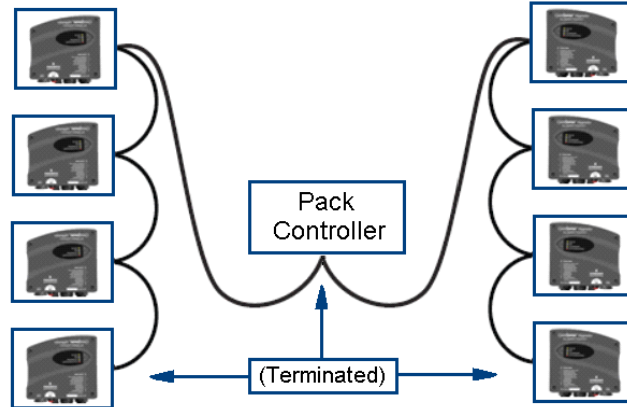


Figure 5: Two-rack daisy-chain connection

CoreSense modules can be connected to a PC through the CoreSense PC Interface software. **Figure 6** depicts how to connect the CoreSense Diagnostics module to the PC, using USB to RS485 Dixell adapter.

Communication Port (+ GND –)



Figure 6

Modbus communication in CoreSense allows communication with any other third-party pack controller. The Emerson E2 controller has – GND + polarity.

The RS485 connection can be removed from the board without switching off the compressor.

For more information on communication with pack controller please contact Application Engineering.

3.12 Reset

The CoreSense Diagnostics module is equipped with a reset button placed below the control module. The reset button may be pushed if necessary to reset the alarm conditions.

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 short cycles	Total number of alarms since the compressor first operation
Current, voltage, power consumption measurement*	

*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.
- Steady **red**: An indication that the control module has failed.

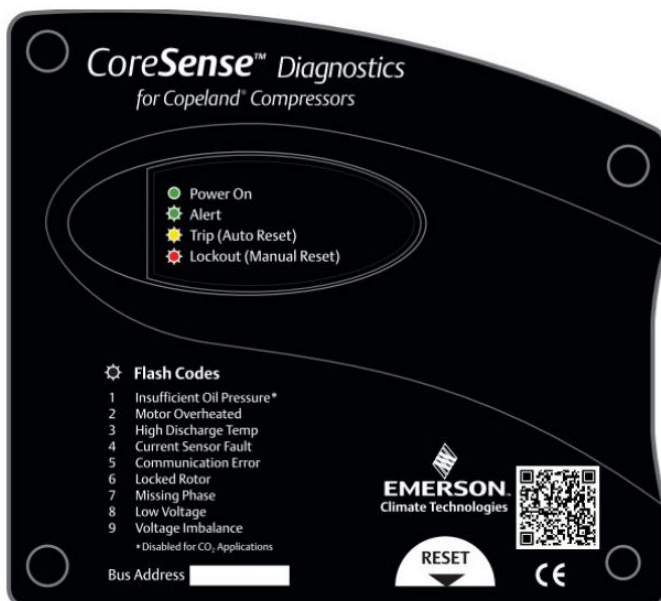
3.15 LEDs on the module to display the failure alarms

Two multi-color LEDs on the CoreSense front module display the failure alarms. The LED on the top is green/red and the LED on the bottom is orange.

For warning/alert (green), trip (orange) 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 again 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 reset has been 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.

The QR code located on the CoreSense cover enables to reach a Quick Troubleshooting page on our website.



Figure 7

LED flashes count	Status LED description			Auto reset time	Lockout condition	Status LED troubleshooting information
1	Insufficient oil pressure	N/A	Insufficient 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	N/A	Motor overheat trip	N/A	2 min	N/A	If flashing orange , compressor is turned off because motor temperature has exceeded set point.
3	High discharge temp.	High discharge temp.	High discharge temp.	2 min	Exceeds max set point	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 auto resetting. If flashing red , discharge temperature has exceeded set point and the compressor is locked out. DLT alarm is configurable as either Trip or Lockout. Factory default is Trip alarm. DLT probe is FACTORY INSTALLED
4	Current sensor fault	N/A	N/A	N/A	N/A	If flashing green , current sensor is disconnected from the sensor module. Compressor run state is not known by the control module.
5	Communication error	N/A	N/A	N/A	N/A	Communication between control module and system controller has been lost. Communication between control module and sensor module has been lost.
6	N/A	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 "Trip" alarm events.
7	N/A	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 trip 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 trip alarms.
9	N/A	Voltage imbalance	N/A	5 min	10 consecutive events	If flashing orange , compressor is turned off due to voltage imbalance.

Table 4

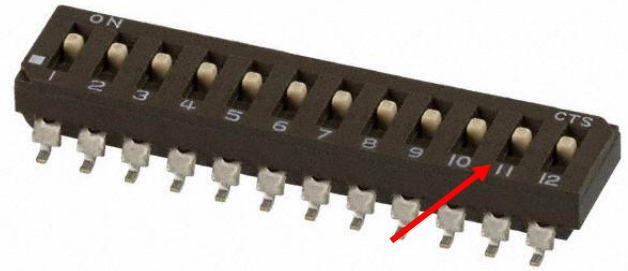
3.16 Oil functionality self-test option

When assembling a Stream compressor at the OEM it is possible to proceed to an oil functionality test during production. To enter this test mode simply switch DIP-switch 11 from Off to On.

This test mode “simulates” current present (or compressor running). After 2 minutes, the oil pressure lockout can be observed.

Test mode:

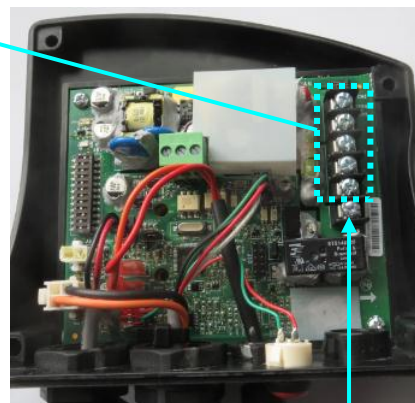
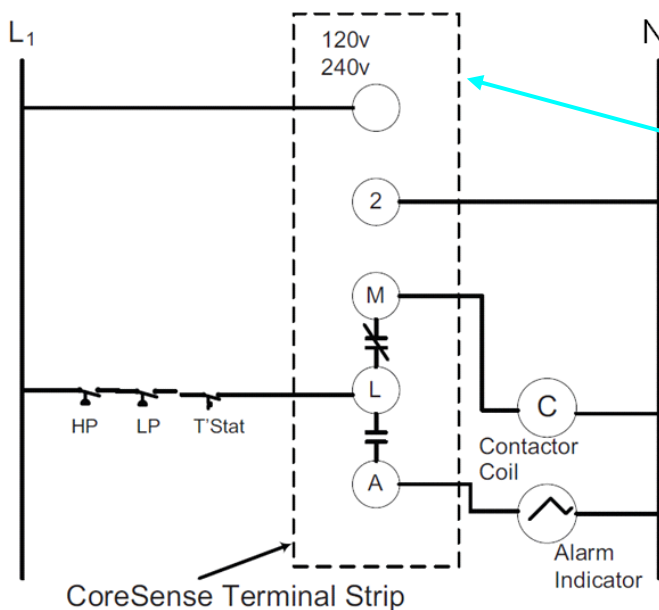
- Step 1: Power On / reset module
- Step 2: Within 5 seconds, switch DIP-switch 11 from Off to On
- Step 3: Low oil pressure warning for 2 minutes followed by low oil pressure lockout (red LED blinking once)
- Step 4: Press reset button



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 8** below shows the recommended basic system wiring for a compressor with CoreSense.



6th terminal used for grounding

Figure 8: Wiring diagram

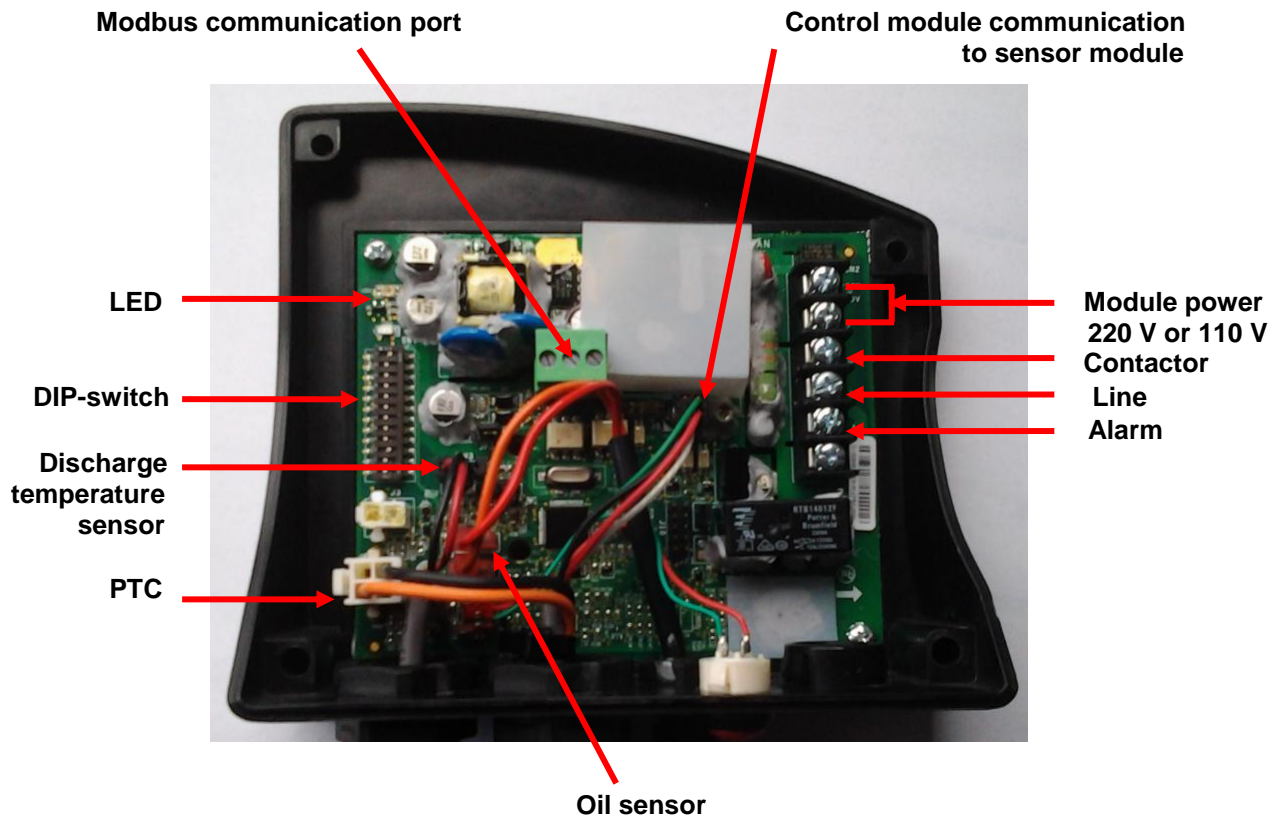


Figure 9: CoreSense wiring terminals description

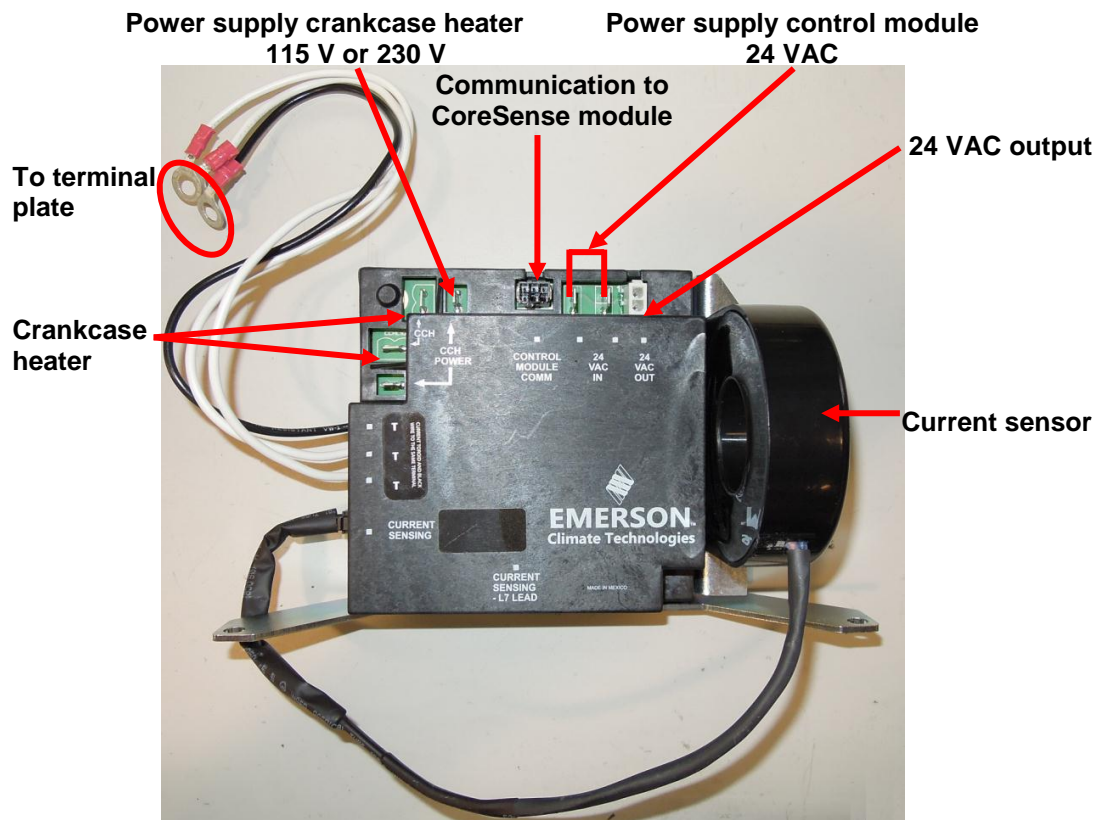
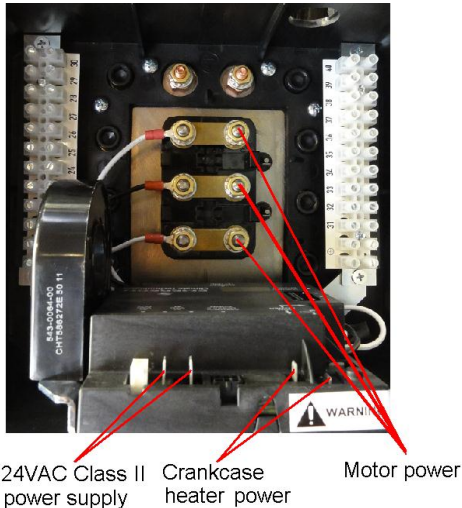


Figure 10: Sensor module with current sensor

4.2 Terminal box and current sensing transformer connections

Make sure that the black lead from the sensor module is always connected to terminal 2 (factory-installed). Black lead from sensor module must always be connected to that terminal of which power supply cable is lead through current sensor.

4.2.1 Installation of current sensing module

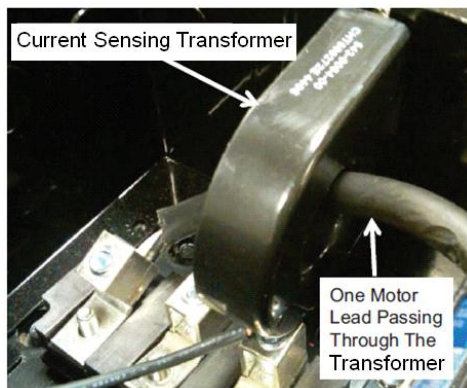


One of the motor power leads passes through the “toroid” (current sensing module). Information from the current sensing module is used to determine running amps, power consumption and locked rotor conditions. There are 3 voltage sensing leads attached to the motor terminals and connected to the sensor 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.

The sensor module needs 3 VA (Volt-Ampere) and a 24 VAC power supply. Therefore a Class II transformer must be used. Class II transformers have a maximum rating of less than 100 VA and a maximum secondary output of 30 VAC.

Figure 11: Current sensing module and T-Box wiring

4.2.2 CoreSense Diagnostics with Y/Δ motors



The terminal box and the current sensing “toroid” connections are factory-installed. One of the motor power leads must be routed through the centre opening of the current sensing transformer (see Figures 12 & 13 below).

Figure 12: Current sensing transformer

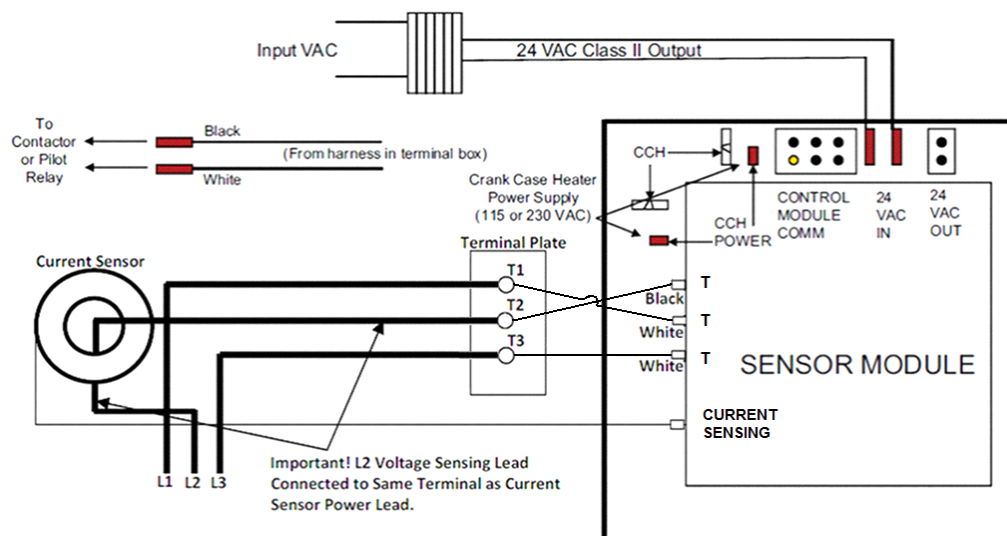


Figure 13: Wiring sensor module and leads routed through the current sensor

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 14 & 15**) 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.

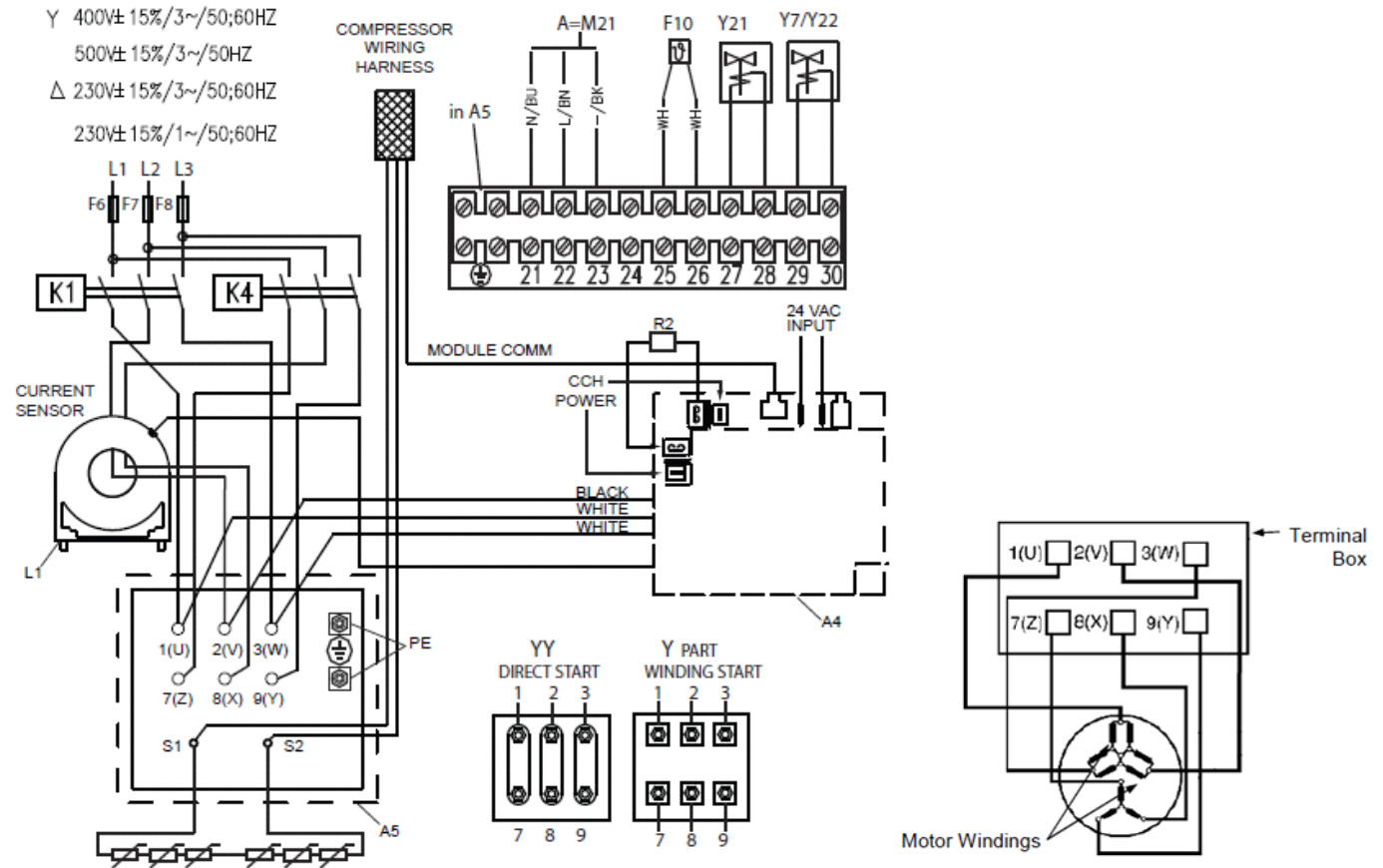


Figure 14: Wiring part winding

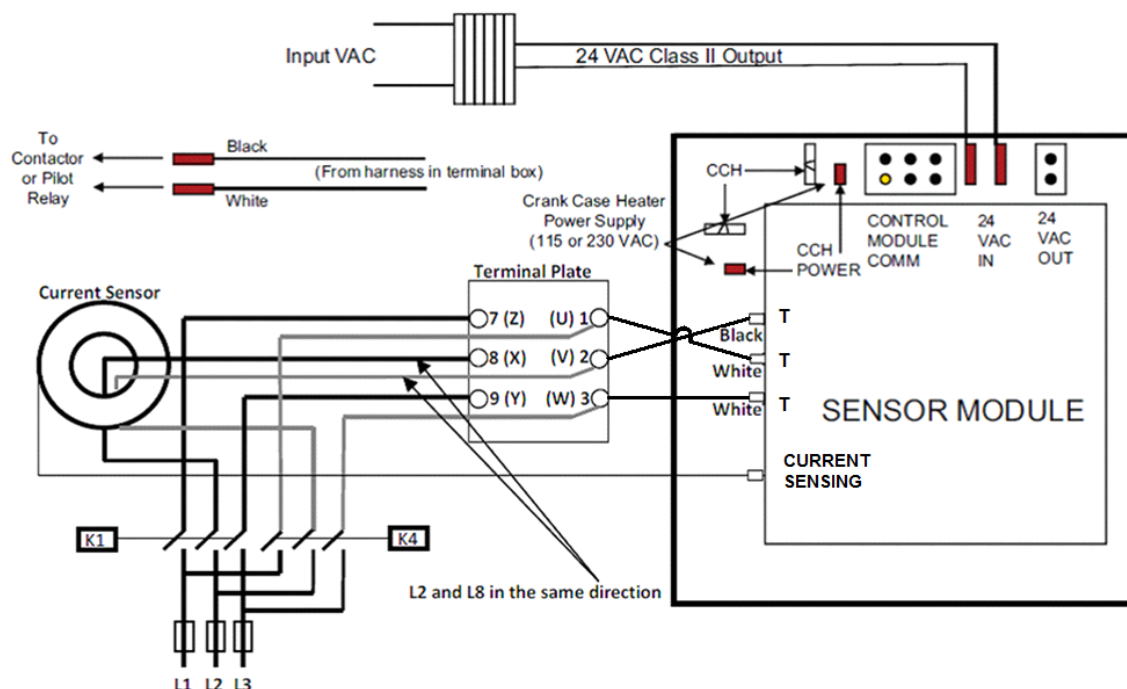


Figure 15: Wiring sensor module and leads routed through the current sensor

5 CoreSense Diagnostics jumper settings

The last compressor in the daisy-chain must be “terminated” by moving the JP3 jumper from “2-3” to “1-2”. For all other compressors the jumper should remain in the default “2-3” position.

JP4 factory setting is “1-2” (2 Stop Bits). Depending on the Modbus parameters, it can be switched to position “2-3” (1 Stop Bits).

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

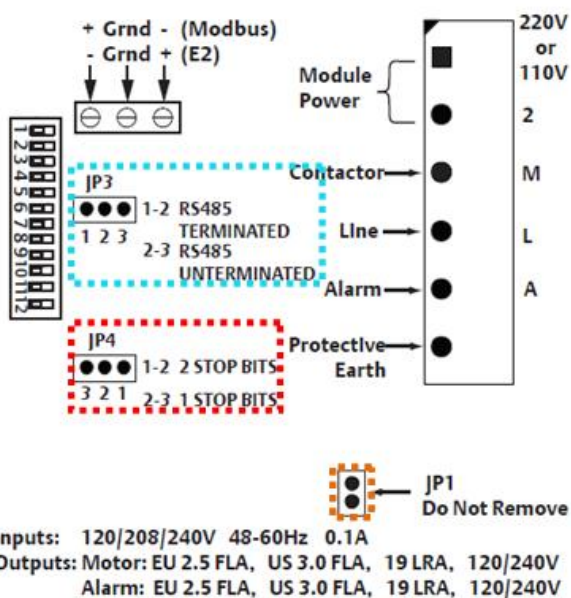


Figure 16: CoreSense circuit board

6 CoreSense Diagnostics DIP-switch settings

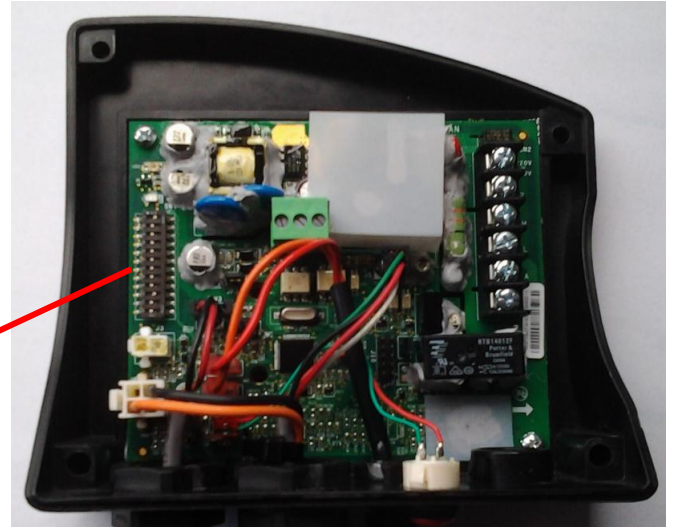
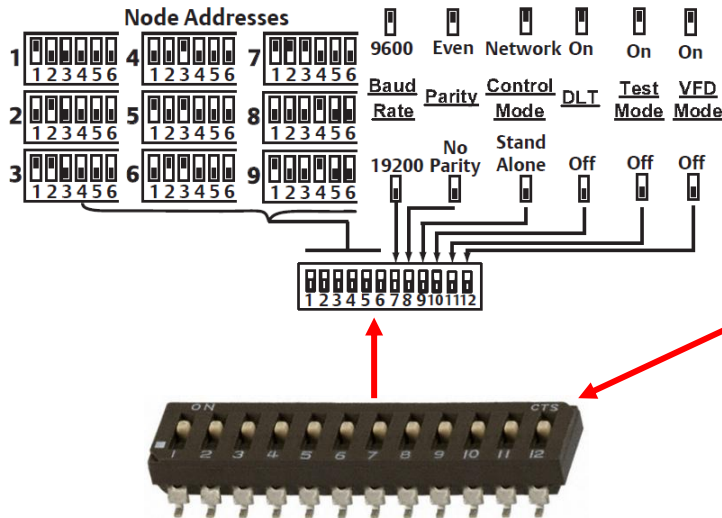


Figure 17: CoreSense Diagnostics DIP-switch

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	Node address for communication	
7	Off	Communications Baud rate	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
11	TBD	Self-test function for oil functionality	
12	Off	On: VFD application	Off: Non VFD application

Table 5: CoreSense Diagnostics DIP-switch setting

If you use CoreSense communication, assign a unique node address to each CoreSense Diagnostics module using switches 1 through 6.

- 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 pack controller.
- Set switch 8 to “Off” for no parity, to “On” for even parity.
- Set switch 9 to “Off” for stand-alone mode, to “On” for network mode. Network mode will generate a communications error if the pack controller fails to communicate with the device. For stand-alone mode, no communications are expected so the communication error is blocked.
- 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.

7 Troubleshooting

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
1 Insufficient oil pressure	<p>Alert: 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>	<ul style="list-style-type: none"> Loose wiring connections between CoreSense module and oil sensor. Faulty oil sensor (missing O-ring or clogged sensor screen). Faulty oil pump. Clogged strainer screen or worn bearings. 	<ul style="list-style-type: none"> Check 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. Check that the harness is fully engaged to the sensor. Measure oil pump differential pressure. If less than 0.48 to 0.62 bar, inspect for clogged oil screen, faulty oil pump, liquid floodback or worn bearings. 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. 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, check harness connector engagement at the module circuit board.
2 Motor overheat	<p>Trip: Appears when the motor is overheated.</p>	<ul style="list-style-type: none"> Motor rotor is mechanically seized. Open circuit in harness. Connector pin not engaging at connector on control module. Faulty CoreSense module. 	<ul style="list-style-type: none"> 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. 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.
3 Discharge temp protection	<p>Alert: Appears when the discharge temperature sensor is defective or disconnected.</p> <p>Trip/Lockout: Appears when the discharge temperature is > 154°C for 2 seconds.</p>	<ul style="list-style-type: none"> Open discharge probe (faulty). The probe connection has not been made to the harness connector. The connector is not plugged into the CoreSense circuit board. The discharge temperature has exceeded the maximum limit 154°C. Blocked condenser. Possible loss of refrigerant. 	<ul style="list-style-type: none"> If there is an alert, check proper probe connection to the harness and proper harness connection into the circuit board. If there is an alert, unplug the discharge temp probe and check if the resistance of the probe is as specified vs its approximate ambient temperature. If the probe resistance is correct inspect the harness connector receptacle for damage and apply NyoGel 760G connector lubricant. 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).

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
4 Connection lost between sensor module and current sensor	Alert: Appears when the signal from current sensor is not communicated to the sensor module.	<ul style="list-style-type: none"> The current sensor is not connected to the sensor module. Faulty current sensor. Faulty sensor module. 	<ul style="list-style-type: none"> Check if the CT connector is connected to the sensor module. If not connect the 4-pin current sensor connector into the sensor module. Check 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. Check 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 did not give positive results, the reason is mis-installed connector or faulty sensor module. Replace the faulty sensor module with new one.
5 Communication error	Alert: Appears when there is no communication between control module and sensor module or pack controller	<ul style="list-style-type: none"> Communication between CoreSense control module and pack controller has been lost. Communication between CoreSense control module and sensor module has been lost. 	<ul style="list-style-type: none"> 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, check 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, check 24 VAC 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 is not 2.3-2.6 VDC, inspect for communication wire failure or wire strands that are "shorting" between the wires or to ground.
6 Locked rotor	Trip: Appears when excessive current is present in the compressor. Refer to AE bulletin for more details. Lockout: Appears when 10 consecutive locked rotor trip alarms occur.	<ul style="list-style-type: none"> Motor rotor is mechanically seized. Excessive current present in the compressor. Damaged valve plates in cylinder head. 	<ul style="list-style-type: none"> Check that motor voltage is adequate (\pm 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.	<ul style="list-style-type: none"> Loose wiring connections at the terminals inside compressor T-Box. Worn out contactors. Line break in one of the phases. 	<ul style="list-style-type: none"> Check voltage supply from the main power buss. Check voltage into and out of contactor. Repair or replace contactor if necessary. Check that motor electrical connections are tight at the compressor motor terminals.

Flash code	Alarm conditions	Possible failure reasons	Troubleshooting measures
8 Low voltage	<p>Trip: Appears when there is a low compressor voltage.</p> <p>Lockout: Appears when 10 consecutive low voltage trip alarms occur.</p>	<ul style="list-style-type: none"> Supply voltage is not in the specified range. Loose wiring connections at the terminal plate. Worn out contactors. Faults with other peripheral electrical loads. 	<ul style="list-style-type: none"> Check voltage supply from the main buss. Check voltage into and out of contactor. Repair or replace contactor if necessary. Measure voltage at the compressor terminal. Check that motor electrical connections are tight at the compressor. Check that there are not any faults with other peripheral electrical loads (for example fan motors).
9 Voltage imbalance	<p>Trip: Appears when the voltage imbalance value exceeds the set value (default 5%).</p>	<ul style="list-style-type: none"> Loose wiring connections at the compressor terminal plate inside T-Box. Worn out contactors. Faults with other peripheral electrical loads. Single phasing conditions. 	<ul style="list-style-type: none"> Check voltage supply from the main buss. Check voltage into and out of contactor. Repair or replace contactor if necessary. Measure voltage at the compressor terminal. Check that motor electrical connections are tight at the compressor. Check that there are not any faults with other peripheral electrical loads (for example fan motors).