# Application Engineering

## The Electronic Motor Protector

**BULLETIN NO:** AE10-1264 R12

## Contents



COPELAND

# Safety

## Important Safety Information

Those involved in the design, manufacture, and installation of a system, system purchasers, and service personnel may need to be aware of hazards and precautions discussed in this section and throughout this document. OEMs integrating the compressor into a system should ensure that their own employees follow this bulletin and provide any necessary safety information to those involved in manufacturing, installing, purchasing, and servicing the system.

## Responsibilities, Qualifications and Training

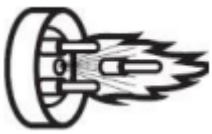
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• OEMs are also responsible for ensuring that all product, service, and cautionary labels remain visible or are appropriately added in a conspicuous location on the system to ensure they are clear to any personnel involved in the installation, commissioning, troubleshooting or maintenance of this equipment.

• Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission, troubleshoot and maintain this equipment. Electrical connections must be made by qualified electrical personnel.

• Observe all applicable standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment.

## Terminal Venting and Other Pressurized System Hazards



If a compressor's electrical terminal pin loses its seal, pressurized oil, refrigerant, and debris may spray out. This is called "terminal venting".

The ejected debris, oil, and refrigerant can injure people or damage property. The oil and refrigerant spray can be ignited by electrical arcing at the terminal or any nearby ignition source, producing flames that may project a significant distance from the compressor. The distance depends on the pressure and the amount of refrigerant and oil mixture in the system. The flames can cause serious or fatal burns and ignite nearby materials.

Each compressor has a terminal cover or molded plug that covers electrical connections. The cover or plug helps to protect against electric shock and the risks of terminal venting. If terminal venting occurs, the cover or plug helps contain the spray of refrigerant and oil and reduces the risk of ignition. If ignition occurs, the plug or cover helps contain the flames. However, neither the terminal cover nor the molded plug can completely eliminate the risk of venting, ignition, or electric shock.

See copeland.com/terminal-venting for more details about terminal venting. Additionally, a compressor's refrigerant lines keep refrigerant and oil under pressure. When removing or recharging refrigerant from this component during service, this can pose a pressurized fluid hazard.

## Flammable Refrigerant Hazards

If flammable refrigerant is released from a system, an explosive concentration can be present in the air near the system. If there is an ignition source nearby, a release of flammable refrigerant can result in a fire or explosion. While systems using flammable refrigerant are designed to mitigate the risk of ignition if the refrigerant is released, fire and explosion can still occur.

See copeland.com/flammable-refrigerants for more information on flammable refrigerant safety.

## Electrical Hazards

Until a system is de-energized, and capacitors have been discharged, the system presents a risk of electric shock.

## Hot Surface and Fire Hazards

While the system is energized, and for some time after it is deenergized, the compressor may be hot. Touching the compressor before it has cooled can result in severe burns. When brazing system components during service, the flames can cause severe burns and ignite nearby combustible materials.

## Lifting Hazards

Certain system components may be very heavy. Improperly lifting system components or the compressor can result in serious personal injury. Use proper lifting techniques when moving.

## POE Oil Hazards

This equipment contains polyol ester (POE) oils. Certain polymers (e.g., PVC/CPVC and polycarbonate) can be harmed if they come into contact with POE oils. If POE oil contacts bare skin, it may cause an allergic skin reaction.

## Precautions

• Always wear personal protective equipment (gloves, eye protection, etc.).

• Keep a fire extinguisher at the jobsite at all times.

• Keep clear of the compressor when power is applied.

- IMMEDIATELY GET AWAY **if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.**

• Never reset a breaker or replace a blown fuse without performing appropriate electrical testing

- **A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault.**

• Disconnect power and use lock-out/tag-out procedures before servicing.

- Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (Note: The system may have more than one power supply.)

- Discharge capacitors for a minimum of two minutes

- Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.

• Allow time for the compressor to cool before servicing.

- Ensure that materials and wiring do not touch high temperature areas of the compressor.

• Keep all non-essential personnel away from the compressor during service.

• For A3 refrigerants (R290) remove refrigerant from both the high and low sides of the compressor. Use a recovery machine and cylinder designed for flammable refrigerants. Do not use standard recovery machines because they contain sources of ignition such as switches, high- and low-pressure controls and relays. Only vent the R290 refrigerant into the atmosphere if the system is in a well-ventilated area.

• Never use a torch to remove the compressor. Only tubing cutters should be used for both A2L and A3 refrigerants.

• Use an appropriate lifting device to install or remove the compressor.

• Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.

• Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.

• Charge the system with only approved refrigerants and refrigeration oils.

• Keep POE oils away from certain polymers (e.g., PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.

• Before energizing the system:

1. Securely fasten the protective terminal cover or molded plug to the compressor, and

2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

## Signal Word Definitions

The signal word explained below are used throughout the document to indicate safety messages.


**DANGER** indicates a hazardous situation which, if not avoided, will result in death or serious injury.


**WARNING** indicates a hazardous situation which, if not avoided, could result in death or serious injury.


**CAUTION**, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

# Introduction

Copeland compressors using solid state protection have PTC (Positive Temperature Coefficient) internal sensors with an avalanching resistance in the event of high temperatures. The sensors are calibrated for proper motor protection.

The supplier is Kriwan Industrie-Elektronic GmbH. The Kriwan modules (INT369R and the new INT 369Diagnose) and sensors are UL recognized and are identical in performance, fit, and function. No wiring changes are required with either module. They have passed all tests for equivalency and reliability. The part number wholesalers purchase will not change, but the module part number in that kit may change. All Texas instruments (TI), and Robertshaw were obsoleted (2004). Also any previous Robertshaw system with low resistance sensors (MP13,23, and 33) has been obsoleted (1981).

The solid-state modules have been developed to interpret the sensors resistance. The modules Kriwan INT369B/C/R, INT369B/C/R/Diagnose, TI 41AA1600E, 31AA1600E and TI 15AA1600B/C, or Robertshaw MP50 and 3450 are electrically interchangeable. If replacing one of the older style modules with a new Kriwan INT369R or INT 369Diagnose, TI 41AA1600E, or 31AA1600E an adapter plate, and a wiring harness is required. These will be included with the new module kit.

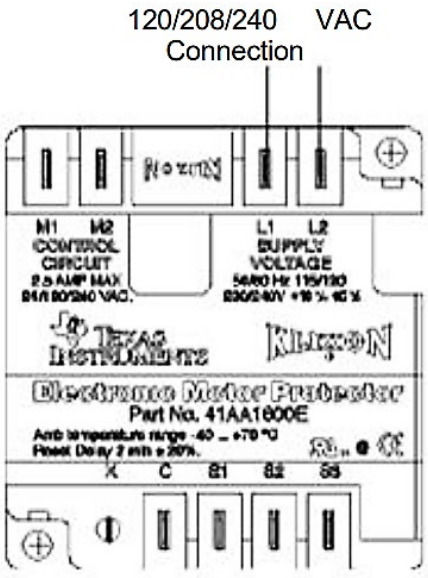
| 998-0524-10 Module Kit | |
|---|---|
| 071-0581-00 or -04 | INT 369R or INT 369Diagnose |
| 003-0764-00 | Adaptor Plate |
| 929-0001-01 | Wire Harness |

## Supply Voltage

The Kriwan INT369 series modules and the 41AA will accept 120/208/240 vac without the use of a jumper connection. See **Figures 1** and **2**. These modules utilize a transformer power supply design, which simplifies installation by eliminating the need to use a jumper wire to select between a 120v or 240v power supply. This upgrade also yields a significant improvement over the old design in its ability to compensate for large voltage fluctuation spikes that could occur. In the past there have been in certain situations, problems with nuisance tripping of the module due to motor noise generation in specific locations. Through extensive laboratory and field testing the nuisance tripping has been eliminated thus providing reliable service.

*Figure 1 INT369R (left) and INT369Diagnose (right)*


*Figure 2 41AA Wiring Connections for Module*




The TI 31AA requires a jumper connection to accept either 120 vac or 208/240 vac! **See Figures 3** and **4**. All other modules require two models, one for 120VAC and another for a 208/240 VAC power source.

*Figure 3 31AA Wiring Connections*

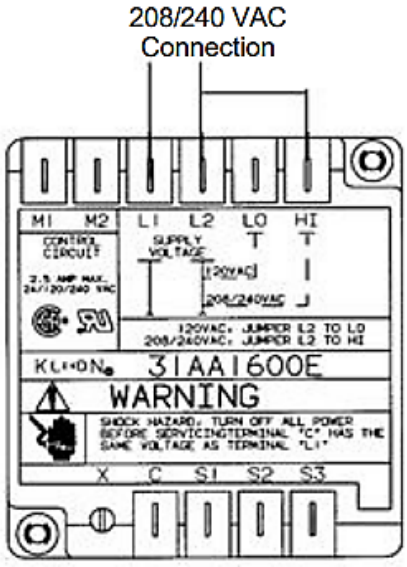
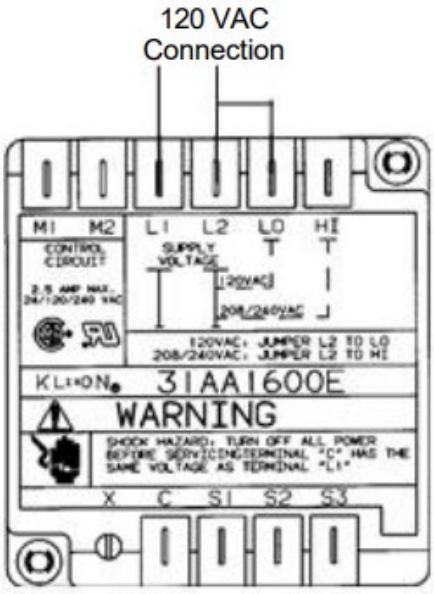



*Figure 4 31AA Wiring Connections*




## Control Specification for Kriwan Sensors and Kriwan INT369R Modules

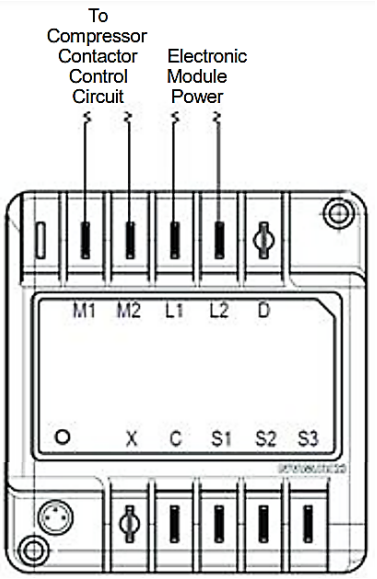
The resistance of the sensor will vary from 30 ohms (cold) to 20,000 ohms (hot). Reset values after a protector trip are from 2700-4500 ohms. The three sensors have one lead connected to form a common connection point (C). The other leads are connected to a separate terminal (S1, S2, and S3).

The modules can time out from the following conditions:

- High Motor Temperature
- Low Line Voltage to Module
- Power Outage

## Module Electrical Connections

*Figure 5 Wiring Connections for Module*




**M1 - M2 Compressor Contactor Control Circuit 2.5A Max 600VA.**

When the proper voltage is present, and the motor temperature is within limits the “M1-M2” circuit is closed, and the pilot circuit is energized after the two minute off-cycle time delay. If the motor temperature rises beyond safe limits, the resistance of the motor sensors rises, causing the control circuit to open.

**L1 - L2 Module Supply Line Voltage 120/208/240 VAC**

These are to be connected to a power source of the proper voltage, normally the line terminals on the compressor motor contactor or the control circuit transformer as

required. The power requirement is very low, approximately 6 VA.

**S1 - S2 - S3 Motor Sensor Connections C Common Lead Motor Sensors**

**D Demand signal (optional, not required)**

| Spec | (120 v) | (240 v) |
|---|---|---|
| Line Voltage | 120 +10% -20% 50/60 HZ | 208/240 +10% -15% 50/60 HZ |
| Low Voltage Trip | 85 VAC +/- 5.5 VAC | 170 VAC +/- 10 VAC |
| Low Voltage Reset | < 94.5 VAC | < 184 VAC |
| Low Voltage Responds | .20 +/- 15 secs | Same |
| Trip Resistance | 13k +/- 3k ohms | Same |
| Reset Resistance | 3.25k +/- .5k | Same |
| Resistance responds | .3 +/- .2 Secs. | Same |
| Trip Time | 120s +/- 20s | Same |
| Temperature Range | -40 ºF to 158 ºF | Same |
| Relay Contact Rating | 2.5 amps 600VA | Same |

## Control Specification for T.I. Sensors Using the 41AA, 31AA, 15AA, or the Mp50 (Before 2004)

1 The resistance of the sensor will vary from 500 ohms (cold) to 20,000 ohms (hot). Reset values after a protector trip are from 2700-4500 ohms. The three sensors have one lead connected to form a common connection point (C). The other leads are connected to a separate terminal (S1, S2, S3).

2 Low Voltage Cut-Out:

a) 120 VAC module: Cut-Out Voltage 85 ±4.5 Volts in normal ambient. Cut-In Voltage 4 Volts above cut-out. Low Voltage response delay 0.2 ±15 seconds.

b) 208/240 VAC module: Cut-Out Voltage 170 ± 8 Volts in normal ambient Cut-In Voltage 5 Volts above cut-out.

c) Dual voltage (TI 31AA module)120VAC or 208/240 VAC. Depending on the voltage supplied, 120 VAC or 208/240 VAC, the low voltage cutout of the 31AA is the same as either 2.a., or 2.b.

d) Dual voltage (TI 41AA module)120/208/240 VAC depending on the voltage supplied,120 VAC or 208/240 VAC, low voltage cut out of the 41AA is as follows

i) 120 VAC module: cut-out voltage 85 +/-5.5 volts in normal ambient, cut-in voltage 3 volts above cut-out. Low voltage response delay 0.2 +/-15 secs.

ii) 280/240 VAC module: cut-out voltage 170 +/-10 volts in normal ambient, cut-in volt- age 3 volts above cut-out voltage.

Note: Normal ambient conditions. (59 °F to 89.6 °F)15 °C to 32 °C

3 Off cycle timer 120 second ±15%with normal ambient

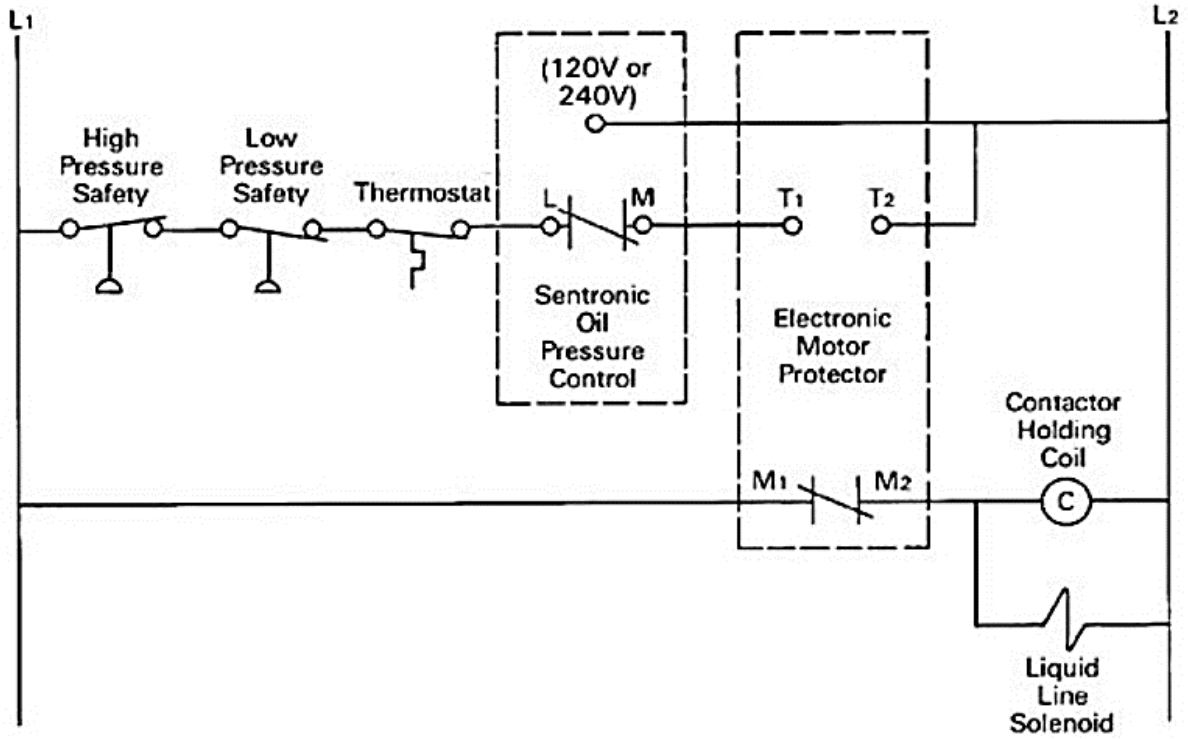
4 The output device, the triac (TI 15AA) or the relay (TI 31AA, TI 41AA, Robertshaw, or Kriwan) has a rating of 2.5 amps 24 VAC to 240 VAC.

## Basic Motor Protection

The solid-state sensor protectors provide excellent protection against high motor temperatures resulting from locked rotor, loss of charge, or motor overload. The combination of low voltage sensing and time delay provide positive protection against low voltage conditions which

can occur in the pilot circuit in the event of a single-phase condition on a three-phase circuit. Field experience indicates that under these single-phase conditions, the control voltage can fall to a level that will cause the contactor to drop out. Removing the compressor from the line can allow the voltage to increase enough to again pull in the contactor, setting up a cycle of contactor chatter that can destroy either the contactor or the compressor or both. The low voltage protection feature removes the compressor from the line in the event of low voltage (“brown- out”) conditions. The module locks the compressor off the line until the voltage rises to the cut-in setting. The time delay provides a two-minute delay before restarting each time the power circuit is opened, providing protection against “blips” in the power supply or a chatter condition in the line power circuit. Service and test personnel must be alert to this Basic Motor Protection. The solid-state sensor protectors provide excellent protection against high motor temperatures resulting from locked rotor, loss of charge, or motor overload. The combination of low voltage sensing and time delay provide positive protection against low voltage conditions which can occur in the pilot circuit in the event of a single-phase condition on a three-phase circuit. Field experience indicates that under these single-phase conditions, the control voltage can fall to a level that will cause the contactor to drop out. Removing the compressor from the line can allow the voltage to increase enough to again pull in the contactor, setting up a cycle of contactor chatter that can destroy either the contactor or the compressor or both. The low voltage protection feature removes the compressor from the line in the event of low voltage (“brown- out”) conditions. The module locks the compressor off the line until the voltage rises to the cut-in setting. The time delay provides a two-minute delay before restarting each time the power circuit is opened, providing protection against “blips” in the power supply or a chatter condition in the line power feature since it is possible in checking the compressor or system, power may be applied, disconnected, and reapplied in less than two minutes. In such case the time delay feature will prevent operation until the time delay has expired, and this may be misinterpreted by service personnel as a module malfunction.

If the system design is such that the operating controls are wired to the module power circuit, the time delay will provide two-minute short cycle protection. If the system refrigerant charge is small enough so that a pump down control circuit is not required, the control devices may be



mounted in the line circuit as in Figure 6. This provides the maximum electrical protection against short cycling or contactor chattering. With larger refrigerant charges (see AE22-1182), a pump down system is essential to protect the compressor against liquid refrigerant. Figure 7 shows a typical circuit, with the liquid line solenoid wired through the protectors to prevent refrigerant migration in the event of a protector trip. This circuit uses the Sentronic oil pressure switch with its jumper from “L” to “2” removed so the Sentronic control switch (“L “to “M “) can be isolated from its control circuit power connections (“L “and “120 “or “240 “). The time delay would be energized in the event of a short circuit protector trip, low voltage, or a break in the power supply to the module. The time delay is not energized on opening of the high- or low-pressure switches. Since it is not connected in the “T1 -T2” power circuit.

## Solid State Components

There are two major components in the protection system.

1 The protector sensors are mounted internally in the motor windings. The characteristics of the sensor are such that a change in temperature causes a change in the sensor’s electrical resistance, the relation between temperature and resistance remains stable and exact, so that calibration of the protection system can be made based on resistance readings.
2 The control module is a sealed enclosure containing a relay or triac, transformer, and several electronic components. Leads from the internal motor sensors are connected to the module as shown on the wiring diagrams. While the exact internal circuitry is quite complicated, basically the module senses the change in resistance of the sensors. As the motor temperature rises or falls, the resistance also rises or falls, triggering the action of the control circuit at predetermined opening and closing settings.

The TI 41AA and the TI 31AA module may be used on either 120 VAC or 208/240 VAC. All other modules must have separate models for 120 VAC and 208/ 240 VAC. Any module output device can handle pilot circuit voltages from 24 V to 240 VAC, since there is no internal connection between the output device circuit and the line power connection.

The solid-state module cannot be repaired in the field, and if the cover is opened or the module physically damaged, the warranty on the module is voided. No attempt should be made to adjust or repair this module, and if it becomes defective, it must be returned intact for warranty replacement.

## High-Potential (Hi-Pot) Testing

The solid-state sensors and the electronic components in the solid-state module are delicate, and can be damaged by exposure to high voltage. Under no circumstances should a high potential test be made at the sensor terminals with the sensor leads connected to the solid-state module. Even though the power and pilot circuit leads are not connected, the module can be damaged.

## Field Troubleshooting

In the event the motor compressor is inoperable or is not operating properly, the solid-state control circuit may be checked as follows:

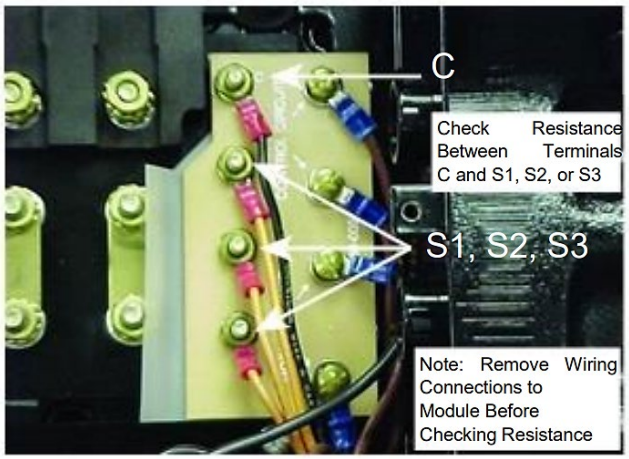
1 If the compressor has been operating and has tripped on the protector, allow the compressor to cool for at least one hour before checking. This allows time for the motor to cool and the control circuit to reset.

**WARNING**

***BEFORE CHECKING THE TI 31AA MODULE OR ITS ATTACHED SENSOR WIRING, BE AWARE THAT THE SENSOR TERMINAL “C “, HAS THE SAME VOLTAGE AS TERMINAL”L1 “!***

2 Disconnect control circuit power to de energize the module. Connect a jumper wire across the “control circuit (“M1-M2”) terminals on the module control circuit terminal board. This will bypass the “control contact” of the module.
3 Reconnect control circuit power. If the compressor will not operate with the jumper wire installed, then the problem is external to the solid-state protection system. If the compressor operates with the module bypassed but will not operate when the jumper wire is removed, then the control circuit relay or triac in the module is open.

4 If after allowing time for motor cooling, the protector remains open, the motor sensors may be checked as follows (see Figure 8):



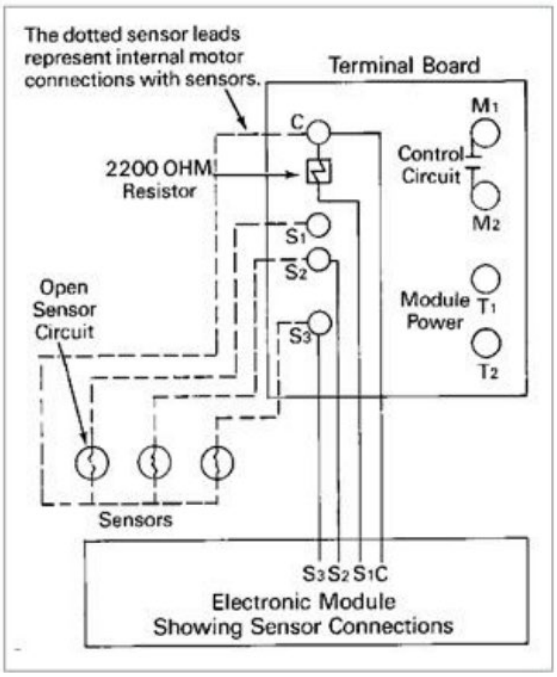

- Disconnect control circuit power to de energize the module. Remove the jumper of Step 2. Remove wiring connections from the sensor and common terminals on the module control circuit terminal board.
- CAUTION: Use Ohmmeter with a maximum 9 VAC for checking. The sensors are sensitive, easily damaged, and no attempt should be made to check continuity through them with other than an ohmmeter. Any external voltage or current applied to the sensors may cause damage requiring compressor replacement.
- Measure the resistance from each sensor terminal to the common terminal. The resistance should be in the following range: 30 ohms Kriwan post year 2004 or 500 ohms pre year 2004 T.I. sensors (cold) to 20,000+ ohms (hot compressor tripped!)

  Resistance readings in this range indicate the sensors are good. A resistance approaching zero indicates a short; a resistance approaching infinity indicates an open connection. Proper operation of the control system is dependent on a continuous parallel circuit through all three sensors with no individual resistance reading higher than 10,000 ohms. On initial start-up, and after any module trip due to high temperatures, the resistance of the sensors must be below the module reset point before the module circuit will close. Reset values are 2700-4500 ohms.

5 If the sensors have the proper resistance, and are below 2700 ohms, the compressor will run with the control circuit bypassed, but will not run when connected properly, the solid-state module is defective and must be replaced. The replacement module must be the same voltage and be compatible with the original module on the compressor.

## Emergency Bypass of a Damaged Solid-State Sensor

In the unlikely event that ONE sensor may be damaged and have an open or shorted circuit, the control module will prevent compressor operation even though the motor may be in perfect condition. If such a situation should be encountered in the field, an emergency means of operating the compressor can be used until such time as a replacement can be made. Disconnect the lead from the solid-state module and the faulty module control circuit terminal board sensor connection; S1, S2 or S3. Connect a properly sized resistor between the solid-state module lead and the common sensor terminal in the compressor terminal box. This indicates to the control module an acceptable resistance in the damaged sensor circuit, and compressor operation can be restored (see Figure 9).

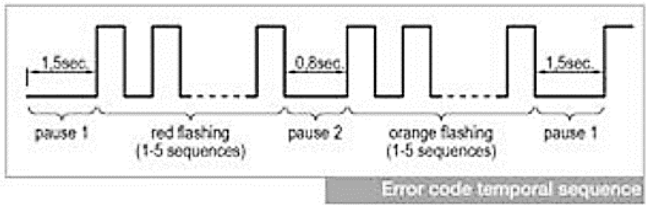



If an internal sensor is shorted, the wire from the sensor to the sensor terminal should be disconnected when installing the resistor. In effect, the compressor will

continue operation with two leg protection rather than three leg protection. While this obviously does not provide the same high degree of protection, it does provide a means of continuing compressor operation with a degree of safety. The protector cut-in and cut-out points will be reduced by approximately 7°F to 10°F, but under normal operating conditions this should present no problem.

Note: At no time should more than one motor sensor be bypassed.

The specifications for the emergency resistor are as follows: One watt (or larger), 2200 ohm ±10% resistor.



Error code temporal sequence

## Overview Flash Code

| | |
|---|---|
| Green Lit | Compressor operational |
| Green Flashing | Compressor running |
| Red/Orange Flashing | Error, compressor is switched off; for error code, see table to the right |

| Error Category | 1st Flashing Sequence (Red LED | 2nd Flashing Sequence (Orange LED) | Error Status |
|---|---|---|---|
| Motor Temperature | 1 | 1 | Nominal response temperature of motor was exceeded |
| | | 2 | Switch off due to locked rotor |
| | | 3 | Time delay active after motor temperature default |
| | | 4 | Sensor fault motor PTC |
| | | 5 | Time delay active after locked rotor |
| General | 3 | 1 | Module undervoltage |
| | | 5 | Time delay active, category general |

## Flash Code

The KRIWAN flash code allows for a quick and easy status display and troubleshooting.

The error code consists of a red and orange pulse frequency. They are continually displayed after each other. There is a 1.5 second pause before the red pulse sequence. There is a 0.8 second pause between the red and orange pulse sequences.

The error code can be determined from the number of pulsing flashes.

**Revision Tracking R12**

The document format has been updated to the new Copeland format
All occurrences of "Emerson" have been removed
A note regarding A3 and R290 venting has been updated