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## Installation, Operation & Troubleshooting for Texas Instruments 2ACE Motor Protection Modules

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**SUBJECT: Installation Operation & Troubleshooting Texas Instruments (TI) “KLIXON”  
2ACE Motor Winding Protectors**

**APPLICATION: 110mm & 127mm Medium Screw Compressors**

*Hartford Compressors Inc.* is presently offering the optional 2ACE module designed to protect the motor from excessive motor winding temperatures. In addition, the 2ACE module can monitor the motor current as well as the motor winding temperature. See service bulletin # SB19a for information on the TI 41AA modules.

There is presently only one 2ACE module being offered by *Hartford Compressors Inc.* for use in our compressors. Do not attempt to install a substitute with a different TI model number!

HCI Part #	Texas Instruments Part #	Thermister Type
055992A1*	2ACE-2C1	PTC (TI)

\* This part number is for a module only. If ordering a module with a replacement compressor, use kit # 056169A1.

### **KRIWAN MOTOR SENSORS**

Until April 2004, Texas Instrument sensors were used in the motors. In May 2004, we began using Kriwan sensors in the motors. Both sensors are compatible with the TI modules.

### **IDENTIFICATION**

The last two digits of the compressor serial number identify the motor style.

i.e. Serial # DWC-A0123-16 (16) Indicates that this is a Leroy Somer motor with the new style (Kriwan) sensors.

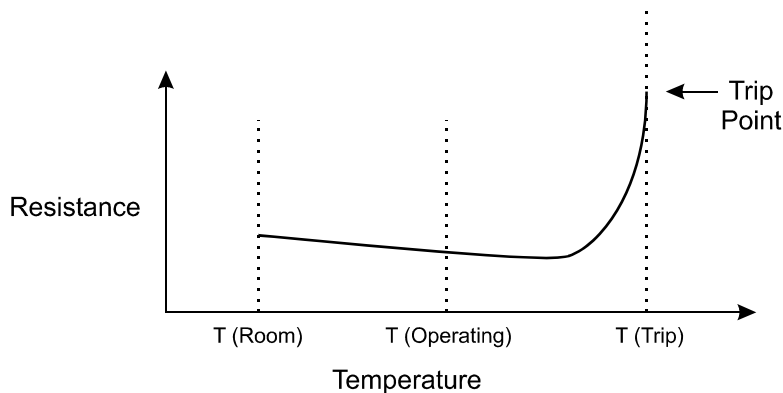
Motors with new sensors will be identified with the numbers **16 – 17** or **18** at the end of the serial number.

### SENSOR RESISTANCE

The following table explains the characteristics of the three types of sensors.

SENSOR	ROOM TEMP 77°F (25°C)	OPERATING TEMP 170°F (76.7°C)	TRIP POINT TEMP AT MODULE 305°F (152°C)
Robertshaw	76 Ω	94 Ω	124 Ω
Texas Instruments	500 - 2500 Ω	< 2,500 Ω	5,000 Ω
Kriwan	10 - 100 Ω	< 100 Ω	13,500 Ω

**Note:** The Texas Instrument 2ACE module cannot read below 200 ohms. To compensate for this when the compressor has Kriwan sensors, 500 – 1000 ohm, 1-watt resistors must be installed in line with the sensor to the module. The TI and the Kriwan sensors will have low resistance readings until just before reaching the trip points. At that point, the resistance will increase rapidly until it reaches the trip point. As seen below the Kriwan sensor will have a lower resistance during operation than it will at room temperature.



### INSTALLATION

Many operating problems can be avoided if the module is properly installed. Here are some helpful hints on installing the module.

#### LOCATION

- Control panel must be well ventilated
- Maximum ambient temperature is 150°F
- Install the module in the electric panel in such a way as to allow the power wires to be installed through the current transformers
- If there are two contactors used for the compressor, it is permissible to run two wires of the same phase through each current transformer

**INSTALLATION AND WIRING MODULE POWER**

- Module input power to terminals **T1** & **T2**
- Input voltage must be between 20 and 28 VAC or 25 and 34 VDC
- Do not ground wires
- To protect the module components, install a ½ amp quick-blow in-line fuse from the power supply

**SENSOR WIRING**

- Wire sensors to **C, S1, S2 & S3**

**Note:** When wiring to Kriwan sensors, install 500 – 1000 ohm resistors in line with the sensor wires.

- The sensor wires must match the motor terminals and the module terminals
- Sensor wires must run in a separate wire conduit from the power wires
- This wire conduit should be installed separately from the main power run

**Note:** “C” is **NOT** a ground. Do **NOT** connect this terminal to any type of ground.

**MODULE RELAY**

- Terminals **M1** & **M2** tie in to a normal open (N/O) relay in the module.
- These terminals are to be wired to the compressor control circuit in such a way as to shut the compressor down if this relay opens. It is recommended that it break the circuit to the compressor contactor coil.

**GENERAL**

- Do not ground any wires
- No jumpers are to be used

**MODULE SETUP**

- Program the must hold amperage (MHA) into the module before energizing the module
- Determine the maximum amperage draw (RLA) of the compressor for the particular application
- The MHA is determined by multiplying the RLA by 1.10
- If the MHA is less than 225 amps, the module can be mounted in either the full line or the half line (for two-step start using two contactors)
- If the MHA is more than 225 amps, the module must be installed with the wires from the lead contactor only
- If wiring only one lead through the module, the module must be set at .5 X MHA

- Once the module setting has been determined, calibrate the module using the 8-position DIP-switch panel in back of the module. The calibration is set using binary logic and can be set in 1 amp increments from 25 to 225 amps. The value of each switch in the “ON” position is tabulated below. Add the values together on the DIP-switches to arrive at the MHA value.

DIP Switch #	1	2	3	4	5	6	7	8
Amp Value	128	64	32	16	8	4	2	1

**Note:** The left position of the DIP-switch is the “ON” position.

- If the 2ACE module is not calibrated with a “Must Hold” setting or is set below the acceptance range, the module will display a “6”
- The module will not function properly until the “Must Hold” setting is calibrated correctly

## MODULE COMMUNICATIONS

- The 2ACE module can be used to supply a control microprocessor with current information hereby eliminating the need for separate current transducers
- The module produces a proportional, load independent 0 to 5 VDC output that is linear over its full-scale range of 0 to 225 amps
- The output voltage value and the input current value are related by  

$$\text{VDC Value (output)} = \text{Amperage Value (Input)} / 45$$
- The module responds to the average AC current and incorporates full-scale signal conditioning of the transducer to produce a low ripple DC output voltage signal direct into the microprocessor without requiring a filter conditioning board
- The 2ACE module is connected the control microprocessor from terminals “B” (Positive) and “G” (Ground)

## OPERATION

The 2ACE module functions in conjunction with sensors that are imbedded in the motor windings

- The sensors are positive temperature coefficient (PTC) thermistors
- Three sensors are connected for normal operation
- On newer compressors the 4<sup>th</sup> sensor is wired to the opposite terminal board as a spare It is designated S4
- If there is no S4 designation on the other terminal board, the spare sensor is installed inside the compressor behind the terminal board

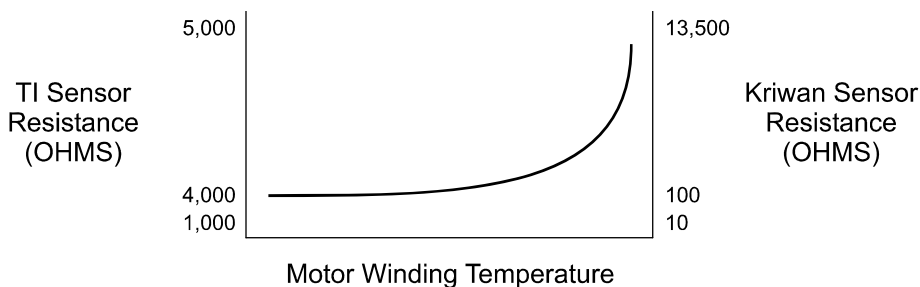
- They are preset to trip at a predetermined temperature

COMPRESSOR	TRIP POINT
MSC	302°F (150°C)

- The module senses the resistance of the sensors
- When the motor winding temperature reaches the set point, the module opens a set of contacts between terminals M1 and M2
- These are wired to the compressor's control circuit shutting down the compressor. In order to reset the module, the power to the module must be interrupted.
- This is normally accomplished with a normally closed (N/C) push button.
- Refer to the attached wiring diagram showing the recommended method of wiring the control.

When reading the sensor resistance, the sensor wires **MUST** be disconnected from the control module. Otherwise an erroneous reading will result.

- During shutdown, after the motor has cooled, the TI thermistors will read from 500 to 2500 ohms (Kriwan sensors will read 10 – 50 ohms)
- At the normal operating temperature (170°F), they will read < 5000 ohms (<13,500 ohms for Kriwan sensors)
- As the temperature approaches the set point, their resistance will increase rapidly until, at the trip point, they will read >5000 ohms (13,500 ohms for Kriwan sensors)



**Note:** When troubleshooting, it is important to realize that, once the compressor shuts down, the motor winding temperature will decrease rapidly and the resulting PTC resistance will also drop rapidly. For this reason, all resistance readings should be taken as soon as possible after the module trips.

- When the module has been calibrated, wired and energized, it utilizes the LED display to provide operating status and fault diagnostic information

- Under normal circumstances, before the compressor is started, the LED display will flash different displays to show the “Must Hold” setting of the module
- For example, if the MHA setting is 123 amps, the display will flash **H, A, 1, 2, 3**

### **TROUBLESHOOTING**

- The 2ACE module will reset automatically if supply power is lost and regained
- For all other faults, the module will not reset automatically
- To reset the module, the power to the module must be interrupted
- As mentioned earlier, this is normally accomplished with a normally closed (N/C) push button
- Refer to the attached wiring diagram showing the recommended method of wiring the control

### **NORMAL CAUSES OF HIGH MOTOR WINDING TEMPERATURES**

- The LED display on the module will show a numbered code when the compressor is operating.
- There are nine different codes that can be displayed in addition to the “Must Hold” display when the compressor is not operating. Each is self-explanatory.

<b>DISPLAY</b>	<b>DEFINITION</b>
0	Normal - No Fault - Module ON - Compressor ON
1	Fault - Current Overload
2	Fault - Loaded unbalance/phase loss: >17% unbalance. Current >.65% MHA
3	Fault - Unloaded unbalance/phase loss: > 25% unbalance, 65%MHA >Current > 40% MHA
4	Fault - Improper phase sequence/miswire
5	Fault - Over-temperature
6	Fault - Out of range of MHA calibration
7	Fault - Unloaded unbalance/phase loss: >50% unbalance, < 40% MHA
8	Fault - Phase loss: > 60% unbalance

- If the compressor shuts off on one of the faults read the LED display and correct the fault.
- If there is no display on the module LED display, de-energize the module for five minutes and restart. The display should come back on and function normally.
- If the motor is overloaded, the amperage will increase resulting in a rise in motor winding temperature above the normal operating temperature.
- A large voltage imbalance will cause the amperage to rise abnormally resulting in an increase in the motor winding temperature. The phase to phase voltage imbalance should not exceed 2%.

- Normally, on air-cooled installations, the motor is indirectly cooled using liquid injection. When the package goes into a “pumpdown” mode, the liquid injection shuts off. This may allow the motor windings to approach the trip point and trip the module even though the compressor has actually shut down. The solution would be to install a separate liquid injection line with solenoid or limit the pumpdown time.

### **OTHER CAUSES OF MOTOR WINDING PROTECTOR MODULE TRIPS**

It has been our experience that, being a solid state control, the module can be susceptible to nuisance trips. We have listed some other problems that may cause the module to trip.

- Loose wires. All wire connections must be tight. Check all connections, especially the thermistor wires.
- Check the module power supply. It must be between 20 & 28 VAC or 25 & 34 VDC.
- Check control voltage quality. Sudden spikes in the supply power can cause the module to trip.
- Stray Voltages: The sensor wires must be run in a separate conduit from the main power wires. If run in the conduit with the main power wires, the voltage from the power can cause erratic readings of the sensors.
- Defective sensor. If one of the sensors is defective, it can give a “trip” signal to the module.
- In rare instances, a sensor may appear to be operating correctly but it will open shortly after the compressor starts.
- Follow the instructions for troubleshooting a sensor that opens sporadically.
- If a sensor is determined to be defective there are two solutions to remedy the problem. See section on repairing a defective sensor.
- High Ambient temperatures. If the module is subjected to temperatures in excess of 150°F, it will trip. There may or may not be a display on the module when this happens.

### **LOCATING A SENSOR THAT OPENS SPORADICALLY**

In rare cases, a sensor will only open when the compressor runs. It will close again when the compressor is shut down. Use the following instructions to find the defective sensor.

When running these tests; closely monitor temperatures and pressures to be sure that the compressor motor does not overheat. It is recommended that a thermometer be installed on the discharge line within 6" of the compressor. The discharge line temperature should not be allowed to go above 170°F.

1. With the compressor shut down and wired normally, install three, 1000 ohm resistors in the module between terminals C and S1, C and S2, C and S3.
2. Run the compressor normally for, between 30 and 60 minutes.
3. If the module trips, the module is bad.
4. If the module does not trip the compressor, remove the resistor between C and S1. Connect wires C and S1 between the compressor and the module
5. Run the compressor for another 30 to 60 minutes.
6. If the module trips, that sensor is bad. Replace the resistor.
7. Shut down the compressor and repeat steps 4, 5 & 6 with sensors S2 and S3.
8. Once you have determined which sensor(s) is bad, continue with the following repairs

**REPAIRING DEFECTIVE SENSORS**

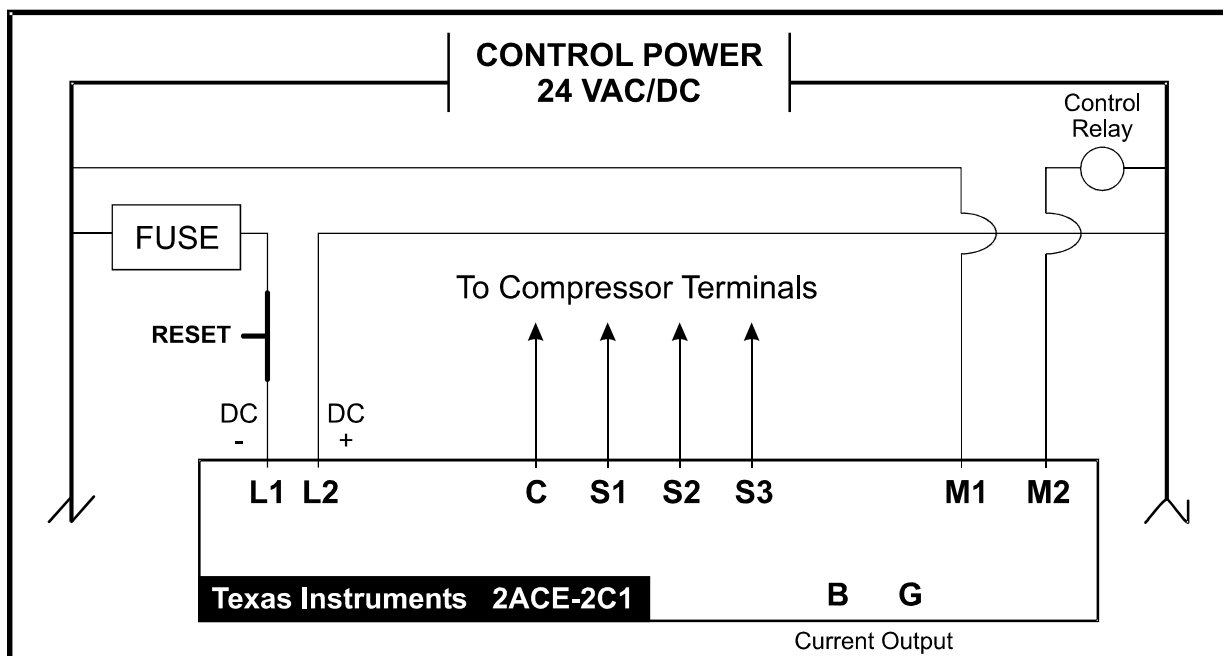
If a temperature sensor is determined to be defective there are two accepted solutions to the problem. The first is to use the spare sensor. The second is to jump out the defective sensor.

**USING THE SPARE SENSOR**

- On newer 127mm compressors built after 2003, there is an installed spare sensor. Between the power terminals there are two 4-post terminal boards. The right hand board has the 4 connectors for the motor sensors. The left hand board has one terminal designated S4. This is the spare sensor.
- If there is no S4 terminal designation, there may be a spare sensor tied behind the right hand board. Call HCI Application Engineering department with the compressor serial number to see if there is a spare sensor installed in the compressor.
- There is a kit available to utilize the spare sensors that are installed inside the compressor. This kit contains a terminal plate o-ring, shrink insulation, a wire tie and instructions. The instruction sheet gives detailed instructions on how to use to the spare sensor.
- If the spare sensor is used, it is recommended that a note be placed on the outside to inform future Service Technicians.

**SENSOR REPLACEMENT KIT: # 055047A1**

- If, after using the spare sensor, there is still a defective sensor, contact HCI Application Engineering Department for further instructions


**TYPICAL WIRING DIAGRAM (2ACE)**