

AE10-1264-R8

THE ELECTRONIC MOTOR PROTECTOR

Revised June, 2004

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.

Copeland will be phasing in a new supplier for solid state modules and sensors semi-hermetic reciprocating compressors. The new supplier will be Kriwan Industrie-Elektronik GmbH. The new Kriwan modules (INT369R) and sensors are UL recognized and are identical in performance, fit, and function. No wiring changes are required. They also passed all tests for equivalency and reliability. The change to Kriwan sensors in 4D/6D new production compressors will begin in September 2003, through the summer of 2004. The part number wholesalers purchase will not change, but the module part number in that kit will change as this transition occurs. All Texas instruments (TI), and Robertshaw will be obsolete (2004). Also any previous Robertshaw system with low resistance sensors (MP13,23,and 33)has been obsoleted (1981).

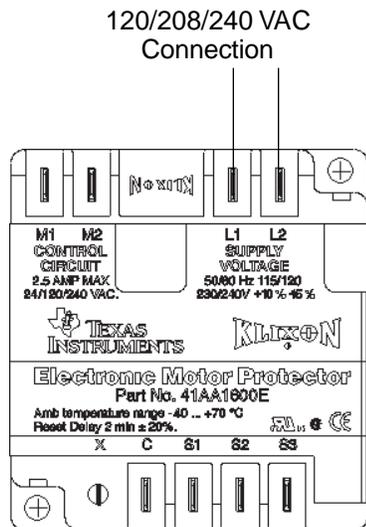
The solid state modules have been developed to interpret the sensors resistance. The modules Kriwan INT369B/C/R, TI 41AA1600E, 31AA1600E and TI 15AA1600B/C, or Robertshaw MP50 and 3450 are electrically interchangeable. If replacing one of the older style modules with a new Kriwan INT369R, TI 41AA1600E, 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

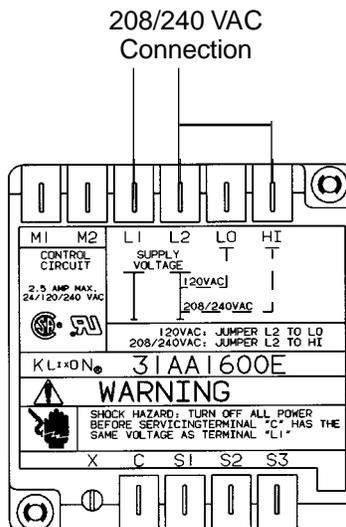
071-0581-00	Kriwan Module INT369R
003-0764-00	Adaptor Plate
929-0001-01	Wire Harness



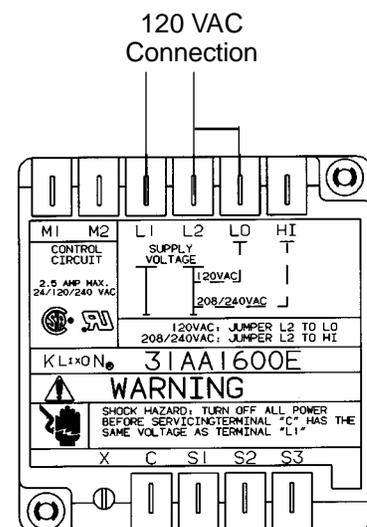
INT369R  
Figure 1



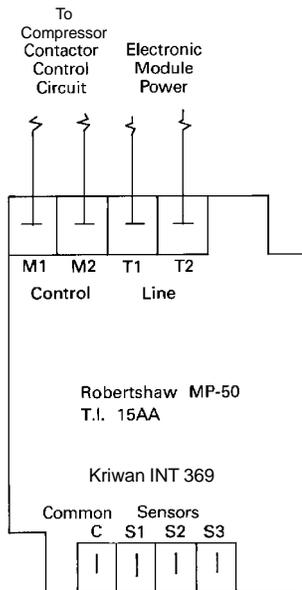
41AA Wiring Connections For Module  
Figure 2



31AA Wiring Connections For Module  
Figure 3



31AA Wiring Connections For Module  
Figure 4



**Wiring Connections For Module  
Figure 5**

### Supply Voltage

The Kriwan INT369R and the 41AA will accept either 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.

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

### Control Specification for Kriwan Sensors and Kriwan INT369R Module. (After 2004)

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 together 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 follow conditions:

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

### Module Electrical Connections (See Figure 5)

**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.

### INT369R # 071-0581-00

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 °F to 158 °F	Same
Relay Contact Rating	2.5 amps 600VA	Same

**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**

**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 together to form a common connection point (C). The other leads are connected to a separate terminals (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 cut-out 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

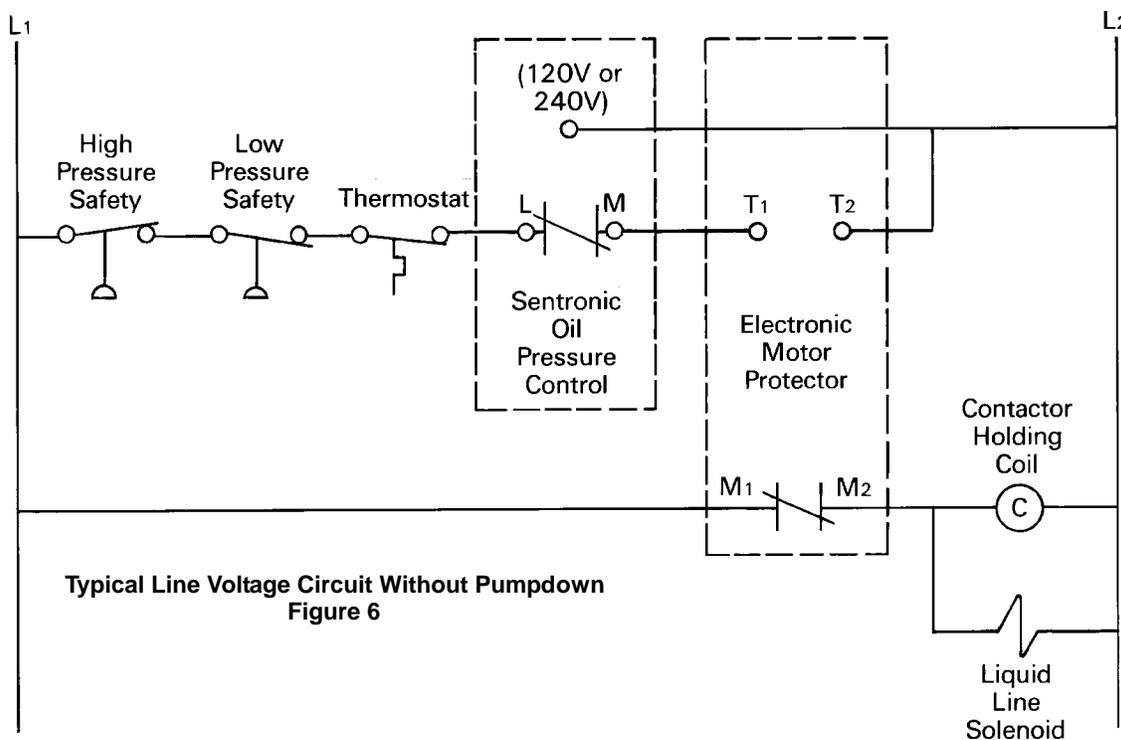
i. 120 VAC module: cut-out voltage 85 +/-5.5 volts in normal ambient, cut-in voltage 3 volts above cut-out. Low voltage response delay 0.2 +/-15 secs.

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



Typical Line Voltage Circuit Without Pumpdown  
Figure 6

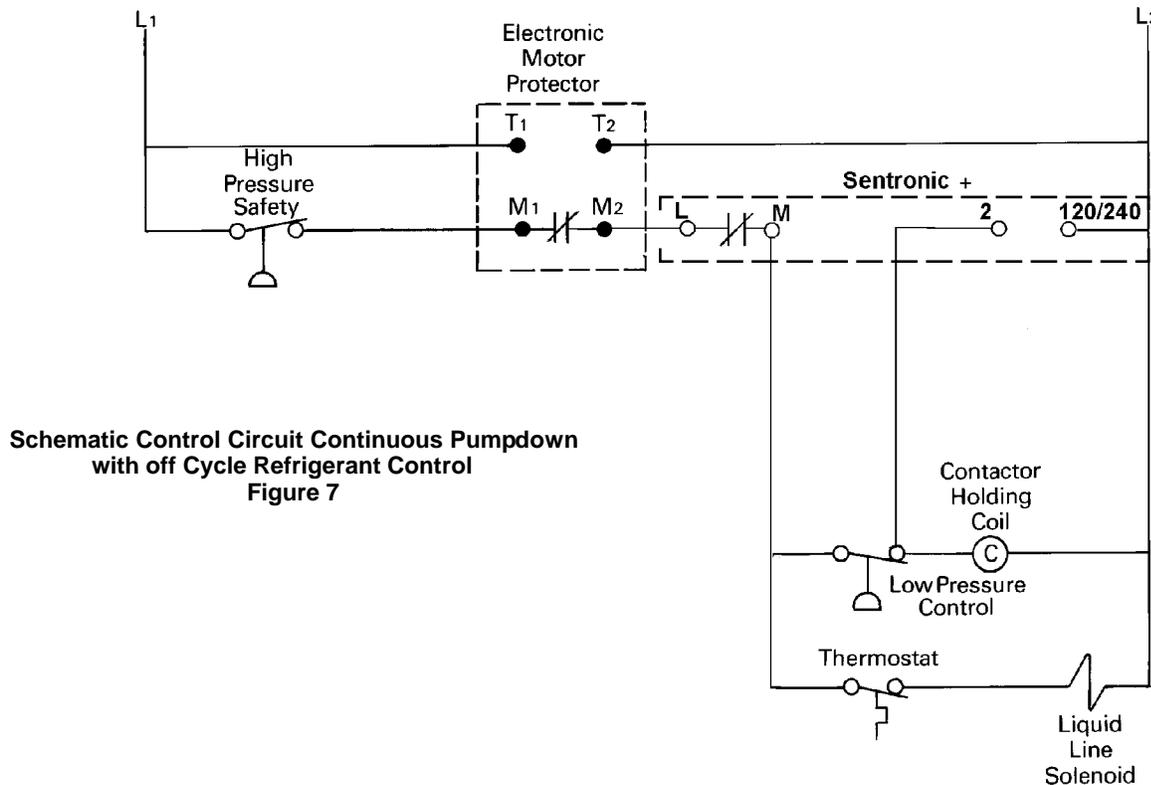
### Basic Motor Protection

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 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 **AE Bulletin 22-1182**), a pumpdown 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.



Schematic Control Circuit Continuous Pumpdown with off Cycle Refrigerant Control  
Figure 7

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 on the basis of 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 also 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.

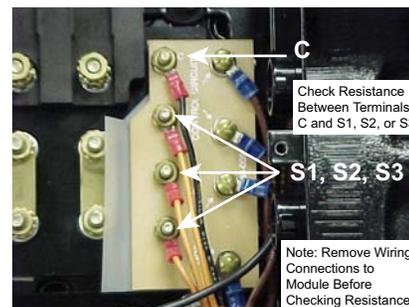
### Field Trouble Shooting

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 still remains open, the protector sensors may be checked as follows (**see Figure 8**):
  - a. 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.
  - b. **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



**Checking Resistance Through Solid State Sensors**  
Figure 8

an ohmmeter. Any external voltage or current applied to the sensors may cause damage requiring compressor replacement.

- c. 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.

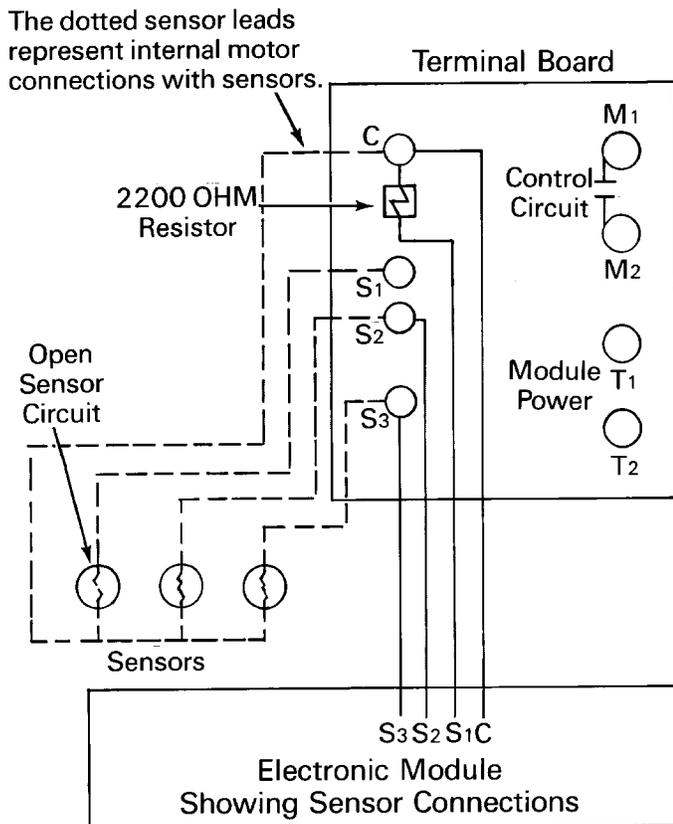
**Emergency Bypass of a Damaged Solid State Sensor**

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



**Emergency Bypass of Damaged Solid State Sensor**  
Figure 9