169

MOTOR MANAGEMENT RELAY

Instruction Manual

Software Rev: 169.E7.5

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INTENT

This manual describes the function, operation and use of the GE Power Management Model 169 and 169 Plus Motor Management Relays.

REVISION HISTORY

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1601-0003-A1	- Rev. 169.E7.2	10/12/93
1601-0003-A2	- Rev. 169.E7.2	01/23/95
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1 INTRODUCTION

1.1 Motor Protection Requirements

Three phase AC motors have become standard in modern industry. These motors are generally rugged and very reliable when used within their rated limits. Newer motors, however, tend to be designed to run much closer to these operational limits and thus, there is less margin available for any type of abnormal supply, load, or operating conditions.

To fully protect these motors, a modern protective device is required. Accurate stator and rotor thermal modeling is necessary to allow the motor to operate within its thermal limits and still give the maximum desired output. As well, other features can be incorporated into a modern relay to fully protect the motor, the associated mechanical system, and the motor operator from all types of faults or overloads.

Motor thermal limits can be exceeded due to increased current from mechanical overloads or supply unbalance. Unbalance can greatly increase heating in the rotor because of the large negative sequence current components present during even small voltage unbalances. A locked or stalled rotor can cause severe heating because of the associated large currents drawn from the supply. Many motor starts over a short period of time can cause overheating as well. Phase-to-phase and phase-to-ground faults can also cause damage to motors and hazards to personnel. Bearing overheating, loss of load, and phase reversal can cause damage to the mechanical load being driven by the motor.

The ideal motor protection relay should monitor the rotor and stator winding temperatures exactly and shut off the motor when thermal limits are reached. This relay should have an exact knowledge of the temperature and proper operating characteristics of the motor and should shut down the motor on the occurrence of any potentially damaging or hazardous condition.

The Multilin Model 169 Motor Management Relay uses motor phase current readings combined with stator RTD temperature readings to thermally model the motor being protected. In addition, the 169 takes into account the heating effects of negative sequence currents in the rotor, and calculates the cooling times of the motor. The relay also monitors the motor and mechanical load for faults and problems.

1.2 169 Relay Features

The Multilin Model 169 Motor Management Relay is a modern microcomputer-based product designed to provide complete, accurate protection for industrial motors and their associated mechanical systems. The 169 offers a wide range of protection, monitoring, and diagnostic features in a single, integrated package. All of the relay setpoints may be programmed in the field using a simple 12 position keypad and 48 character alphanumeric display. A built-in "HELP" function can instruct the user on the proper function of each of the programming keys and on the meaning of each displayed message.

One 169 relay is required per motor. Phase and ground fault currents are monitored through current transformers so that motors of any line voltage can be protected. The relay is used as a pilot device to cause a contactor or breaker to open under fault conditions; that is, it does not carry the primary motor current.

The relay comes in two different models, thus allowing for choice of the most cost effective relay for each application. The 169 Plus has the following features which the model 169 does not: custom curve selectability, motor statistical records, speed switch input, differential relay input, two auxiliary output relays, two additional RTD inputs, single shot emergency restart feature, an RS 422 communications port, unbalance input to thermal memory, start inhibit feature, and spare input terminals.

The custom curve feature of the model 169 Plus gives the user additional flexibility. If one of the eight standard overload curves is not suitable for the application under consideration, the user can enter his own breakpoints to form a custom curve. This means that the 169 Plus can offer optimum motor protection in situations where other relays cannot. Such applications include induced fan drives where the motor stator and rotor thermal capacities can differ significantly.

An important feature of the Multilin 169 Plus relay, is its ability to "learn" individual motor parameters. The relay actually adapts itself to each application by "learning" values of motor inrush current, negative sequence current K factor, cooldown rates, and acceleration time. These values may be used to improve the 169's protective capabilities (when enabled) and are continually updated. The model 169 learns inrush current only.

The 169 Plus calculates both positive and negative sequence currents. The equivalent motor heating current is calculated based on the "learned" K factor. This, combined with RTD temperature readings by a motor thermal modeling algorithm, gives the 169 Plus a complete thermal model of the motor being protected. Thus, the 169 Plus will allow maximum motor power output while providing complete thermal protection.

1 INTRODUCTION

The 169 Plus relay provides a complete statistical record of the motor being protected. The total motor running hours, the number of motor starts, and the total number of relay trips since the last commissioning are stored and can be viewed on the display. As well, the number of short circuit, RTD, ground fault, unbalance, overload, start, and rapid trips can be recalled by simple keypad commands. These values are stored along with all of the relay setpoints in a non-volatile memory within the relay. Thus, even when control power is removed from the 169 Plus, the statistical record and all relay setpoints will remain intact.

The 169 can provide one of various output signals for remote metering or programmable controller attachment. Analog signals of motor current as a percentage of full load, hottest stator RTD temperature, percentage of phase CT secondary current, or motor thermal capacity are available by simple field programming. A total of four output relays are provided on the 169 Plus, including a latched trip relay, an alarm relay, and two auxiliary relays. The model 169 provides a latched trip relay and an alarm relay. All output relays may be programmed via the keypad to trip on specific types of faults or overloads.

When an output relay becomes active, the 169 will display the cause of the trip, and if applicable, the lock-out time remaining. Pre-trip values of motor current, unbalance, ground fault current, and maximum stator RTD temperature are stored by the 169 and may be recalled using the keypad.

The correct operation of the Multilin 169 relay is continually checked by a built-in firmware self-test routine. If any part of the relay malfunctions under this self-test, an alarm indication will tell the operator that service is required.

Table 1-1 Model 169 and 169 Plus Relay Features

Protection Features

- Overloads
- Stator Winding Overtemperature (Alarm and Trip)
- Multiple Starts
- Short Circuit
- Locked Rotor
- Rapid Trip/Mechanical Jam
- Unbalance/Single Phasing
- Ground Fault (Alarm and Trip)
- Phase Reversal
- Bearing Overtemperature (Alarm and Trip)
- Undercurrent
- Variable Lock-Out Time

Operational Features

- Microcomputer controlled
- Keypad programmable
- 48 character alphanumeric display
- Built-in "HELP" function
- Eight selectable standard overload curves
- User defined custom overload curve capability (169 Plus)
- Continual relay circuitry self-check

Monitoring and Display Features

- Negative sequence phase current unbalance measurement
- Ground fault (earth leakage) current measurement
- Up to six stator RTD inputs
- Two additional RTD inputs on the model 169, four on the 169 Plus
- Monitoring of motor ambient air temperature
- Display of all SETPOINTS or ACTUAL VALUES upon request
- Display of relay TRIP/ALARM and HELP messages

Communications and Control Features

- One latched, main trip relay
- One alarm relay
- Emergency restart capability
- Pre-trip alarm warnings
- 4-20mA output of motor current as a percentage of full load, motor thermal capacity, hottest stator RTD temperature, or percentage of phase CT secondary current
- Two auxiliary relays (169 Plus)
- Optional single-shot restart on running overload trip (169 Plus)
- Speed switch, differential relay, and spare input (169 Plus)
- RS 422 port for connection to programmable controllers and computers (169 Plus)

Statistical and Memory Features

- Recall of all pre-trip motor values
- Tamperproof setpoints stored in non-volatile memory
- Microcomputer "learns" motor inrush current, acceleration time*, cooldown rates*, and negative sequence current heating K factor* (* 169 Plus only)
- Complete record of motor statistical data: motor running hours, number of starts, number and type of relay trips (169 Plus)

1.3 Typical Applications

The many features of the 169 make it an ideal choice for a wide range of motor protection applications. Versatile features and controls allow the relay to protect associated mechanical equipment as well as the motor. The 169 should be considered for the following and other typical uses:

1. Protection of motors and equipment from operator abuse.
2. Protection of personnel from shock hazards due to winding shorts or earth leakage current from moisture.
3. Protection of gears, pumps, fans, saw mills, cutters, and compressors from mechanical jam.
4. Indication of loss of suction for pumps or loss of air flow for fans using the undercurrent feature.
5. Protection of motor and load bearings from excessive heat buildup due to mechanical wear.
6. Protection of motors operated in environments with varying ambient temperatures.
7. Communication with programmable controllers and computers for integrated plant control.
8. Protection of high inertia, long acceleration drive systems using a custom overload curve.
9. Statistical record-keeping for effective maintenance programs.
10. Complete protection, allowing maximum motor utilization with minimum downtime, for all AC motors.

1.4 Technical Specifications

Phase Current Inputs

conversion: calibrated RMS

range: 0.05 to 12 × phase CT primary amps setpoint

full scale: 12 × phase CT primary amps setpoint

accuracy: ±0.5% of full scale (0.05 to 2 X phase CT primary amps setpoint)
±1.0% of full scale (over 2 X phase CT primary amps setpoint)

Ground Fault Current Input

conversion: calibrated RMS

range: 0.1 to 1.0 X G/F CT primary amps setpoint (5 Amp secondary CT)
1.0 to 10.0 amps (2000:1 CT)

full scale: 1 × G/F CT primary amps setpoint (5 Amp secondary CT)
10 amps (2000:1 CT)

accuracy: ±4% of G/F CT primary amps setpoint (5 Amp secondary CT)
± 0.3 amps primary (2000:1 CT)

Overload Curves

trip time accuracy: ±1 sec. up to 13 sec.
±8% of trip time over 13 sec.

detection level: ±1% of primary CT amps

Unbalance

display accuracy: ±2 percentage points of true negative sequence unbalance (In/Ip)

Relay Lock-out Time

accuracy: +/- 1 minute with control power applied
+/- 20% of total lock-out time with no control power applied

Trip/Alarm Delay Times

accuracy: ±0.5 sec. or 2% of total time, whichever is greater with the exception of:

1. "INST."setpoints: less than 50 msec.
2. Ground Fault 0.5 Second delay: ±150 msec.
3. Ground Fault 250 msec delay: +75 msec, -150 msec.

Phase Reversal Trip Time

relay response time: within 3.5 sec. of motor start attempt

Differential Relay Input

relay response time: 100 msec. maximum (contact closure to output relay activation)

RTD Inputs

sensor types:	10 Ω copper 100 Ω nickel 120 Ω nickel 100 Ω platinum (specified with order)
display accuracy:	±2 C
trip/alarm setpoint range:	0 to 200°C
dead band:	3°C
maximum lead resistance:	25% of RTD 0°C resistance

Relay Contacts

type:	form C
rated load:	10 A @ 250 VAC / 10 A @ 30 VDC (resistive load) 7.5 A @ 250 VAC / 5 A @ 30 VDC (inductive load) 0.5 A @ 125 VDC (resistive load) 0.3 A @ 125 VDC (inductive load)
maximum operating voltage:	380 VAC, 125 VDC
maximum operating current:	10 Amps
minimum permissible load:	5 VDC, 100 mA

NOTE: AC inductive load PF = 0.4
DC inductive load L/R = 7 msec.

Analog Current Output (4-20 mA standard)

output:	4-20 mA /	0-20 mA /	0-1 mA
maximum load resistance:	300 Ω	300 Ω	2000 Ω
maximum output (saturation):	20.2 mA	20.2 mA	1.01 mA
accuracy:	±1% of full scale reading		

polarity: terminal 58 ("-") must be at ground potential (ie. output is not isolated)

Control Power

AC nominal:	120 VAC, range: 240 VAC, range:	90-150 VAC 180-270 VAC
frequency:	50/60 Hz	
maximum power consumption:		40 VA
DC nominal:	24 VDC, range: 48 VDC, range: 125 VDC, range: 250 VDC, range:	20-30 VDC 30-55 VDC 80-150 VDC 160-300 VDC
maximum power consumption:		30 W

Environment

operating temperature range:	–10°C to +60°C
display operational range:	0°C to +55°C

CT Burden Due to Connection of 169 Relay

phase CT: 1 amp or 5 amp input:	less than 0.50 VA at rated load
ground fault CT: 5 amp input:	less than 0.50 VA at rated load
2000:1 input:	can be driven by GE Power Management 2000:1 CT

Running Hours Counter

accuracy: ±1%

Note: It is recommended that all 169 relays be powered up at least once per year to avoid deterioration of electrolytic capacitors in the power supply.

Due to updating technology, specifications may be improved without notice.

2.1 Physical Dimensions

The 169 relay is contained in a compact plastic and metal housing with the keypad, display, and all indicators located on the front panel. The physical dimensions of the 169 unit are given in Figure 2-1.

Multilin also provides phase and ground fault CTs if required. Dimensions for these are shown in Figure 2-2. Note: Dimensions of Figure 2-2 are for 100:5 to 1000:5 phase CT's, for the dimensions of 50:5 and 75:5 CT's, consult factory.

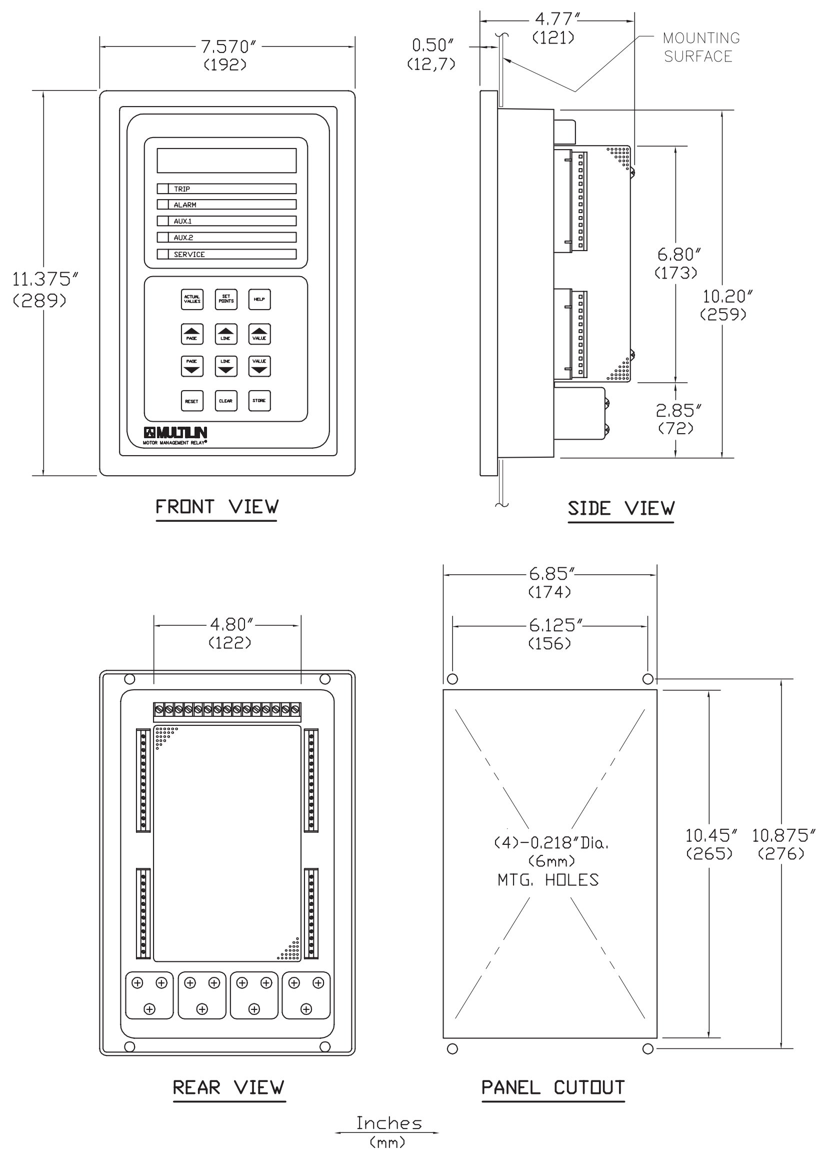
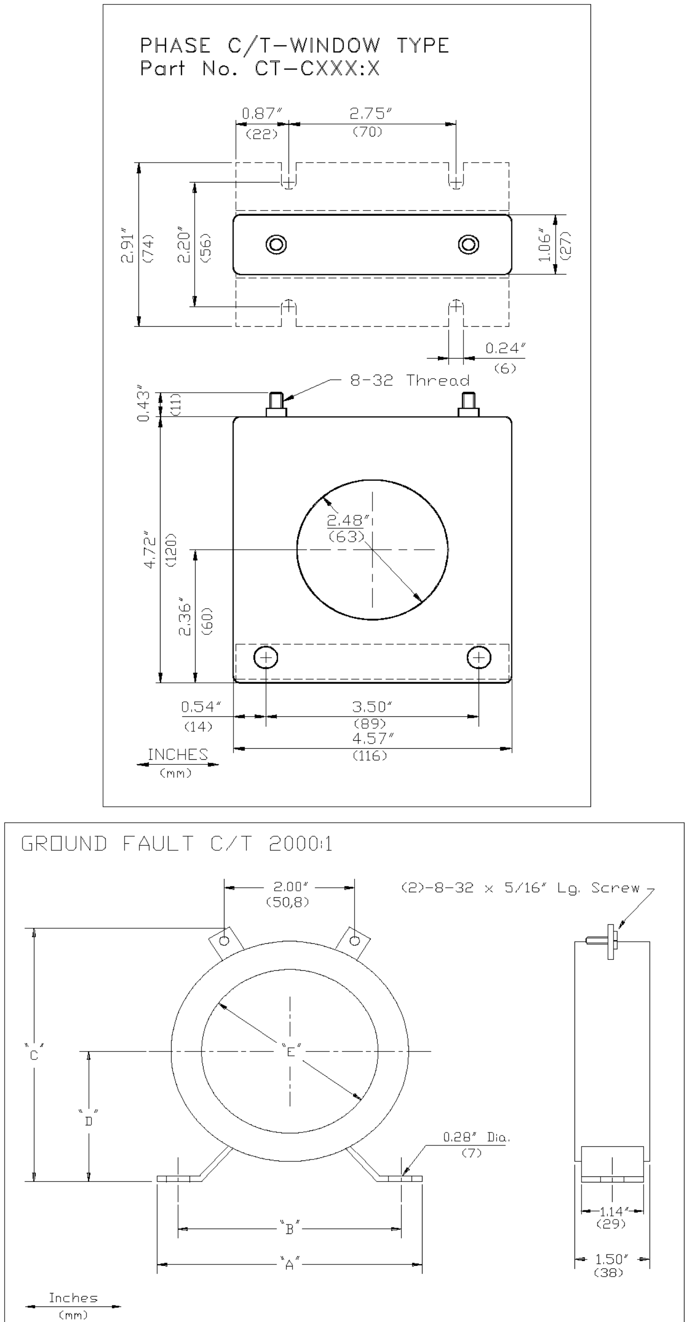


Figure 2-1 Physical Dimensions



PART NO.	DIMENSIONS									
	A		B		C		D		E	
	in	mm	in	mm	in	mm	in	mm	in	mm
CT–HGF5	7.80	198	7.05	179	8.15	207	3.94	100	5.50	140
CT–HGF3	6.06	154	5.28	134	6.18	157	3.15	80	3.54	90

Figure 2-2 CT Dimensions

2.2 Mounting

The 169 should be positioned so that the display is visible and the front panel keypad is accessible. A cut-out is made in the mounting panel and the unit is mounted as shown in Figure 2-3. Four washers and 10-32 X 3/8" mounting screws are provided.

Although the 169 circuitry is internally shielded, to minimize noise pickup and interference the relay should be placed away from high current conductors or sources of strong magnetic fields.

Connections to the relay are made through terminal blocks and CTs located on the rear of the unit.

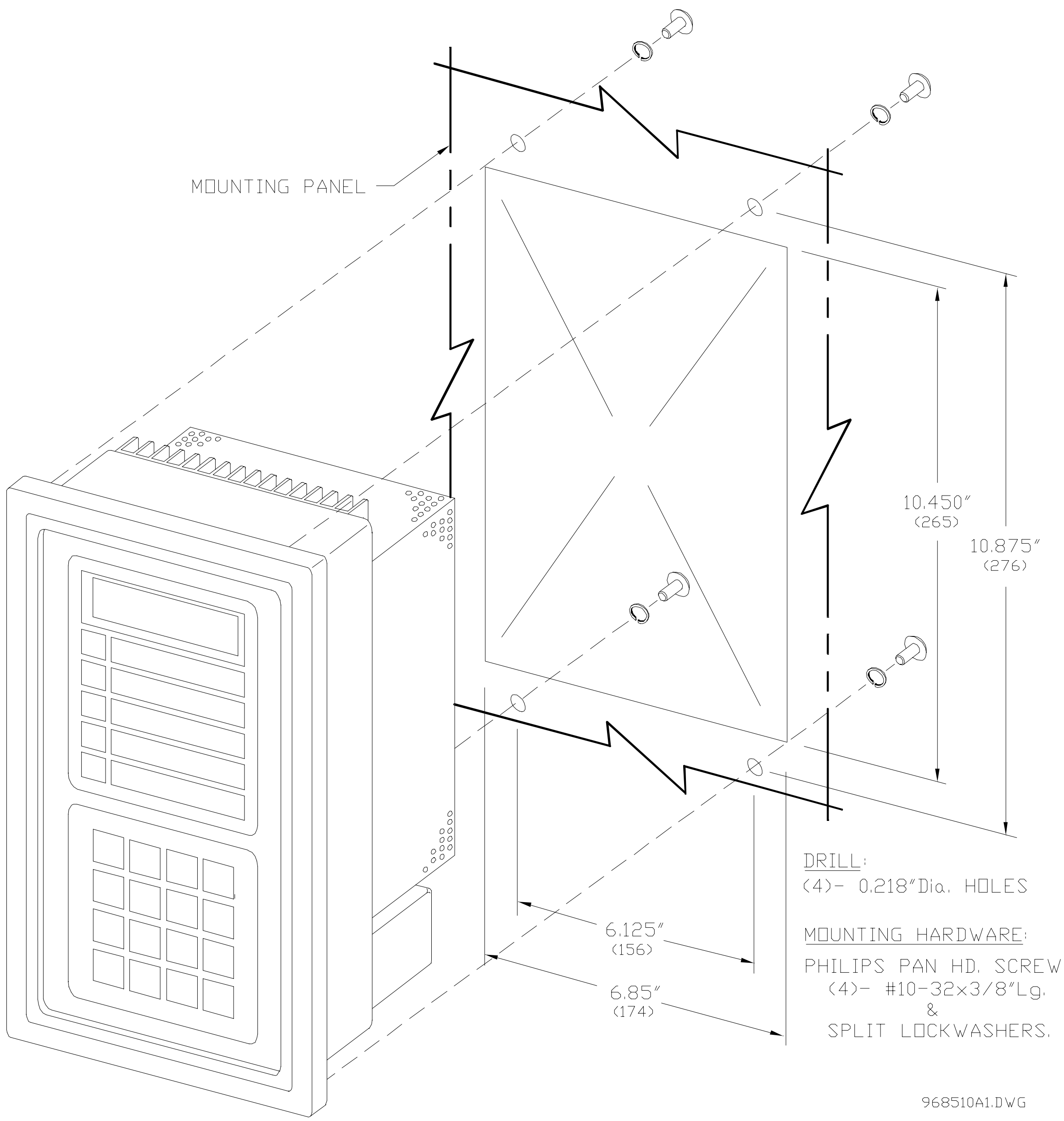


Figure 2-3 Relay Mounting

2.3 External Connections

The connections made to the 169 relay will vary depending on the programming of the unit. It is not necessary to use all of the connections provided; a minimal configuration would include supply power, three phase current CT inputs and the Trip relay contacts wired in series with the contactor control relay or circuit breaker shunt trip coil. Connections to these and the other terminals outlined below will be explained in the following sections. Figures 2-4, 2-6, 2-7 show typical connections to the 169 relay.

NOTE: The rear of the 169 relay shows output relay contacts in their power down state. Figures 2-4, 2-6, 2-7 show output relay contacts with power applied, no trips or alarms, Factory Configurations, i.e. TRIP - fail-safe, ALARM - non-fail-safe, AUX.1 - non-fail-safe, AUX.2 - fail-safe). See Figure 2-5 for a complete list of all possible output relay contact states. See page 62 for a description of the RELAY FAILSAFE CODE.

Table 2-1 169 External Connections

Inputs

- Supply Power L, G, N
- Phase CTs
- Ground Fault CTs
- 6 Stator RTDs
- 2 additional RTDs on the 169, 4 on the 169 Plus
- Emergency Restart keyswitch
- External Reset pushbutton
- Programming Access jumper or keyswitch
- Speed Switch input on the 169 Plus
- Differential Relay input on the 169 Plus
- Spare Input on the 169 Plus

Outputs

- 2 Sets of Relay Contacts (NO/NC) on the 169, 4 on the 169 Plus
- Programmable Analog Current Output Terminals
- RS 422 Serial Communication Port on the 169 Plus

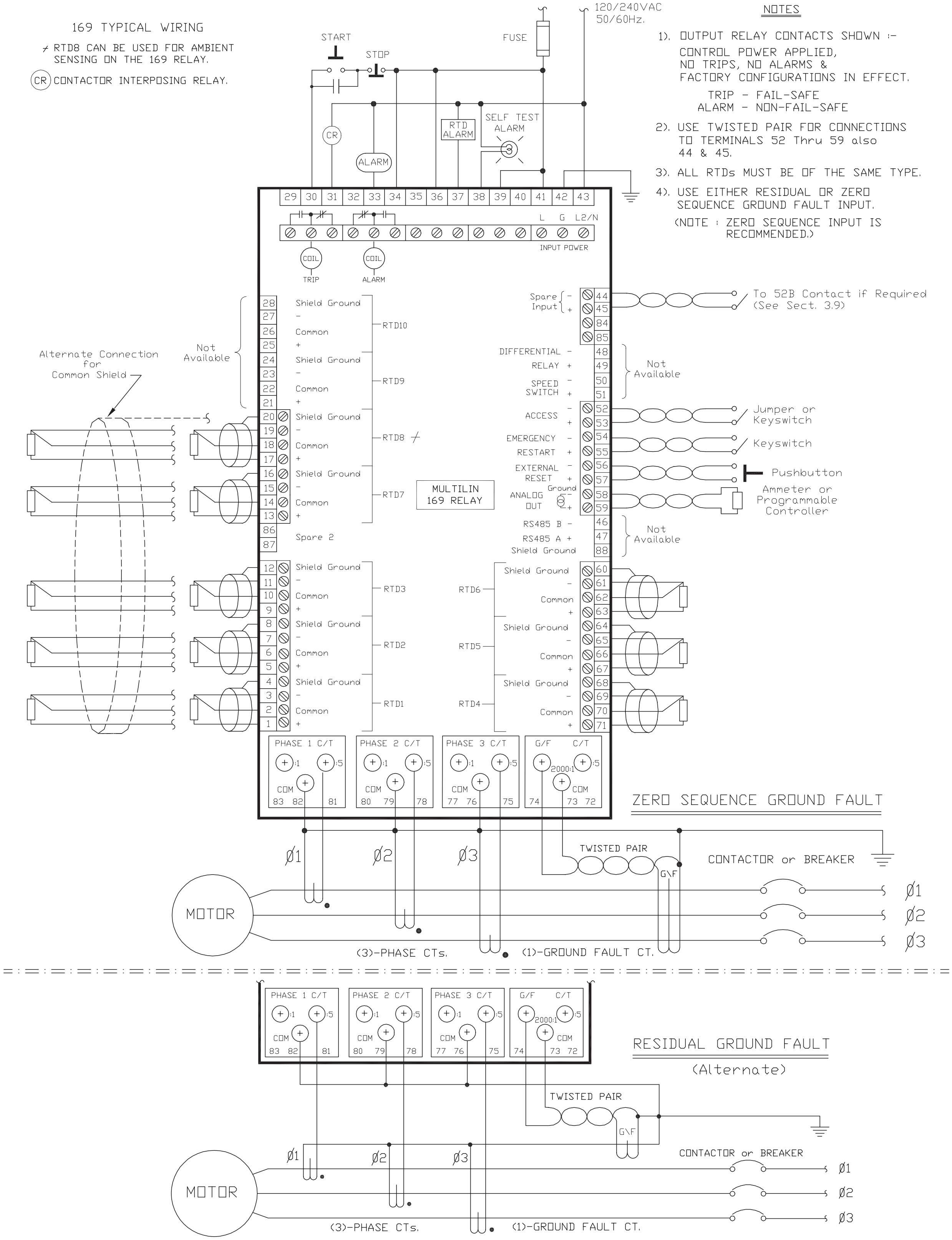
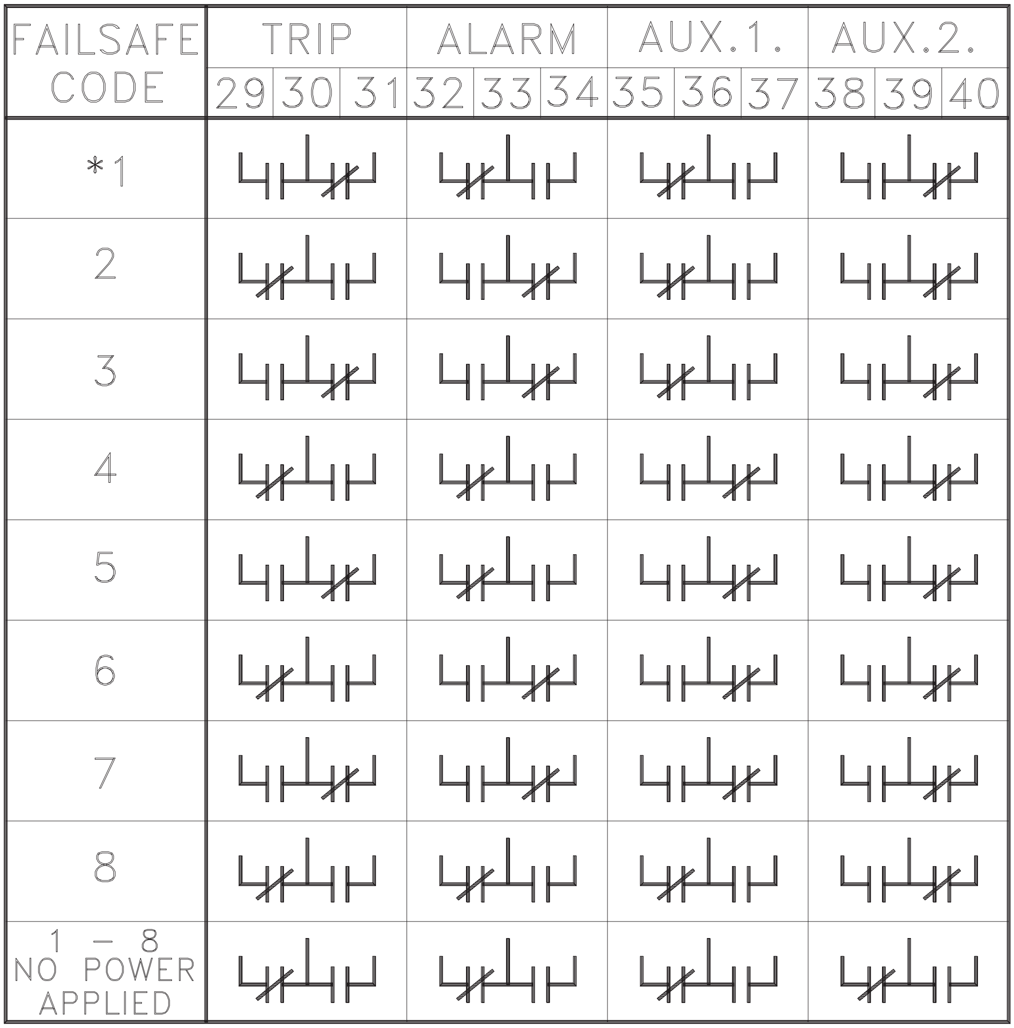


Figure 2-4 Relay Wiring Diagram (AC control power)



NOTES: 1). CONTACTS SHOWN WITH CONTROL POWER APPLIED, NO TRIPS, NO ALARMS.

2). * :– FACTORY PRESET VALUE.

Figure 2-5 Output Relay Contact States

WARNING: In locations where system voltage disturbances cause voltage levels to dip below the range specified in specifications (1.5), any relay contact programmed failsafe may change state. To avoid tripping the motor in this case, trip relay contacts should be programmed non-failsafe.

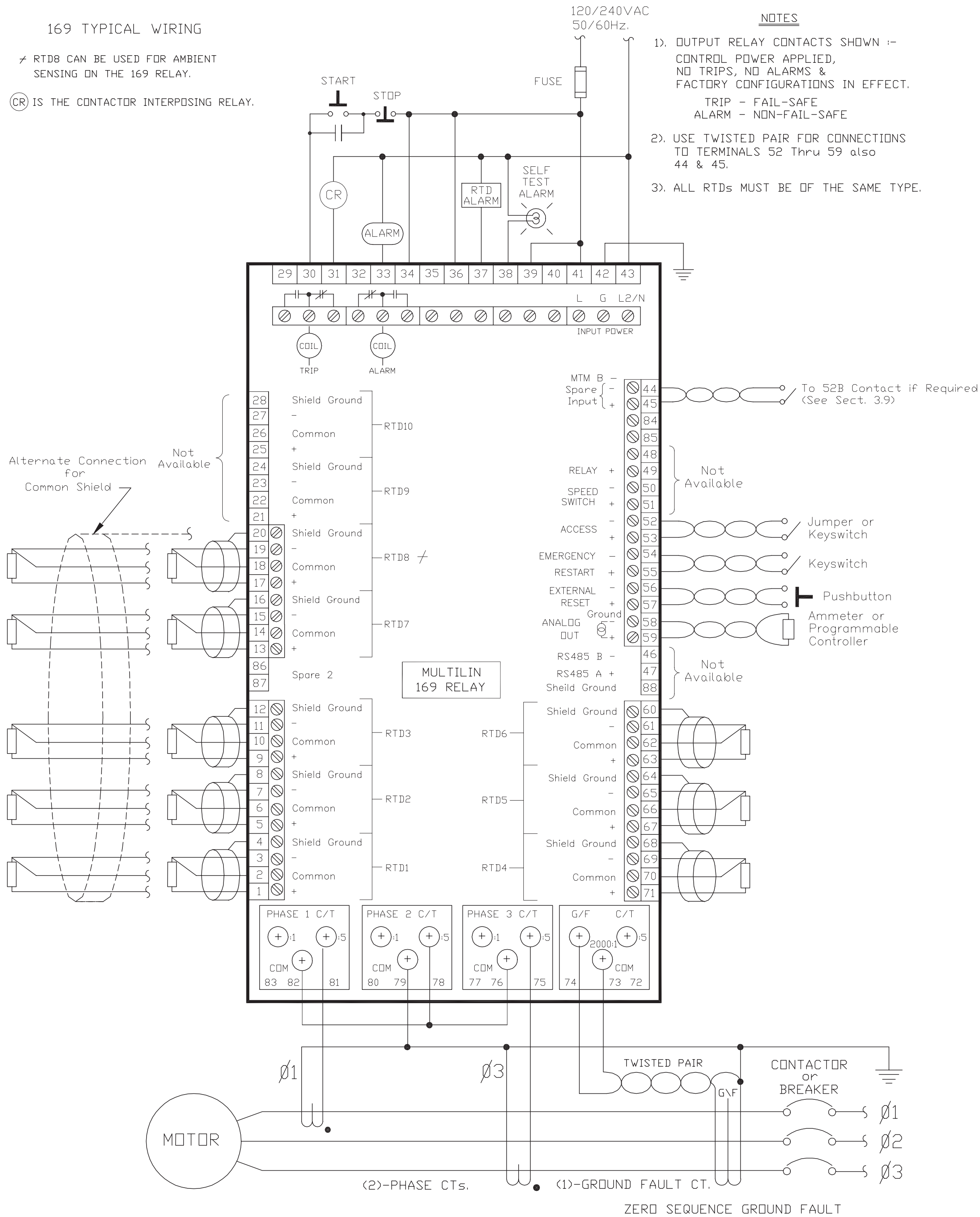


Figure 2-6 Relay Wiring Diagram (Two Phase CTs)

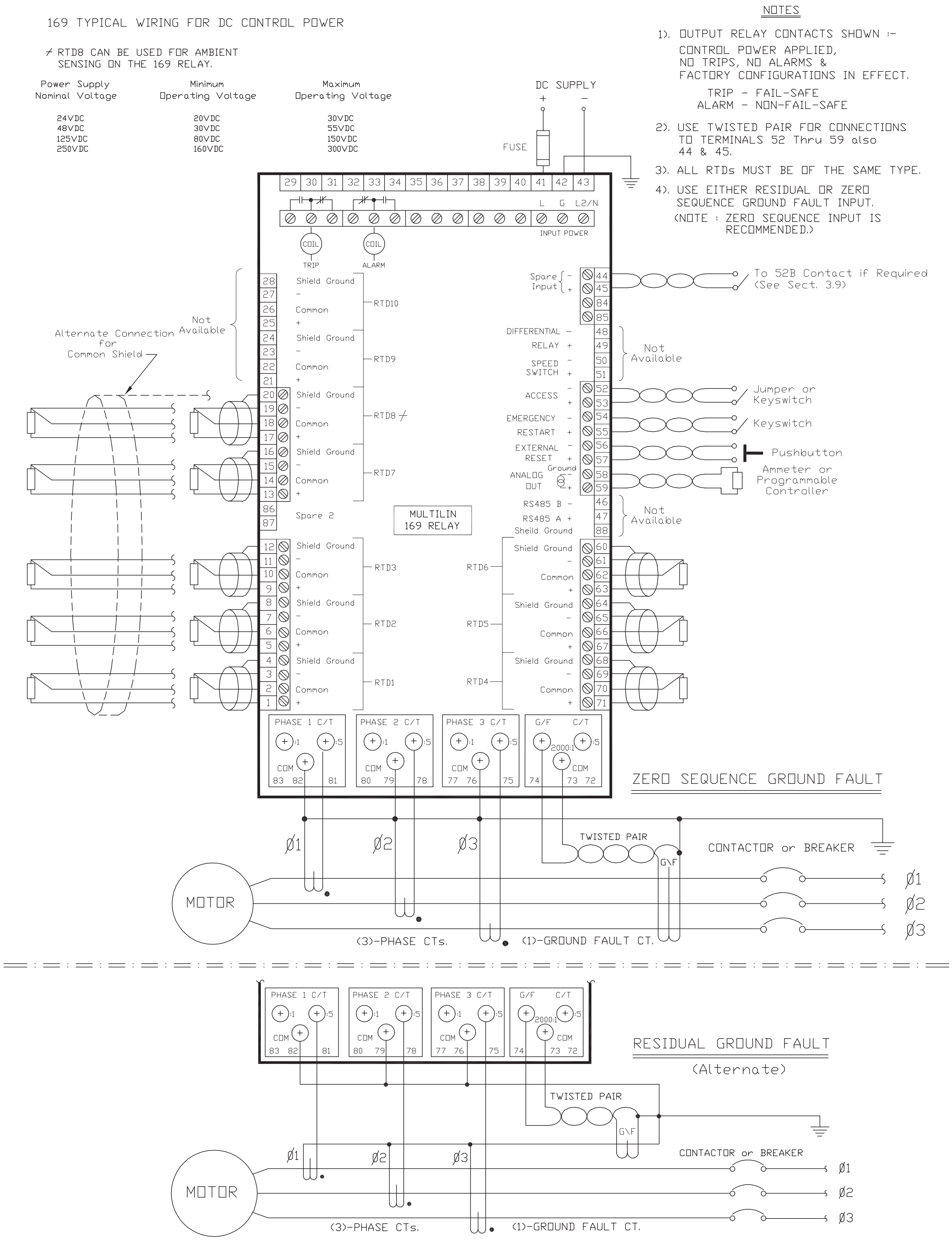


Figure 2-7 Relay Wiring Diagram (DC Control Power)

2.4 Control Power

Control power for the relay is nominally either 120/240 VAC at 50 Hz/60 Hz or either 24, 48, 125, or 250 VDC. The AC voltage is selected by means of a slide switch on the power supply circuit board as shown in Figure 2-8. If an alternative voltage is selected, ensure that the control power label on the back of the 169 Relay reflects the change. This board is accessed by removing the perforated cover on the rear of the unit. The switch must be correctly set before control power is applied to the 169. Maximum power consumption for the unit is 40 VA (AC version) or 30 W (DC version).

The 169 will operate properly over a wide range of supply voltages typically found in industrial environments (see control power specifications in section 1.5). When the supply voltage drops below the minimum, the output relays will return to their power down states but all setpoints and statistical data will remain stored in the relay memory. Motor lock-out time will be adhered to with or without control power applied.

Control power must be applied to the 169 relay, and the relay programmed, before the motor is energized. Power is applied at terminals 41, 42, and 43 which is a terminal block having #6 screws.

NOTE: Chassis ground terminal 42 must be connected directly to the dedicated cubicle ground conductor to prevent transients from damaging the 169/169 Plus resulting from changes in ground potential within the cubicle.

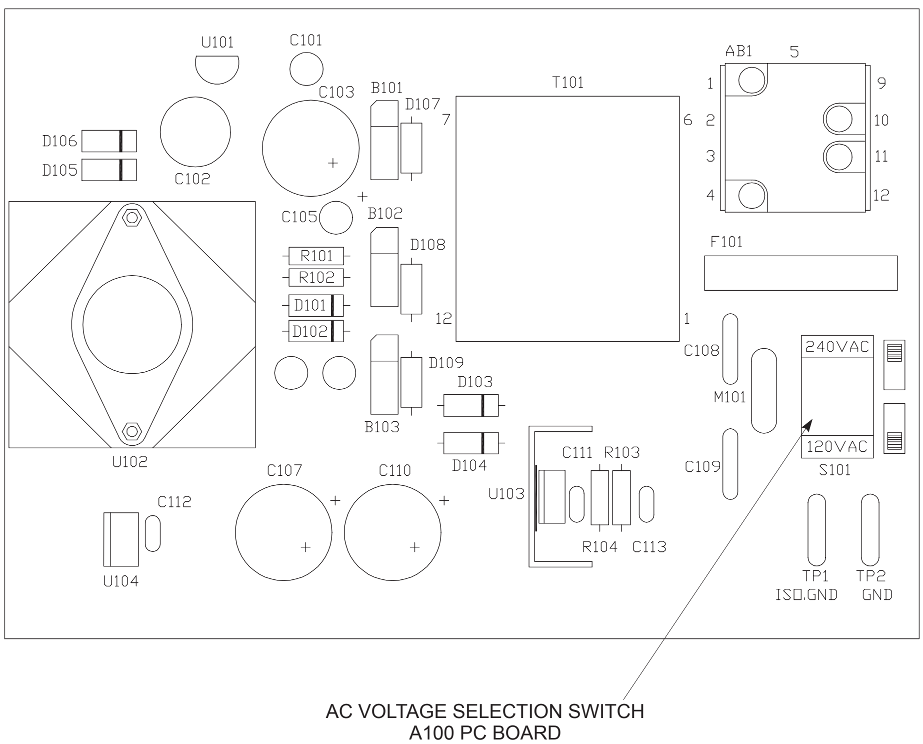


Figure 2-8 AC Voltage Selection (120/240 VAC models only)

2.5 Phase CTs

One CT for each of the three motor phases is required to input a current into the relay proportional to the motor phase current. The phase sequence must be as shown in Figures 2-4 and 2-7 in order for the phase reversal function to operate properly. If two phase CTs are used as shown in Figure 2-6 the phase reversal function cannot be used (see section 3.19). The CTs used can have either a 1 amp or 5 amp secondary and should be chosen so that the motor full load current is between 50 and 95 percent of the rated CT primary amps. The CT ratio should thus be of the form n:1 or n:5 where n is between 20 and 1500. The ratio of the CT used must be programmed into the 169 (see section 3.7).

The CT connections to the relay are made between the ":1" and "COM" terminals for 1 amp CTs or between the ":5" and "COM" terminals for CTs with a 5 amp secondary. The connections to the 169 internal phase CTs are made directly via #10 screws.

2.6 Ground Fault CT

All current carrying conductors must pass through a separate ground fault CT in order for the ground fault function to operate correctly. If a safety ground is used it should pass outside the CT window.

The ground fault CT is connected to terminals 73 and 72 for 5 amp secondary CTs or to terminals 73 and 74 for Multilin 2000:1 CTs. as shown in Figures 2-4, 2-6, 2-7. The polarity of the ground fault CT connection is not important. It is recommended that the two CT leads be twisted together to minimize noise pickup. If a 2000:1 ground fault CT is used, the secondary output will be a low level signal which allows for sensitive ground fault detection.

The zero sequence ground fault connection is recommended. If the residual ground fault method is used the 169 relay will not display ground fault current in direct primary amps.

The connections to the 169 internal ground fault CT are made directly via #10 screws.

2.7 Trip Relay Contacts

The main control relay or shunt trip coil of the motor starter or circuit breaker should be connected to the Trip relay contacts of the 169. These contacts are available as normally open (NO), normally closed (NC), and can switch up to 10 amps at either 250 VAC or 30 VDC with a resistive load. Silver cadmium oxide contacts are used because of their ability to handle high inrush currents on inductive loads. Contact Multilin if these contacts are to be used for carrying low currents since they are not recommended for use below 0.1 amps. Connection to the motor contactor or breaker is shown in Figures 2-4, 2-6, 2-7.

The Trip output relay will remain latched after a trip. This means that once this relay has been activated it will remain in the active state until the 169 is manually reset. The Trip relay contacts may be reset by pressing the RESET key (see section 3.1) if motor conditions allow, or by using the Emergency Restart feature (see section 2.12). An optional single shot restart can be selected on the 169 Plus to automatically reset the relay after a running OVERLOAD TRIP. This feature is selected or defeated in page 5 of SETPOINTS mode.

The Trip relay may be programmed to be fail-safe or non-fail-safe. When in the fail-safe mode, relay activation or a loss of power condition will cause the relay contacts to go to their power down state. Thus, in order to cause a trip on loss of power to the 169, output relays should be programmed as fail-safe.

The Trip relay cannot be reset if a lock-out is in effect. Lock-out time will be adhered to regardless of whether control power is present or not.

The Trip relay can be programmed to activate on any combination of the following trip conditions: overload, stator RTD overtemperature, rapid trip, unbalance, ground fault, short circuit, RTD overtemperature, phase reversal, acceleration time, number of starts per hour, single phase, speed switch closure on start, differential relay closure, spare input closure, and start inhibit (see section 3.4 for factory preset configurations). Connections to the Trip relay contacts are made via a terminal block which uses #6 screws.

NOTE: The rear of the 169 relay shows output relay contacts in their power down state. Figures 2-4, 2-6, 2-7 show output relay contacts with power applied, no trips or alarms, and Factory Configurations in effect (i.e. TRIP - fail-safe, ALARM - non-fail-safe, AUX.1 - non-fail-safe, AUX.2 - fail-safe). See Figure 2-5 for a list of all possible contact states.

2.8 Alarm Relay Contacts

These contacts are available as normally open (NO), normally closed (NC), with the same ratings as the Trip relay but can only be programmed to activate when alarm setpoint levels are reached. (On a Draw-out version of 169, only one set of alarm contacts is available and the user must specify normally open or normally closed when ordering). Thus these contacts may be used to signal a low level fault condition prior to motor shut-down.

Conditions which can be programmed to activate the relay are alarm levels for the following functions: immediate overload, unbalance, undercurrent, ground fault, stator RTD overtemperature, RTD overtemperature, broken RTD sensor, spare input alarm, self-test alarm, and start inhibit (see section 3.4 for factory preset configurations). The relay can be configured as latched or unlatched and fail-safe or non-fail-safe. Connections to the Alarm relay contacts are made via a terminal block which uses #6 screws.

NOTE: The rear of the 169 relay shows output relay contacts in their power down state. Figures 2-4, 2-6, 2-7 show output relay contacts with power applied, no trips or alarms, and Factory Configurations in effect (i.e. TRIP - fail-safe, ALARM - non-fail-safe, AUX.1 - non-fail-safe, AUX.2 - fail-safe). See Figure 2-5 for a list of all possible contact states.

2.9 Auxiliary Relay #1 Contacts (169 Plus)

Auxiliary relay #1 is provided to give an extra set of NO/NC contacts which operate independently of the other relay contacts. (On a Draw-out version of 169, only one set of Aux.1 contacts is available and the user must specify normally open or normally closed when ordering). This auxiliary relay has the same ratings as the Trip relay.

Auxiliary relay #1 can be configured as latched or unlatched and fail-safe or non-fail-safe. The conditions that will activate this relay can be any trip or alarm indications (see section 3.4 for factory preset configurations).

These contacts may be used for alarm purposes or to trip devices other than the motor contactor. For example, the ground fault and short circuit functions may be directed to Auxiliary relay #1 to trip the main circuit breaker rather than the motor starter.

Connections to the relay contacts are made via a terminal block which uses #6 screws.

NOTE: The rear of the 169 relay shows output relay contacts in their power down state. Figures 2-4, 2-6, 2-7 show output relay contacts with power applied, no trips or alarms, and Factory Configurations in effect (i.e. TRIP - fail-safe, ALARM - non-fail-safe, AUX.1 - non-fail-safe, AUX.2 - fail-safe). See Figure 2-5 for a list of all possible contact states.

2.10 Auxiliary Relay #2 Contacts (169 Plus)

This relay provides another set of NO/NC contacts with the same ratings as the other relays. (On a Draw-out version of 169, only one set of Aux.2 contacts is available and the user must specify normally open or normally closed when ordering). This relay is different from the others in the fact that it is permanently programmed as latched and fail-safe.

This relay may be programmed to activate on any combination of alarm conditions (see section 3.4 for factory preset configurations). The feature assignment programming is thus the same as for the Alarm relay.

Connections to the relay contacts are made via a terminal block which uses #6 screws.

NOTE: The rear of the 169 relay shows output relay contacts in their power down state. Figures 2-4, 2-6, 2-7 show output relay contacts with power applied, no trips or alarms, and Factory Configurations in effect (i.e. TRIP - fail-safe, ALARM - non-fail-safe, AUX.1 - non-fail-safe, AUX.2 - fail-safe). See Figure 2-5 for a list of all possible contact states.

2.11 RTD Sensor Connections

Up to six resistance temperature detectors (RTDs) may be used for motor stator temperature monitoring. The remaining RTD inputs may be used for motor and load bearing, or other temperature monitoring functions. All RTDs must be of the same type. RTD #8 (RTD #10 on the 169 Plus) may be used to monitor ambient air temperature. This is done to enhance protection in environments where the ambient temperature varies considerably. Use of stator RTDs will allow the 169 to "learn" the actual cooling times of the motor. When no stator RTDs are used the 169 will not learn the actual motor cooling times, but will rely on the user defined preset values. The number of stator RTDs used together with RTD trip and alarm temperatures must be programmed into the 169 (see sections 3.16, 3.17). The RTD type to be used must be specified when ordering the 169 relay. If the type of RTD in use is to be changed, the 169 must be returned to the factory.

Each RTD has four connections to the 169 relay as shown in Figures 2-4, 2-6, 2-7. Since the RTD indicates temperature by the value of its resistance, it is necessary to compensate for the resistance of the connecting wires, which is dependent on lead length and ambient temperature. The 169 uses a circuit to cancel this resistance and read only the actual RTD resistance. Correct operation will occur providing all three wires are of the same length and the lead resistance is not greater than 25% of the RTD 0 C resistance. This can be accomplished by using identical lengths of the same type of wire. If 10 Ω copper RTDs are to be used special care should be taken to keep the lead resistance as low as possible.

If RTD #8 (RTD #10 on the 169 Plus) is to be used for ambient air temperature measurement the RTD should be placed and mounted somewhere in the motor cooling air intake flow. The sensor should be in direct contact with the cooling air but not with any surface that is at a temperature other than the cooling air. This RTD is selected for ambient temperature use in page 5 of SETPOINTS mode.

If no RTD sensor is to be connected to any of the RTD terminals on the 169, the terminals may be left open.

If fewer than 6 stator RTDs are to be employed, they should be connected to the lowest numbered relay RTD connections. For example, if 3 stator RTDs are to be used they should be connected to the terminals for RTD1, RTD2, and RTD3 (terminals #1-12). Other RTDs should be connected to the terminals for RTD7-RTD10 (terminals #13-28) as shown in Figure 2-4.

The connections are made via terminal blocks which can accommodate up to #12 AWG multi-strand wire.

Note: Shielded, three wire cable must be used in industrial environments to prevent noise pickup. Wherever possible, the RTD leads should be kept close to grounded metal casings and avoid areas of high electromagnetic or radio frequency fields. RTD leads should not run adjacent to, or in the same conduit as high current carrying wires. It is recommended to use a three wire shielded cable of #18 AWG copper conductors. The shield connection of the RTD should not be grounded at the sensor end as there is an internal ground on the 169. This arrangement prevents noise pickup that would otherwise occur from circulating currents due to differences in ground potentials on a doubly grounded shield.

2.12 Emergency Restart Terminals

If it is desired to occasionally override relay trips or lock-outs and restart the motor, a normally open keyswitch should be installed between terminals 54 and 55. Momentarily shorting these terminals together will cause the thermal memory of the 169 to discharge to 0% (if RTD input to thermal memory is enabled, thermal memory can be reduced to 0% by keeping terminals 54 and 55 shorted together for more than 11 seconds; see section 3.20). The Emergency Restart terminals can thus be used to override an OVERLOAD TRIP. Shorting the Emergency Restart terminals together will also decrement the relay's internal starts/hour counter by 1 and therefore allow the operator to override a STARTS/HOUR TRIP.

Note: This option should be used only when an immediate restart after a lock-out trip is required for process integrity or personnel safety. Discharging the thermal memory of the 169 gives the relay an unrealistic value for the thermal capacity remaining in the motor and it is possible to thermally damage the motor by restarting it. Thus, complete protection may be compromised in order to restart the motor using this feature.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.13 External Reset Terminals

An external reset switch, which operates similarly to the keypad RESET key (see section 3.1), can be connected to terminals 56 and 57 for remote reset operation. The switch should have normally open contacts. Upon closure of these contacts the relay will be reset. This external reset is normally equivalent to pressing the keypad RESET key but a special reset feature can be selected on page 5 of setpoints mode, so that the keypad RESET key will not cause Auxiliary relay #1 to be reset (see section 3.22). Keeping the External Reset terminals shorted together will cause the 169 to be reset whenever motor conditions allow.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.14 Analog Output Terminals (Non-Isolated)

Terminals 58 and 59 of the 169 are available for an analog current output representing one of percentage of motor thermal capacity used, motor current as a percentage of full load (i.e. 0-1 XFLC), hottest stator RTD temperature as a percentage of 200 C or CT secondary current as a percentage of CT secondary amps rating. The choice of output is selected in page 5 of SETPOINTS mode. This selection can be made or changed at any time without affecting the protective features of the relay.

The output current range is standard at 4-20 mA. Contact Multilin if a different current range is required. 4 mA output corresponds to a low scale reading (i.e. 0% thermal capacity used, 0 XFLC phase current, 0 C hottest stator RTD temperature, or 0 A phase CT secondary current). 20 mA output current corresponds to a high scale reading (i.e. 100% thermal capacity used, 1 XFLC or greater phase current, 200 C or greater hottest stator RTD temperature, or either 1 A (or greater) or 5 A (or greater) phase CT secondary depending on the CT used).

This output is a current source suitable for connection to a remote meter, chart recorder, programmable controller, or computer load. Current levels are not affected by the total lead and load resistance as long as it does not exceed 300 Ω for the 4-20 mA range. For readings greater than 100% of full scale the output will saturate at 20.2 mA.

This analog output is not isolated. Terminal 58 is internally connected to system ground. Consequently the negative terminal of the connected load device must be at ground potential.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.15 Differential Relay Terminals (169 Plus)

Terminals 48 and 49 are provided for connection to a differential relay. This allows an external differential relay to be connected to a 169 Plus relay. A contact closure between these terminals will cause an immediate activation of the output relay assigned to the differential relay input function. After a DIFFERENTIAL INPUT TRIP terminals 48 and 49 must be open circuited in order to reset the relay.

If no differential relay is to be used terminals 48 and 49 should be left open.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.16 Speed Switch Terminals (169 Plus)

Terminals 50 and 51 are provided for connection to an external speed switch. This allows the 169 Plus relay to utilize a speed device for locked rotor protection. **During a motor start attempt** if no contact closure between terminals 50 and 51 occurs within the "SPEED SWITCH TIME DELAY" (SETPOINTS, page 5) the output relay assigned to the speed switch function will activate. This function must be enabled in order for operation to occur (SETPOINTS, page 5). After a SPEED SWITCH TRIP terminals 50 and 51 must be open circuited in order to reset the relay.

If no speed switch is to be used terminals 50 and 51 should be left open.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.17 Programming Access Terminals

When a jumper wire is connected between ACCESS terminals 52 and 53 all setpoints and configurations can be programmed using the keypad. Once programming is complete the jumper will normally be removed from these terminals. When this is done all actual and setpoint values can still be accessed for viewing; however, if an attempt is made to store a new setpoint value the message "ILLEGAL ACCESS" will appear on the display and the previous setpoint will remain intact. In this way all of the programmed setpoints will remain secure and tamperproof. Alternatively, these terminals can be wired to an external keyswitch to permit setpoint programming upon closure of the switch.

A twisted pair of wires should be used for connection to an external switch. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.18 RS-422 Serial Communications Terminals (169 Plus)

Terminals 46 and 47 are provided for a digital serial communication link with other 169 Plus relays, computers, or programmable controllers. Up to 20 169 Plus "SLAVES" can be connected to one "MASTER" (169 Plus or other device) as shown in Figure 2-9. If devices other than 169 Plus relays are to be connected in the serial link a copy of the "Multilin 169 Plus Relay Communication Protocol" will be required. This can be obtained by contacting Multilin. Note that when using a device other than a 169 Plus to program a 169 Plus SLAVE, setpoints sent to the SLAVE must be within the ranges listed in Table 3-3.

Each communication link must have only one MASTER. If the MASTER is a 169 Plus this relay cannot be used for motor protection. Only relays programmed as SLAVEs can be used for motor protection. The MASTER should be centrally located and can be used to view ACTUAL VALUES and SETPOINTS from each relay SLAVE. SETPOINTS in each SLAVE can also be changed from the MASTER. In order to do this the MASTER relay must have its Access terminals (52,53) shorted together.

Relays are programmed as MASTER or SLAVE using the last 2 setpoints of page 5 of SETPOINTS mode (see section 3.4). Each SLAVE in the communication link must be programmed with a different SLAVE ADDRESS. When a relay is programmed as a MASTER it will display all of the ACTUAL VALUES and SETPOINTS of the SLAVE relay it is addressing. To view data from a different SLAVE the ADDRESSED SLAVE setpoint must be changed.

To avoid contention and improper reading of data ensure that the following conditions are met:

1. Each communication link has only one MASTER.

2. Each 169 Plus SLAVE in the link has a different SLAVE ADDRESS.

The wires joining relays in the communication link should be a twisted pair. These wires should be routed away from high power AC lines and other sources of electrical noise. The total length of the communications link should not exceed 4000 feet. When connecting units in a communication link each 169 Plus relay must have terminal 47 connected to terminal 47 of the next unit in the link, and terminal 46 connected to terminal 46.

As shown in Figure 2-9 the first and last devices in the link should have a terminating resistor placed across terminals 46 and 47. The value of these resistors should match the characteristic impedance of the line wire being used. A typical value is 50 Ω, 1/4 watt.

Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

Note: The difference in potentials between serial master ground and the 169 Plus slave (terminal 42) must not exceed 10 volts. If a large difference in ground potentials does exist, communication on the serial communication link will not be possible. In addition damage to the 169 Plus may result.

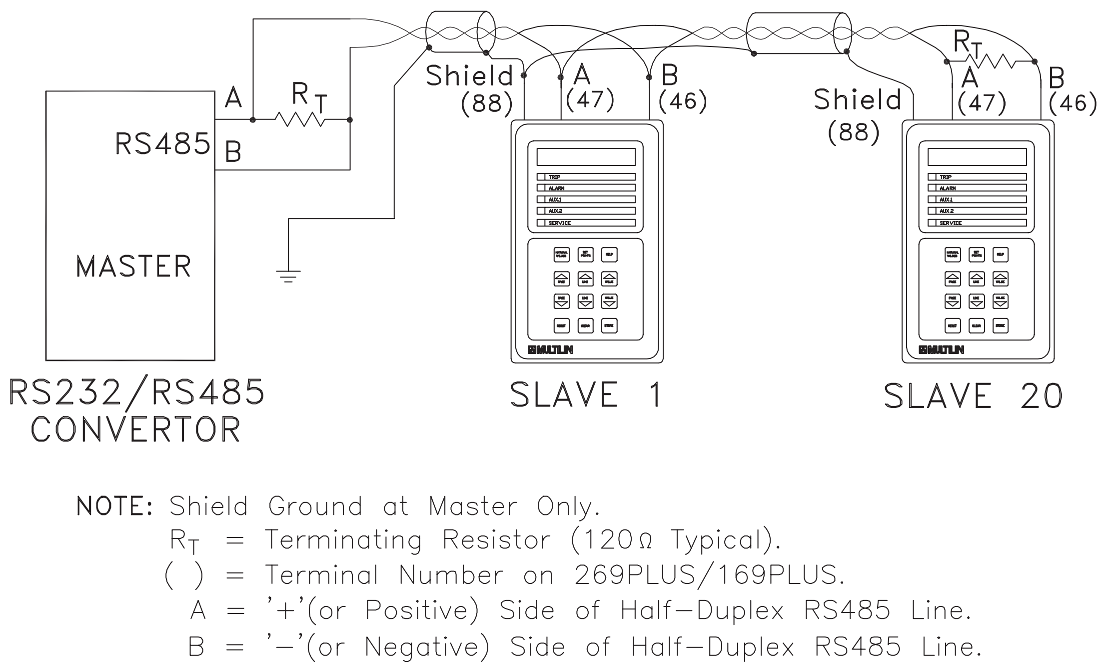


Figure 2-9 Serial Communication Link Wiring

2.19 Display Adjustment

Once the 169 relay has been installed and input power applied, the contrast of the LCD display may have to be adjusted. This adjustment has been made at the factory for average lighting conditions and a standard viewing angle but can be changed to optimize the display readability in different environments. To alter the display contrast the trimpot on the rear of the unit marked "CONTRAST" must be adjusted with a small slotted screwdriver.

2.20 Front Panel Faceplate

The front panel faceplate is composed of a polycarbonate material that can be cleaned with isopropyl or denatured alcohol, freon, naphtha, or mild soap and water.

2.21 Spare Input Terminals (169 Plus)

Terminals 44 and 45 are provided for an additional relay contact input. A contact closure between these terminals will cause a "SPARE INPUT TRIP" and/or a "SPARE INPUT ALARM" after the appropriate time delay (page 5 of SETPOINTS). These terminals must be open circuited in order to reset the relay after a SPARE INPUT TRIP or ALARM.

A twisted pair of wires should be used. Connection to the 169 is made via a terminal block which can accommodate up to #12 AWG multi-strand wire.

2.22 169 Drawout Relay

The model 169 and 169 Plus relays are available in a drawout case option. The operation of the relay is the same as described elsewhere in this manual except for the differences noted in this section. The physical dimensions of the drawout relay are as shown in Figure 2-10. The relay should be mounted as shown in Figure 2-11.

The drawout 169 relay can be removed from service without causing motor shut-down. This can be useful for replacing, calibrating, or testing units.

RELAY MOUNTING - Make cutout as shown and drill six 7/32" holes on mounting panel. Approximately 2-1/2" should be clear at the top and bottom of the cutout in the panel for the hinged door. Ensure that the five #6-32 nuts are removed from the threaded studs in the mounting flange and that the drawout chassis has been removed from the drawout case. Install the case from the rear of the mounting panel by aligning the five #6-32 threaded case studs to the previously drilled holes. With the studs protruding through the holes secure the case on the right hand side with two #6-32 nuts provided. Install the hinged door on the front of the mounting panel using three #6-32 nuts provided. There must be at least 1/2" clearance on the hinged side of the drawout relay to allow the door to open.

RELAY REMOVAL - Open the hinged door. Next remove the two ten finger connecting plugs making sure the top one is removed first. Swivel the cradle-to-case hinged levers at each end of the 169 cradle assembly and slide the assembly out of the case.

RELAY INSTALLATION - Slide the 169 cradle assembly completely into the case. Swivel the hinged levers in to lock the 169 cradle assembly into the drawout case. Install the two ten finger connecting plugs making sure the bottom plug is installed first. Close the hinged door and secure with the captive screw.

IMPORTANT NOTE: When removing the drawout relay cradle assembly the top ten finger connecting plug must be withdrawn first. This isolates the 169 output relay contacts before power is removed from the relay. When installing the drawout relay cradle assembly the bottom ten finger connecting plug must be installed first. This causes power to be applied to the 169 relay before the output relay contacts are placed in the circuit.

After a 169 relay cradle assembly has been removed from the drawout case it is recommended that the hinged door be closed in order to reduce the risk of electric shock.

Due to the hardware configuration of the drawout relay shorting bars, the RELAY FAILSAFE CODE (SETPOINTS, page 5) should not be changed without consulting the factory. Wiring for the 169 Plus drawout is shown in Figure 2-12. If it is required that any of the output relay configurations in Figure 2-12 be different than shown, this information must be stated when the relay is ordered.

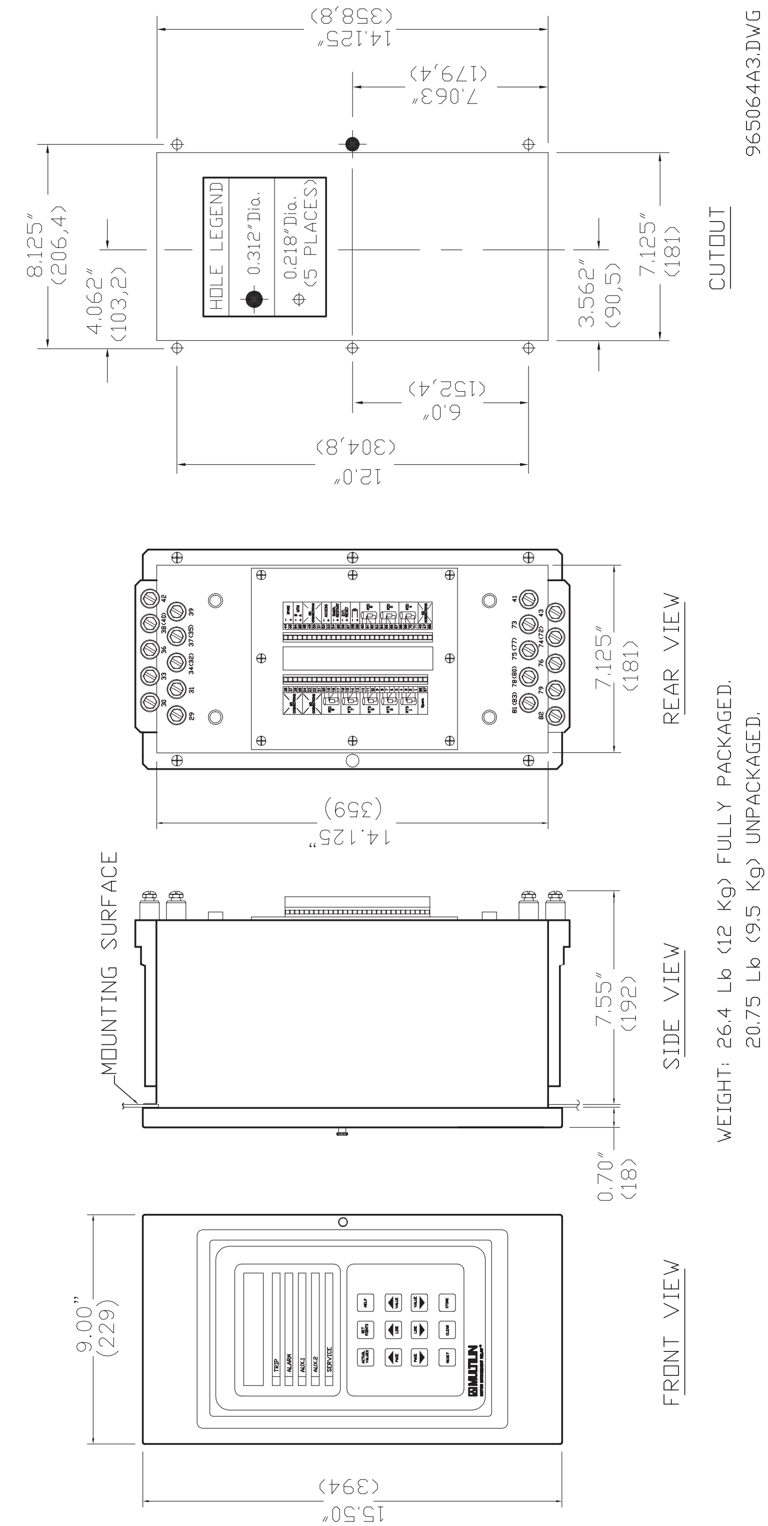


Figure 2-10 169 Drawout Relay Physical Dimensions

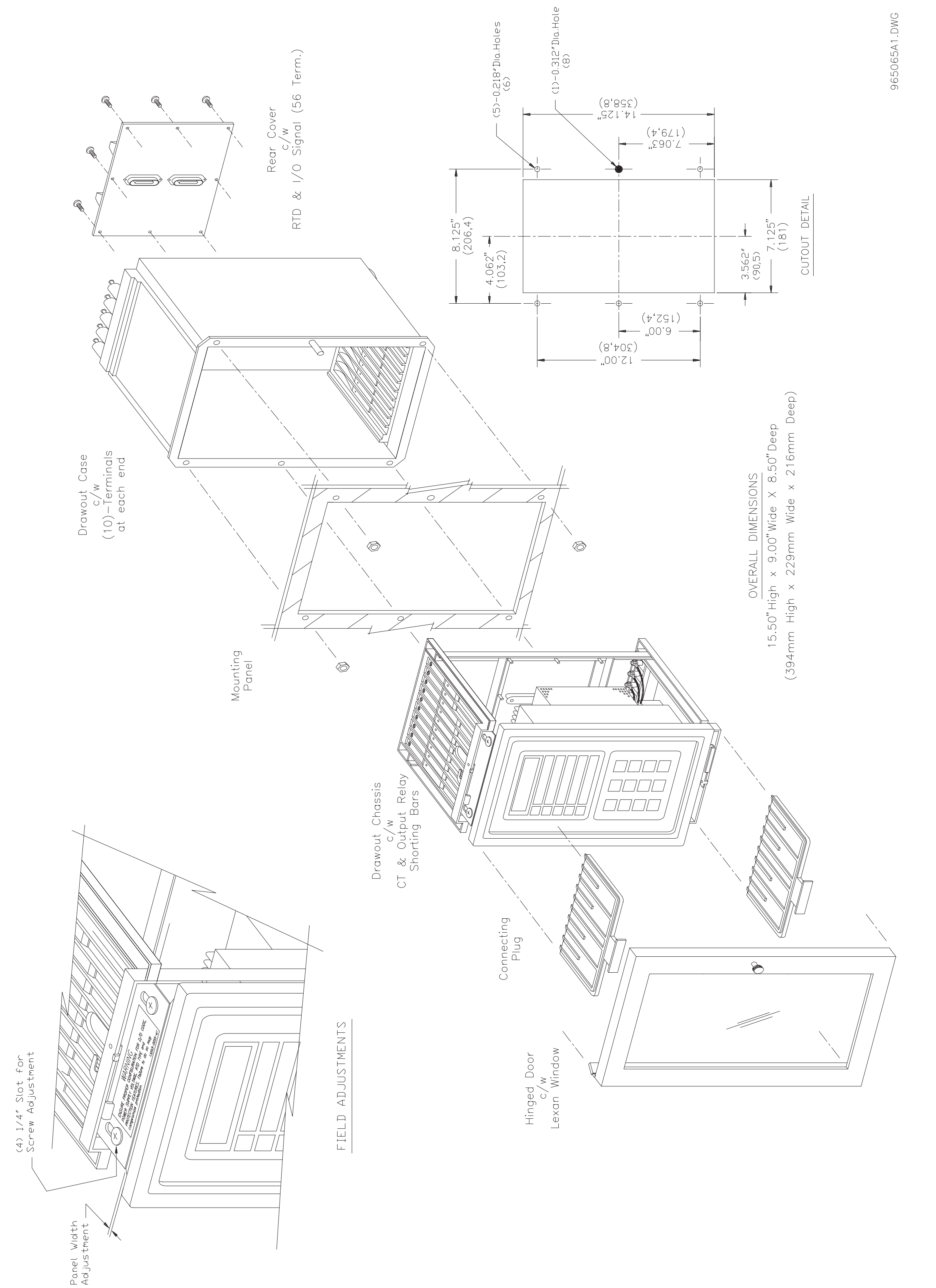


Figure 2-11 169 Drawout Relay Mounting

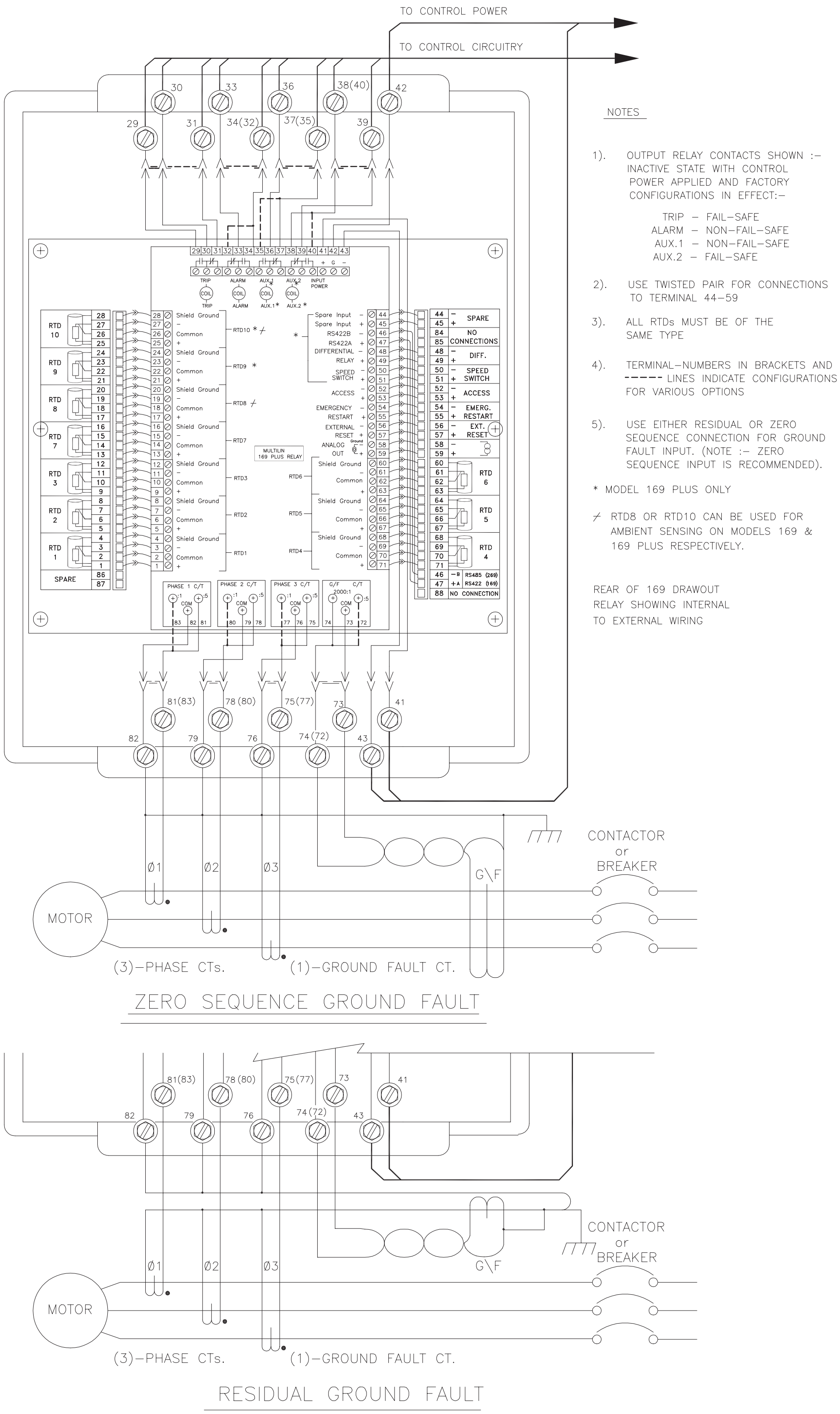


Figure 2-12 169 Plus Drawout Relay Typical Wiring Diagram

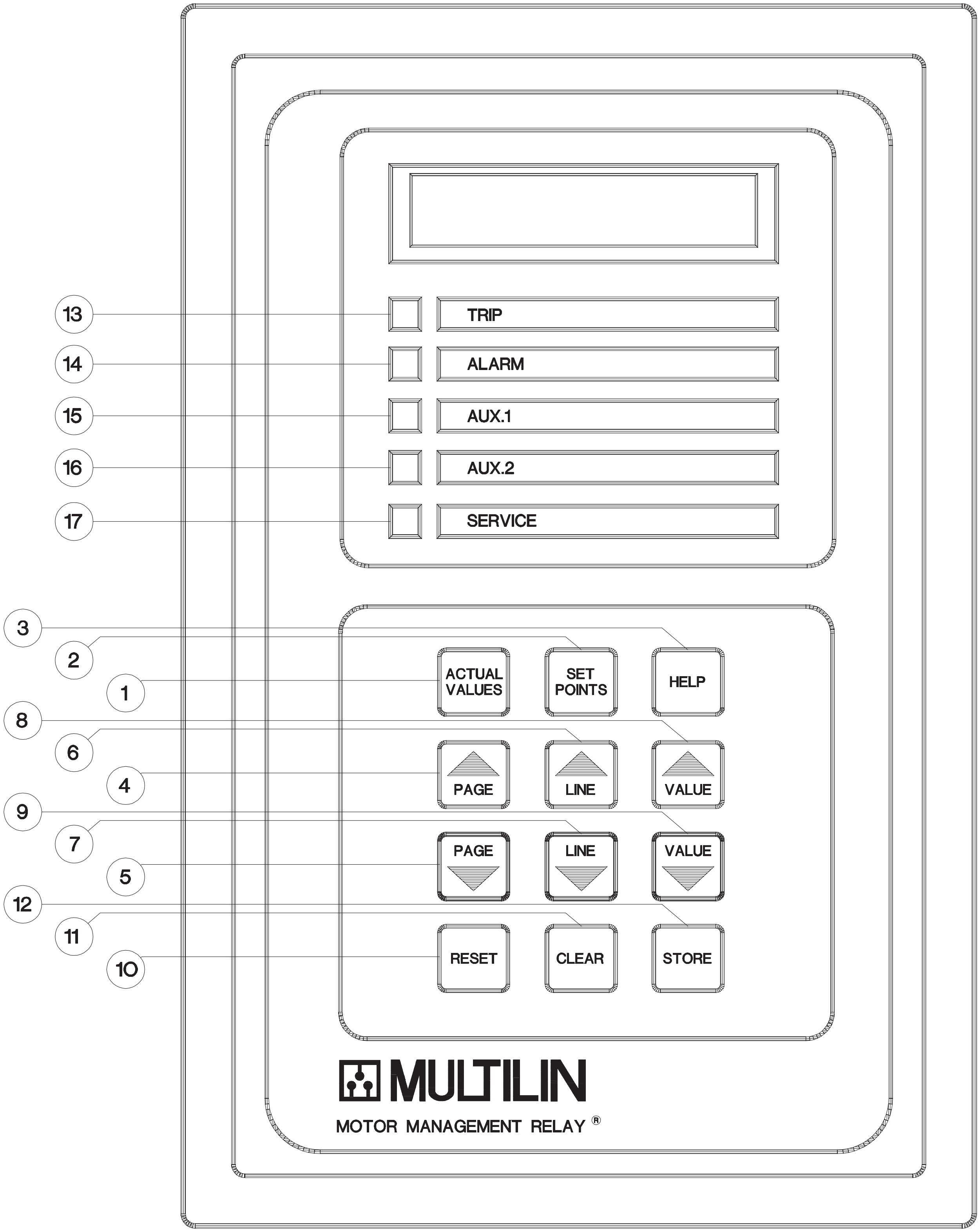


Figure 3-1 Front Panel Controls and Indicators

3.1 Controls and Indicators

Once the 169 relay has been wired and control power applied, it is ready to be programmed for the given application. Programming is accomplished using the 12 position keypad and 48 character alphanumeric display shown in Figure 3-1. The function of each key on the keypad and each of the indicators is briefly explained in Table 3-1.

Table 3-1 Controls and Indicators

No.	Name	Description
1	ACTUAL VALUES	**FUNCTION:** The ACTUAL VALUES key allows the user to examine all of the actual motor operating parameters. There are six pages of ACTUAL VALUES data: • page 1: Phase Current Data • page 2: RTD Temperature Data • page 3: Motor Capacity Data • page 4: Statistical Data • page 5: Pre-trip Data • page 6: Learned Parameters
		EFFECT: Pressing this key will put the relay into ACTUAL VALUES mode. The flash message **ACTUAL VALUES HAS SIX PAGES OF DATA** will be displayed for 2 seconds. The beginning of page 1 of ACTUAL VALUES mode will then be shown: **PAGE 1: ACTUAL VALUES PHASE CURRENT DATA**
2	SET POINTS	**USE:** This key can be pressed at any time, in any mode to view actual motor values. To go from page to page the PAGE UP and PAGE DOWN keys can be used. To go from line to line within a page the LINE UP and LINE DOWN keys can be used.
		FUNCTION: The SET POINTS key allows the user to examine and alter all trip, alarm, and other relay setpoints. There are six pages of setpoints data: • page 1: Motor Amps Setpoints • page 2: RTD Setpoints • page 3: O/L Curve Setpoints • page 4: Relay Configuration • page 5: System Configuration • page 6: Multilin Service Codes

No.	Name	Description
		EFFECT: Pressing this key will put the relay into SETPOINTS mode. The flash message, **SETPOINTS HAS SIX PAGES OF DATA** is displayed for 2 seconds. The beginning of page 1 of SETPOINTS mode is then shown: **PAGE 1: SETPOINT VALUES MOTOR AMPS SETPOINTS** **USE:** This key can be pressed at any time, in any mode, to view or alter relay setpoints. To go from page to page the PAGE UP and PAGE DOWN keys can be used. To go from line to line within a page the LINE UP and LINE DOWN keys can be used. To alter a setpoint, the VALUE UP and VALUE DOWN keys can be used. All setpoints will increment and decrement to pre-determined limits. When the desired value is reached, the STORE key must be used to save the new setpoint. If an altered setpoint is not stored the previous value will still be in effect. If the Access jumper is not installed a STORE will not be allowed and the flash message "ILLEGAL ACCESS" will be displayed for 2 seconds.
3	HELP	**FUNCTION:** The HELP key allows the user to obtain information on the function and use of each of the other keys on the keypad and on each of the ACTUAL VALUES, SETPOINTS, and TRIP/ALARM messages.
		EFFECT: Pressing this key will put the relay into HELP mode. If this key is pressed with the first line of a page (i.e. a page header) on the display the message, **Press KEY of interest or HELP again for details** will be displayed. To obtain information on the function of a particular key, the key must be pressed. To obtain information on the previously displayed ACTUAL VALUES, SETPOINTS, or TRIP/ALARM message the HELP key should be pressed again. If this key is pressed with any other message shown on the display, only information on the previous line will be available.
		USE: This key will have no effect when a flash message or HELP message is shown on the display. Once HELP mode is entered the LINE UP and LINE DOWN keys can be used to view the HELP message. The CLEAR key is used to exit from HELP mode and return to the previous display mode. The ACTUAL VALUES and SET POINTS keys can also be used to exit HELP mode.
4,5	PAGE UP PAGE DOWN	**FUNCTION:** The PAGE DOWN and PAGE UP keys allow the user to scan the next or previous pages of either ACTUAL VALUES or SETPOINTS modes. If either key is held for more than 1/2 second the next or previous pages will be selected at a fast rate.
		EFFECT: Pressing the PAGE DOWN key will cause the display to show the first line of the next page of information. Pressing the PAGE UP key will cause the display to show the first line of the previous page.
		USE: These keys can be used any time the relay is in either the ACTUAL VALUES or SETPOINTS modes.
6, 7	LINE UP LINE DOWN	**FUNCTION:** The LINE DOWN, and LINE UP keys allow the user to scan the next or previous lines of the currently selected page. If either key is held for more than 1/2 second the next or previous lines will be selected at a fast rate.

No.	Name	Description
		EFFECT: Pressing the LINE DOWN key will cause the display to show the next line of the currently selected page of information. Pressing the LINE UP key will cause the display to show the line immediately in front of the currently displayed line.
		USE: These keys can be used at any time in any relay mode of operation. If the display shows the last line of a page the LINE DOWN key will have no effect. If the display shows the first line of a page the LINE UP key will have no effect.
8,9	VALUE UP VALUE DOWN	**FUNCTION:** The VALUE UP and VALUE DOWN keys allow the user to alter the currently selected setpoint. If either key is held for more than 1/2 second the setpoint selected will increment or decrement at a fast rate. If either key is held for more than 2 seconds the setpoint selected will increment or decrement at a very fast rate.
		EFFECT: Pressing the VALUE UP key will cause the currently displayed setpoint value to increment. Pressing the VALUE DOWN key will cause the currently displayed setpoint value to decrement. For YES/NO questions, pressing either key will cause the answer to change. Any changed setpoint will not be used internally until the STORE key is pressed.
		USE: These keys can be pressed any time a setpoint is displayed in SETPOINTS mode or when a YES/NO question is displayed in ACTUAL VALUES mode (see STORE key). When the desired setpoint value is reached the STORE key is used to save it. If an altered setpoint is not stored the previous value will still be in effect.
10	RESET	**FUNCTION:** The RESET key allows the user to reset the 169 after any of the latched output relays have become active so that a motor start can be attempted.
		EFFECT: Pressing this key will reset (i.e. return to an inactive state) any of the active output relay contacts if motor conditions allow (see below). The message, **RESET NOT POSSIBLE - Condition still present** will be displayed if any active output relays cannot be reset
		USE: A latched relay cannot be reset if the trip/alarm condition persists (e.g. an OVERLOAD TRIP lock-out or a high RTD temperature). Pre-trip motor values may be viewed in ACTUAL VALUES mode page 5 (Pre-trip Data). If an immediate restart is required after an OVERLOAD or STARTS/HOUR TRIP the Emergency Restart terminals (see section 2.12) may be shorted together. This will reduce the lock-out time to 0 minutes.
11	CLEAR	**FUNCTION:** In SETPOINTS mode the CLEAR key allows the user to return an altered, non-stored setpoint to its original value. In HELP mode the CLEAR key allows the user to return to the previous display mode.
		EFFECT: When this key is pressed in SETPOINTS mode any altered, currently displayed setpoint will be returned to its original value. When this key is pressed in HELP mode the relay will return to the line and page of the mode active when the HELP key was pressed.
		USE: This key can be used in SETPOINTS or HELP modes only. In SETPOINTS mode it can only be used when a displayed setpoint has been changed with the VALUE UP/VALUE DOWN keys but has not yet been stored. After a setpoint has been stored the CLEAR key will have no effect. In HELP mode the CLEAR key can be used any time there is a HELP message on the display.

No.	Name	Description
12	STORE	**FUNCTION:** The STORE key allows the user to store new setpoints into the 169 relay's internal memory.
		EFFECT: When this key is pressed in SETPOINTS mode the currently displayed setpoint will be stored and will immediately come into effect. When a setpoint is stored the flash message, **new setpoint stored** will appear on the display. The STORE key can be pressed in ACTUAL VALUES mode to clear the maximum actual temperature data. To do this the following message from page 2 of ACTUAL VALUES mode must be displayed after the "NO" value is altered to say "YES" by pressing the VALUE UP/VALUE DOWN key: **CLEAR LAST ACCESS DATA ? YES** Then when the STORE key is pressed the following flash message will appear on the display: **last access data cleared** The maximum actual temperature data (see section 3.24) will then be cleared. The STORE key can be pressed in ACTUAL VALUES mode to start a new motor commissioning (i.e. clear statistical data). To do this the following message from page 4 of ACTUAL VALUES mode must be displayed after the "NO" value is altered to say "YES" by pressing the VALUE UP/VALUE DOWN key: **START COMMISSIONING? YES** Then when the STORE key is pressed the following flash message will appear on the display: **COMMISSIONING data cleared** All statistical data (see section 3.24) will then be cleared.
		USE: The STORE key can be used only in SETPOINTS mode to store new setpoints, or in ACTUAL VALUES mode to clear the maximum actual temperature data or start a new commissioning (i.e. clear statistical data). This key will have no effect unless the Access terminals are shorted together.
13	TRIP	LED indicator used to show the state of the Trip output relay. When on, the trip relay is active. When off, the Trip relay is inactive.
14	ALARM	LED indicator used to show the state of the Alarm output relay. When on, the Alarm relay is active. When off, the Alarm relay is inactive.
15	AUX. 1	LED indicator used to show the state of Auxiliary relay #1. When on, Aux. relay #1 is active. When off, Aux. relay #1 is inactive.
16	AUX. 2	LED indicator used to show the state of Auxiliary relay #2. When on, Aux. relay #2 is active. When off, Aux. relay #2 is inactive.

No.	Name	Description
17	SERVICE	LED indicator used to show the result of the 169 self-test feature. When flashing, the relay has failed the self-test and service is required. When on steady, the supply voltage may be too low. This LED may be on momentarily during relay power up.

3.2 169 Relay Display Modes

The 169 relay display is used for viewing actual motor values, setpoint values, HELP messages, and TRIP/ALARM messages. This is accomplished by having the relay in one of four possible modes of operation:

1. ACTUAL VALUES mode
2. SETPOINTS mode
3. HELP mode
4. TRIP/ALARM mode

The relay will operate correctly, giving full motor protection, regardless of which display mode is currently in effect. The different modes affect only the data that appears on the 169 relay's 48 character alphanumeric display.

TRIP/ALARM mode can only be entered by having one or more of the trip or alarm level setpoints exceeded. The other display modes can be entered using the ACTUAL VALUES, SET POINTS, or HELP keys (see section 3.1).

The ACTUAL VALUES and SETPOINTS modes are based on a book-like system of "pages" and "lines". One line from any page may be displayed at any given time. To "turn" a page, the PAGE UP and PAGE DOWN keys are used. To scan the lines on a page the LINE UP and LINE DOWN keys are used. In the HELP and TRIP/ALARM modes only the LINE UP and LINE DOWN keys are needed.

When control power is applied to the relay the following power up message will be displayed:

MULTILIN 169 RELAY
REVISION XXX   XX/XX

or

MULTILIN 169 PLUS RELAY
REVISION XXX   XX/XX

After this the display will show, (factory default settings)

I1= XXX   I2= XXX
I3= XXX   (AMPS) ---

which is in page 1 of ACTUAL VALUES mode.

A description of each display mode is given in the following sections.

3.3 ACTUAL VALUES Mode

In ACTUAL VALUES mode, any of the parameters monitored or calculated by the 169 relay may be viewed by the user. This mode is divided into six separate pages of data each of which contains a different group of actual motor values. The six pages and the lines in each page are as shown in Table 3-2.

Table 3-2 Actual Values

PAGE	LINE	DESCRIPTION
1	1	**PAGE 1: ACTUAL VALUES PHASE CURRENT DATA** ACTUAL VALUES page 1 header.
1	2	**MOTOR STARTING ###1###2###3###4###5###6** Motor starting current level (seen only during a motor start).
1	3	**I1= XXXX I2= XXXX I3= XXXX (AMPS) ---** Motor phase current data. ("---" becomes "RUN" when motor is running).
1	4	**I(3 ph avg) = XXXX AMPS Max Stator RTD = XXX C** Average of 3 phase currents. Maximum of 6 stator RTDs.
1	5	**UNBALANCE RATIO (In/Ip) U/B = XXX PERCENT** Ratio of negative to positive sequence currents.
1	6	**GROUND FAULT CURRENT G/F = XX.X AMPS** Actual ground fault current.
1	7	**END OF PAGE ONE ACTUAL VALUES** Last line of page 1.

PAGE	LINE	DESCRIPTION
2	1	**PAGE 2: ACTUAL VALUES RTD TEMPERATURE DATA** ACTUAL VALUES page 2 header.
2	2	**HOTTEST STATOR RTD RTD # X = XXX C** Maximum stator RTD temperature.
2	3	**STATOR TEMPERATURE RTD #1= XXX DEGREES C** or **RTD TEMPERATURE RTD #1= XXX DEGREES C** RTD #1 temperature.
2	4	**STATOR TEMPERATURE RTD #2= XXX DEGREES C** or **RTD TEMPERATURE RTD #2= XXX DEGREES C** RTD #2 temperature.
2	5	**STATOR TEMPERATURE RTD #3= XXX DEGREES C** or **RTD TEMPERATURE RTD #3= XXX DEGREES** RTD #3 temperature.
2	6	**STATOR TEMPERATURE RTD #4= XXX DEGREES C** or **RTD TEMPERATURE RTD #4= XXX DEGREES C** RTD #4 temperature.

PAGE	LINE	DESCRIPTION
2	7	**STATOR TEMPERATURE RTD #5= XXX DEGREES C** or **RTD TEMPERATURE RTD #5= XXX DEGREES C** RTD #5 temperature.
2	8	**STATOR TEMPERATURE RTD #6= XXX DEGREES C** or **RTD TEMPERATURE RTD #6= XXX DEGREES C** RTD #6 temperature.
2	9	**RTD TEMPERATURE RTD #7= XXX DEGREES C** RTD #7 temperature.
2	10	**RTD TEMPERATURE RTD #8= XXX DEGREES C** or **AMBIENT TEMPERATURE RTD #8= XXX DEGREES C** RTD #8 temperature. Ambient seen when RTD #8 is used for ambient sensing on model 169.
2	11	**RTD TEMPERATURE RTD #9= XXX DEGREES C** RTD #9 temperature.
2	12	**RTD TEMPERATURE RTD #10= XXX DEGREES C** or **AMBIENT TEMPERATURE RTD #10= XXX DEGREES C** RTD #10 temperature. Ambient seen when RTD #10 is used for ambient sensing on model 169.
2	13	**MAX. STATOR SINCE LAST ACCESS: RTD# X = XXX** Maximum stator RTD temperature since last access.

PAGE	LINE	DESCRIPTION
2	14	**MAXIMUM RTD#7 TEMP SINCE LAST ACCESS: RTD# X = XXX** Maximum RTD #7 temperature since last access.
2	15	**MAXIMUM RTD#8 TEMP SINCE LAST ACCESS = XXX C** Maximum RTD #8 temperature since last access.
2	16	**MAXIMUM RTD#9 TEMP SINCE LAST ACCESS = XXX C** Maximum RTD #9 temperature since last access.
2	17	**MAX. RTD# 10 TEMP SINCE LAST ACCESS = XXX C** Maximum RTD #10 temperature since last access.
2	18	**CLEAR LAST ACCESS DATA? XXX** Used to clear the data in the last 5 lines (see section 3.1, STORE key).
2	19	**END OF PAGE TWO ACTUAL VALUES** Last line of page 2.

PAGE	LINE	DESCRIPTION
3	1	**PAGE 3: ACTUAL VALUES MOTOR CAPACITY DATA** ACTUAL VALUES page 3 header.
3	2	**ESTIMATED TIME TO TRIP = XXX SECONDS** Estimated time to overload trip under present conditions (seen only during overloads).
3	3	**MOTOR LOAD AS A PERCENT FULL LOAD = XXX PERCENT** Actual motor current as a percentage of full load.
3	4	**THERMAL CAPACITY USED = XXX PERCENT** Percentage of motor thermal capacity used.
3	5	**END OF PAGE THREE ACTUAL VALUES** Last line of page 3.

PAGE	LINE	DESCRIPTION
4	1	**PAGE 4: ACTUAL VALUES STATISTICAL DATA** ACTUAL VALUES page 4 header.
4	2	**RUNNING HRS SINCE LAST COMMISSIONING XXXXX HRS** Total motor running hours since last commissioning.
4	3	**# OF STARTS SINCE LAST COMMISSIONING XXX** Total number of motor starts since last commissioning.
4	4	**# OF TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay trips since last commissioning.
4	5	**# O/L TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay overload trips since last commissioning.
4	6	**# RAPID TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay rapid trips since last commissioning.
4	7	**# U/B TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay unbalance trips since last commissioning.
4	8	**# G/F TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay ground fault and differential input trips since last commissioning.
4	9	**# RTD TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay RTD trips since last commissioning.
4	10	**# S/C TRIPS SINCE LAST COMMISSIONING XXX** Total number of relay short circuit trips since last commissioning.
4	11	**#START TRIPS SINCE LAST COMMISSIONING XXX** Total number of acceleration time, phase reversal and speed switch trips since last commissioning.

PAGE	LINE	DESCRIPTION
4	12	**START NEW COMMISSIONING? XXX** Used to clear the data in the last 10 lines (see section 3.1, STORE key).
4	13	**END OF PAGE FOUR ACTUAL VALUES** Last line of page 4.

PAGE	LINE	DESCRIPTION
5	1	**PAGE 5: ACTUAL VALUES PRE-TRIP DATA** ACTUAL VALUES page 5 header.
5	2	**PRE-TRIP AVERAGE MOTOR CURRENT = XXXXX AMPS** Average motor phase current prior to last relay trip.
5	3	**PRE-TRIP U/B RATIO (In/Ip) XXX PERCENT** Ratio of negative to positive sequence currents prior to last relay trip.
5	4	**PRE-TRIP G/F CURRENT G/F = XXX AMPS** Ground fault current prior to last relay trip.
5	5	**PRE-TRIP MAX STATOR RTD RTD # X = XXX C** Maximum stator RTD temperature prior to last relay trip.
5	6	**END OF PAGE FIVE ACTUAL VALUES** Last line of page 5.

PAGE	LINE	DESCRIPTION
6	1	**PAGE 6: ACTUAL VALUES LEARNED PARAMETERS** ACTUAL VALUES page 6 header.
6	2	**LEARNED Istart (AVG.OF 4 STARTS) = XXX AMPS** Learned average motor starting current over past 4 starts.
6	3	**LEARNED Istart (last one) = XXX AMPS** Learned motor starting current from last start.
6	4	**LEARNED K FACTOR K = XX.X** Learned value of negative sequence K factor.
6	5	**LEARNED RUNNING COOL TIME= XXX MIN.** Learned motor cooling time with motor running (see section 3.20).
6	6	**LEARNED STOPPED COOL TIME= XXX MIN.** Learned motor cooling time with motor stopped (see section 3.20).
6	7	**LEARNED ACCEL. TIME ACCEL. TIME = XX.X SEC.** Learned motor acceleration time.
6	8	**LEARNED Start Capacity required = XX PERCENT** Learned motor thermal capacity used during a start.
6	9	**END OF PAGE SIX ACTUAL VALUES** Last line of page 6.

** 169 Plus only*

To place the relay in ACTUAL VALUES mode, the ACTUAL VALUES key must be pressed. When this is done the following flash message will appear for 2 seconds,

```
ACTUAL VALUES HAS SIX
  PAGES OF DATA
```

The display will then show,

```
PAGE 1: ACTUAL VALUES
PHASE CURRENT DATA
```

which is the beginning of page 1.

If the relay is in SETPOINTS mode or ACTUAL VALUES mode and no key is pressed for more than four minutes the display will change to, (factory default settings)

```
I1=  XXX    I2=  XXX
I3=  XXX    (AMPS) ---
```

which is the third line in page 1 of ACTUAL VALUES mode. This default display line can be changed in page 5 of SETPOINTS mode.

When in this mode the PAGE UP, PAGE DOWN, LINE UP, and LINE DOWN keys (see section 3.1) can be used to examine all of the actual motor data outlined above.

3.4 SETPOINTS Mode

In SETPOINTS mode any or all of the motor trip/alarm setpoints may be either viewed or altered. This mode is divided into six separate pages of data each of which contains a different group of relay setpoints.

To enter SETPOINTS mode the SET POINTS key must be pressed. When in this mode, if no key is pressed for more than four minutes, the display will automatically go into ACTUAL VALUES mode as explained in section 3.3. To return to SETPOINTS mode the SET POINTS key must be pressed. When this key is pressed the following flash message will appear on the display,

SETPOINTS HAS SIX
PAGES OF DATA

Then the display will show,

PAGE 1: SETPOINT VALUES
MOTOR AMPS SETPOINTS

which is the first line of the first page of SETPOINTS mode. The PAGE UP, PAGE DOWN, LINE UP, and LINE DOWN keys (see section 3.1) may then be used to view all of the SETPOINTS data.

When setpoints are to be changed, the VALUE UP, VALUE DOWN, STORE, and CLEAR keys (see section 3.1) are used. The Access terminals must first be shorted together (see section 2.17). The PAGE UP, PAGE DOWN, LINE UP, and LINE DOWN keys are used to display the setpoints that are to be changed. The setpoints themselves are changed by pressing the VALUE UP or VALUE DOWN keys until the desired setpoint value is reached. To return the setpoint to its original value the CLEAR key can be used. When the setpoint is adjusted to its proper value the STORE key should be pressed in order to store the setpoint into the 169's internal memory. Once the STORE key is pressed the flash message,

new setpoint stored

will appear on the display and the new setpoint value will be used by the 169 relay.

If an attempt is made to store a new setpoint value without the Access terminals shorted together the new value will not be stored and the flash message,

ILLEGAL ACCESS

will appear on the display. To make the setpoints tamperproof the Access terminals should be shorted together only when setpoints are to be changed.

Setpoints may be changed while the motor is running; however it is not recommended to change important protection parameters without first stopping the motor.

Setpoints will remain stored indefinitely in the 169 relay's internal non-volatile memory even when control power to the unit is removed.

All six pages of data and the lines in each page are as shown in Table 3-3. Also shown are the ranges and increments for each setpoint. It should be noted that the 169 relay's motor protection parameters are based on the data entered by the user. Thus this data must be complete and accurate for the given system.

Table 3-3 SETPOINTS

PAGE	INFORMATION LINE	RANGE	MANUAL REF
1	**PAGE 1: SETPOINTS VALUES MOTOR AMPS SETPOINTS**		
1	**PHASE CT RATIO SECONDARY = X AMP**	:1 or :5	3.7
1	**PHASE CT RATIO CT RATIO = XXXX:x**	20-1500 (increments of 1)	3.7
1	**MOTOR FULL LOAD CURRENT FLC= XXXX AMPS**	10-1500 amps (increments of 1)	3.7
1	**ACCEL.TIME= XXX.X SECONDS Consult motor data sheet**	0.5-125.0 or OFF (increments of 0.5)	3.8
1	**STARTS/HOUR= X Consult motor data sheet**	1-5 starts or OFF (increments of 1)	3.9
1	**UNBALANCE ALARM LEVEL U/B ALARM= XX PERCENT**	4-30 % or OFF (increments of 1)	3.10
1	**U/B ALARM TIME DELAY TIME DELAY = XXX SEC**	3-255 seconds (increments of 1)	3.10
1	**UNBALANCE TRIP LEVEL U/B TRIP= XX PERCENT**	4-30 % or OFF (increments of 1)	3.10
1	**U/B TRIP TIME DELAY U/B DELAY= XXX SECONDS**	3-255 seconds (increments of 1)	3.10
1	**G/F CT RATIO :5 ? XXX (NO indicates 2000:1)**	YES (5 amp secondary) or NO (2000:1)	3.11
1	**G/F CT RATIO G/F CT = XXX:5**	50-250 (increments of 50) (Not seen if ratio is 2000:1)	3.11
1	**GROUND FAULT ALARM LEVEL G/F ALARM= XXX AMPS**	2000:1 CT: 1.0-10.0 amps or OFF (steps of 1.0) 5 A secondary CT: 10-100% of primary amps or OFF (increments of 10%)	3.11
1	**G/F ALARM TIME DELAY TIME DELAY = XXX SEC**	1-255 seconds (increments of 1)	3.11
1	**GROUND FAULT TRIP LEVEL G/F TRIP = XXX AMPS**	2000:1 CT: 1.0-10.0 A or OFF (steps of 1.0) 5 A secondary CT: 10-100% of primary amps or OFF (increments of 10%)	3.11

PAGE	INFORMATION LINE	RANGE	MANUAL REF
1	**G/F TRIP TIME DELAY** **G/F DELAY= XX.X SECONDS**	0.0 (Instantaneous) – 20.0 seconds (increments of 0.5). Additional time delay of 0.25 seconds following 20.0.	3.11
1	**UNDERCURRENT ALARM LEVEL** **U/C ALARM= XXXX AMPS**	1-1000 amps or OFF (increments of 1)	3.12
1	**UNDERCURRENT TIME DELAY** **U/C DELAY= XXX SECONDS**	1-255 seconds (increments of 1)	3.12
1	**RAPID TRIP / MECH. JAM** **TRIP LEVEL= X.X X FLC**	1.5xFLC-4.5xFLC or OFF (steps of 0.5xFLC)	3.13
1	**RAPID TRIP TIME DELAY** **DELAY= XXX.X SECONDS**	0.5-125.0 seconds (increments of 0.5)	3.13
1	**SHORT CIRCUIT TRIP LEVEL** **S/C TRIP= XX X FLC**	4xFLC-12xFLC or OFF (increments of 1xFLC)	3.14
1	**SHORT CIRCUIT TIME DELAY** **S/C DELAY= XX.X SECONDS**	Instantaneous or 0.5-20.5 sec. (steps of 0.5)	3.14
1	**IMMEDIATE OVERLOAD** **LEVEL = X.XX X FLC**	1.01xFLC-1.50xFLC or OFF (steps of 0.01xFLC)	3.15
1	**END OF PAGE ONE** **SETPOINT VALUES**		

PAGE	INFORMATION LINE	RANGE	MANUAL REF
2	PAGE 2: SETPOINT VALUES RTD SETPOINTS		
2	# OF STATOR RTDS USED # OF RTDs = X	0-6 (increments of 1)	3.16
2	RTD #1 ALARM LEVEL = XXX DEGREES C or STATOR #1 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #1 TRIP LEVEL = XXX DEGREES C or STATOR #1 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #2 ALARM LEVEL = XXX DEGREES C or STATOR #2 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #2 TRIP LEVEL = XXX DEGREES C or STATOR #2 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #3 ALARM LEVEL = XXX DEGREES C or STATOR #3 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #3 TRIP LEVEL = XXX DEGREES C or STATOR #3 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16

PAGE	INFORMATION LINE	RANGE	MANUAL REF
2	RTD #4 ALARM LEVEL = XXX DEGREES C or STATOR #4 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #4 TRIP LEVEL = XXX DEGREES C or STATOR #4 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #5 ALARM LEVEL = XXX DEGREES C or STATOR #5 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #5 TRIP LEVEL = XXX DEGREES C or STATOR #5 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #6 ALARM LEVEL = XXX DEGREES C or STATOR #6 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #6 TRIP LEVEL = XXX DEGREES C or STATOR #6 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.16
2	RTD #7 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	RTD #7 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17

PAGE	INFORMATION LINE	RANGE	MANUAL REF
2	RTD #8 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	RTD #8 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	RTD #9 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	RTD #9 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	RTD #10 ALARM LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
*2	RTD #10 TRIP LEVEL = XXX DEGREES C	0-200 degrees C or OFF (increments of 1)	3.17
2	END OF PAGE TWO SETPOINT VALUES	0-200 degrees C or OFF (increments of 1)	

PAGE	INFORMATION LINE	RANGE	MANUAL REF
3	PAGE 3: SETPOINT VALUES O/L CURVE SETPOINTS		
*3	CUSTOM CURVE? XXX YES voids selected curve	YES or NO	3.18
3	SELECTED CURVE NUMBER CURVE # = X	1-8 (this line is not seen when using a custom curve on a 169 Plus)	3.18
3	Check all custom curve entries before exiting	(The following lines are not seen when using standard curves)	3.18
*3	TRIP TIME @ 1.05 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.10 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.20 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.30 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.40 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.50 X FLC = XXXXX SECONDS	1-12000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 1.75 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 2.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 2.25 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 2.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 2.75 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 3.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18

PAGE	INFORMATION LINE	RANGE	MANUAL REF
*3	TRIP TIME @ 3.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 4.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 4.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 5.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 5.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 6.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 6.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 7.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 7.50 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
*3	TRIP TIME @ 8.00 X FLC = XXXX SECONDS	1-2000 seconds (increments of 1)	3.18
3	END OF PAGE THREE SETPOINT VALUES		

*** 169 Plus only*

PAGE	DESCRIPTION
4	**PAGE 4: SETPOINT VALUES RELAY CONFIGURATION** This page assigns trip and alarm functions to specific output relays (i.e. TRIP, ALARM, AUX. 1, AUX. 2 on the 169 Plus, or TRIP and ALARM on the model 169). Each trip/alarm function is assigned separately to the appropriate relay or to "NO" relay. If an alarm feature is assigned to no relay, it can still become active (i.e. cause the appropriate alarm message to be displayed if setpoints are exceeded) but no output relay activation will occur. Possible assignments and factory values are shown below. **Only one TRIP may occur at any one time. TRIP functions <u>must</u> therefore be used to trip the motor. Once one TRIP function is active, no other trip may occur.**
4	**Assign XXXXXXXXXXXXXXXX to XXXXXXXXXXXX relay**

For the model 169 Plus:

Feature	Possible Assignments	Factory Value
O/L TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
U/B TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
S/C TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
RAPID TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
STATOR RTD TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
RTD TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
G/F TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
ACCEL. TIME TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
PHASE REV. TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
STARTS/HOUR TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
SPEED SWITCH TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
DIFFERENTIAL TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
SINGLE PHASE TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
SPARE INPUT TRIP	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
START INHIBIT	TRIP or AUX. 1 or TRIP & AUX.1	TRIP RELAY
O/L WARNING	ALARM or AUX. 1 or AUX. 2 or NO	ALARM RELAY
G/F ALARM	ALARM or AUX. 1 or AUX. 2 or NO	ALARM RELAY
U/B ALARM	ALARM or AUX. 1 or AUX. 2 or NO	ALARM RELAY
U/C ALARM	ALARM or AUX. 1 or AUX. 2 or NO	ALARM RELAY
STATOR RTD ALARM	ALARM or AUX. 1 or AUX. 2 or NO	AUX. 1 RELAY
RTD ALARM	ALARM or AUX. 1 or AUX. 2 or NO	AUX. 1 RELAY
NO SENSOR ALARM	ALARM or AUX. 1 or AUX. 2 or NO	AUX. 1 RELAY
SELF-TEST FAIL	ALARM or AUX. 1 or AUX. 2 or NO	AUX. 2 RELAY
SPARE INPUT ALARM	ALARM or AUX. 1 or AUX. 2 or NO	NO RELAY

For the model 169:

Feature	Possible Assignments	Factory Value
O/L TRIP	(not shown)	TRIP RELAY
U/B TRIP	(not shown)	TRIP RELAY
S/C TRIP	(not shown)	TRIP RELAY
RAPID TRIP	(not shown)	TRIP RELAY
STATOR RTD TRIP	(not shown)	TRIP RELAY
RTD TRIP	(not shown)	TRIP RELAY
G/F TRIP	(not shown)	TRIP RELAY
ACCEL. TIME TRIP	(not shown)	TRIP RELAY
PHASE REV. TRIP	(not shown)	TRIP RELAY
STARTS/HOUR TRIP	(not shown)	TRIP RELAY
SINGLE PHASE TRIP	(not shown)	TRIP RELAY
O/L WARNING	ALARM or NO	ALARM RELAY
G/F ALARM	ALARM or NO	ALARM RELAY
U/B ALARM	ALARM or NO	ALARM RELAY
U/C ALARM	ALARM or NO	ALARM RELAY
STATOR RTD ALARM	ALARM or NO	ALARM RELAY
RTD ALARM	ALARM or NO	ALARM RELAY
NO SENSOR ALARM	ALARM or NO	ALARM RELAY
SELF-TEST FAIL	ALARM or NO	ALARM RELAY

PAGE	DESCRIPTION
5	**PAGE 5: SETPOINT VALUES SYSTEM CONFIGURATION** This page is used to configure the 169 relay to exactly match the motor and motor system being protected. Various special features can be selected, defeated, or adjusted in this page of setpoints.
5	**NORMAL RUN DISPLAY SHOWS LINE = LINE XX** This code determines the line of the selected page in ACTUAL VALUES MODE to which the display will return if no key is pressed for more than four minutes and no trips or alarms are present: 1-40 - line number in selected page (see Table 3-2); Factory Value = 2
5	**NORMAL RUN DISPLAY SHOWS PAGE = PAGE XX** This code determines the page in ACTUAL VALUES mode to which the display will return if no key is pressed for more than four minutes and no trips or alarms are present: 1 or 7 - page 1 (see Table 3-2) 2 or 8 - page 2 3 or 9 - page 3 4 or 10 - page 4 5 - page 5 6 - page 6 Factory Value = 1
5	**DEFEAT NO SENSOR ALARM? XXX** This code is used to enable or defeat the Broken RTD Sensor Alarm. This alarm will only become active for open circuit RTDs chosen for use: YES - RTD Broken Sensor Alarm defeated; NO - RTD Broken Sensor Alarm enabled. Factory Value = YES
5	**DEFEAT RTD INPUT TO THERMAL MEMORY ? XXX** This code is used to enable or defeat the thermal memory RTD bias feature of the relay (see section 3.20). With this feature defeated the effect of the stator RTD temperature is not included in the thermal memory: YES - RTD bias defeated (RTD temperature does not affect thermal memory); NO - RTD bias enabled (thermal memory reduced as per figure 3-4) Factory Value = YES
5	**RTD BIAS CURVE MINIMUM VALUE = XXX C** Not seen when RTD input to thermal memory is defeated. This code is used to set the RTD bias minimum value (see figure 3-4): 0-200 - RTD bias curve minimum value in degrees C; Factory Value = 90

PAGE	DESCRIPTION
5	**RTD BIAS CURVE MAXIMUM VALUE = XXX C** Not seen when RTD bias is defeated. This code sets the RTD bias maximum value (see figure 3-4): 0-200 - RTD bias maximum value in degrees C.; Factory Value = 190
5	**DEFEAT U/B INPUT TO THERMAL MEMORY ? XXX** (model 169 Plus only) This code is used to defeat or enable the unbalance bias function. With this feature defeated the effect of negative sequence unbalance is not included in the thermal memory: YES - Unbalance bias defeated, thermal memory affected by average of three phase currents. NO - Unbalance bias enabled, thermal memory affected by equivalent motor heating current (including negative sequence contribution). **Note: This setpoint should not be changed to NO until the 169 Plus relay has learned a value for K. The learned K factor is used to bias the thermal memory as explained in section 3.20. The learned K value can be examined in ACTUAL VALUES mode, page 6.** Factory Value = YES
5	**DEFAULT K VALUE = XX (OFF selects learned K)** Seen only when U/B input to thermal memory is enabled (model 169 Plus only). This setpoint is used to select a value for the negative sequence unbalance K factor (see section 3.20): 1-19 (increments of 1) or OFF - OFF indicates learned K value is to be used. Factory Value = 6
5	**DEFEAT LEARNED COOL TIME ? XX** (model 169 Plus only) This code is used to tell the 169 relay to use the learned motor cooling time values. These times can be examined in ACTUAL VALUES mode, page 6. When learned values are not used, the user entered default times will be used: YES - Relay uses default cool times; NO - uses learned cool times from page 6 of ACTUAL VALUES **Note: This setpoint should be set to "YES" (relay uses default cool times) until the 169 relay has learned reasonable motor cooldown times.** Factory Value = YES
5	**ENTER RUNNING COOL TIME = XXX MINUTES** Not seen if cooldown time learned values are used. This code is seen when the learned motor cooling times are not used. This value represents the time for the thermal memory to discharge from 100% to 0% with the motor running in a non-overload condition: 1-45 - cooling time in minutes; Factory Value = 15

PAGE	DESCRIPTION
5	**ENTER STOPPED COOL TIME = XXX MINUTES** Not seen if cooldown time learned values are used. This code is seen when the learned motor cooling times are not used by the 169. This value represents the time for the thermal memory to discharge from 100% to 0% with the motor stopped. The OVERLOAD TRIP lockout time is 85% of this value (see section 3.20). 5-135 - cooling time in minutes. Factory Value = 30
5	**RTD 8 AMBIENT SENSOR ? XXX** or **RTD10 AMBIENT SENSOR ? XXX** (RTD 8 – model 169; RTD 10 – model 169 Plus). This code is used to select one of the bearing RTDs as an ambient air temperature sensor. When stored as YES, trip and alarm levels for the selected RTD will be automatically set to "OFF". See section 3.20. YES - Indicated RTD will be used for ambient air temperature measurement NO - Indicated RTD will be used for other (non-stator) temperature measurement Factory Value = NO
5	**DEFEAT SPEED SWITCH? XXX** (model 169 Plus only) This setpoint is used to defeat or enable the Speed Switch Trip. YES - Speed Switch function disabled, no speed switch used NO - Speed Switch function enabled, speed switch can be used Factory Value = YES
5	**SPEED SWITCH TIME DELAY = XXX.X SEC.** Not seen if speed switch function is disabled (model 169 Plus only). This setpoint is used to set the time delay for the operation of the speed switch function. 0.5-100.0 (increments of 0.5) - time delay in seconds; Factory Value = 2.0
5	**ANALOG OUTPUT PARAMETER = XXXXXXXXXXXXXX** This setpoint is used to select the analog current output function. Thermal Memory - Motor thermal capacity used Motor Load - Motor current as a percentage of full load Max Stator RTD - Hottest stator RTD temperature (0-200 C) CT secondary - CT secondary current as a percentage of CT secondary amps rating Factory Value = Max Stator RTD

PAGE	DESCRIPTION
5	**Enable Single-shot restart ? XXX** (model 169 Plus only) This setpoint is used to enable or defeat the single-shot restart feature described in section 3.22. YES - Single-shot restart enabled; NO - Single-shot restart disabled. Factory Value = NO
5	**Enable start inhibit? XXX** (model 169 Plus only) This setpoint is used to enable or defeat the Start Inhibit feature of the relay described in section 3.20: YES - Start Inhibit enabled; NO – Start Inhibit disabled **Note: This setpoint should not be changed until the 169 relay has obtained a reasonable value for the "LEARNED Start Capacity required" (SETPOINTS mode, page 6).** Factory Value = NO
5	**Enable special external reset function? XXX** (model 169 Plus only) This setpoint is used to enable or defeat the special external reset feature described in sections 2.13, 3.22. YES - special external reset enabled; NO - special external reset disabled. Factory Value = NO
5	**Enable phase reversal? XXX** This code is used to defeat or enable the Phase Reversal Trip function. YES - Phase Reversal Trip function enabled; NO - Phase Reversal Trip function disabled **Note: If only two phase CTs are used, as shown in Figure 2-6, this setpoint must be set to NO.** Factory Value = NO

PAGE	DESCRIPTION
5	**RELAY ALARM** **LATCHCODE = XX** This setpoint allows the choice of output relay latch attributes. A latched output relay must be manually reset. An unlatched relay will be automatically reset when the condition that caused the relay activation goes away. **Note: Trip functions must always be manually reset regardless of the Latchcode value chosen here.** This setpoint allows Alarm functions to be either manually or automatically resetable. The Immediate O/L Alarm function will always be automatically reset regardless of the Latchcode. latched = manual reset, unlatched = automatic reset (see Table 3-6 for complete relay functions/configurations) *For the model 169 Plus:* **Value / Trip / Alarm / Aux. 1 / Aux. 2** 1 / latched / unlatched / unlatched / latched 2 or 3 / latched / latched / unlatched / latched 4 or 5 / latched / unlatched / latched / latched 6 or 7 / latched / latched / latched / latched *For the model 169:* **Value / Trip / Alarm** 1 or 4 or 5 / latched / unlatched 2 or 3 or 6 or 7 / latched / latched Factory Value = 1
5	**RELAY FAILSAFE** **CODE = X** This code allows the choice of output relay fail-safe attributes. FS = fail-safe, NFS = non-fail-safe (see Glossary). See Table 3-7 for complete relay functions/configurations. *For the model 169 Plus:* **Value / Trip / Alarm / Aux. 1 / Aux. 2** 1 / FS / NFS / NFS / FS (see Figure 2-5) 2 / NFS / FS / NFS / FS 3 / FS / FS / NFS / FS 4 / NFS / NFS / FS / FS 5 / FS / NFS / FS / FS 6 / NFS / FS / FS / FS 7 / FS / FS / FS / FS 8 / NFS / NFS / NFS / FS *For the model 169:* **Value / Trip / Alarm** 1 or 5 / FS / NFS (see Figure 2-5) 2 or 6 / NFS / FS 3 or 7 / FS / FS 4 or 8 / NFS / NFS Factory Value = 1 **Note: Due to the hardware configuration of the 169/169 Plus drawout relay this code cannot be changed on any drawout models without corresponding hardware change.**

PAGE	DESCRIPTION
5	**SPARE INPUT ALARM TIME DELAY = XXX SEC.** (model 169 Plus only) This setpoint is used to set the time delay for the Spare Input Alarm: 1-254 (increments of 1) or OFF - time delay in seconds (OFF disables this function) Factory Value = OFF
5	**SPARE INPUT TRIP TIME DELAY = XXX SEC.** (model 169 Plus only) This setpoint is used to set the time delay for the operation of the Spare Input Trip function: 1-254 (increments of 1) or OFF - time delay in seconds (OFF disables this function) Factory Value = OFF
5	**ENABLE AUTO-RESET OF START TRIPS ? XXX** This setpoint is used to automatically reset either STARTS/HOUR or START INHIBIT trips when conditions permit. YES – relay automatically resets after the STARTS/HOUR or START INHIBIT lockout time has run out.; NO - relay must be manually reset after the STARTS/HOUR or START INHIBIT lockout time has run out. Factory Value = NO
5	**FLC THERMAL CAPACITY REDUCTION = XX PERCENT** This setpoint is used to set the level to which the thermal memory will discharge to when the motor is running at full load current. This level may be set as the percentage difference of the hot motor thermal damage curve to the cold motor thermal damage curve. Range: 5% - 50% increments of 1%; Factory Value = 15%
5	**SERIAL = MASTER ? XXX (No Indicates Slave)** (model 169 Plus only) This setpoint is used to select the relay as either a MASTER or a SLAVE for connection in a serial communication link. When a relay is configured as a MASTER **<u>it cannot be used for motor protection (see section 2.18):</u>** YES - relay is configured as a MASTER; NO - relay is configured as a SLAVE. Factory Value = NO **Note: If this setpoint is changed to YES and phase currents are injected relay failure will occur.**
5	**SLAVE ADDRESS = XXX** Seen only when relay is chosen as a SLAVE (model 169 Plus only). This setpoint is used to set the address of the relay to distinguish it from other devices in a serial communication link (see section 2.18): 1-254 or OFF - relay SLAVE address (OFF indicates no address). Factory Value = OFF

PAGE	DESCRIPTION
5	**ADDRESSED SLAVE = XXX** Seen only when relay is chosen as a MASTER (model 169 Plus only). This setpoint is used to set the address of the SLAVE relay with which the MASTER will communicate (see section 2.18): 1-254 or OFF - address of SLAVE relay (OFF indicates no address). Factory Value = OFF
5	**END OF PAGE FIVE SETPOINT VALUES**

PAGE	DESCRIPTION
6	**PAGE 6: SETPOINT VALUES MULTILIN SERVICE CODES** This page is used for 169 relay testing both in the field and at the Multilin factory. The first four lines of this page are available to the user for testing the relay once it is installed. The other lines in this page are only accessible to Multilin service personnel by entering an access code.
6	**EXERCISE RELAY : XXXXXX** This line is used to test the operation of the 169 output relay contacts and to test any connected switchgear. This can only be done when the motor is stopped. Pressing the VALUE UP or VALUE DOWN keys, followed by the STORE key, will cause different output relays to change state: NO - No output relays activated; TRIP - Trip relay activated; ALARM - Alarm relay activated AUX.1 - Aux. 1 relay activated (169 Plus only) AUX.2 - Aux. 2 relay activated (169 Plus only) ALL - All output relays activated (169 Plus only)
6	**TEMPERATURE= XXX C FOR FORCED RTD # X** This line is used to force the 169 relay to read a single RTD. The RTD number is chosen by pressing the VALUE UP or VALUE DOWN keys. This will only work when the motor is stopped: 1-8 (169), 1-10 (169 Plus) - RTD number to be read continuously
6	**ANALOG OUT FORCED TO: XXXXXX SCALE** This line is used to force the analog current output of the 169 relay to a certain value to test the relay and any associated meters. This will only work when the motor is stopped: NORMAL - Analog current output left unchanged ZERO - Analog current output forced to zero MID - Analog current output forced to the middle of the scale FULL - Analog current output forced to a full scale output
6	**STATUS = XXXXXX FOR: XXXXXXXXXXXX SWITCH** This line can be used to check the status (either OPEN or SHORT) of any of the following terminals: EXT.RESET, EMG.RESTART, or ACCESS (169) EXT.RESET, EMG.RESTART, ACCESS, SPEED, DIFF. or SPARE (169 Plus)
6	**SERVICE USE ONLY CODE = XXX** This line is used by Multilin service personnel for calibration and service to the 169 relay.
6	**MULTILIN 169 PLUS RELAY REVISION XX XX/XX** or **MULTILIN 169 RELAY REVISION XX XX/XX** This is the 169 relay firmware revision identifier line.

3.5 HELP Mode

This display mode should be used whenever help is required in using the 169 relay. The HELP key can provide the user with information on the proper function and use of each key on the keypad or can provide information about the currently displayed ACTUAL VALUES, SETPOINTS, or TRIP/ALARM message. Pressing the HELP key has no effect when a flash message or HELP message is on the display.

If the HELP key is pressed with the first line of a page (i.e. a page header) on the display the following message will appear:

Press KEY of interest or
HELP again for details

The user should then press the key for which instruction is required or press the HELP key again to access information on the previously displayed ACTUAL VALUES, SETPOINTS, or TRIP/ALARM message. When the desired key is pressed the display will show the message:

Press LINE DOWN for
info or CLEAR to exit

The LINE DOWN key can then be used to display the requested HELP message.

If the HELP key is pressed with any line that is not a page header on the display the HELP message shown will be for the previously displayed ACTUAL VALUES, SETPOINTS, or TRIP/ALARM message.

Pressing the CLEAR key at any time during the HELP message will return the display to the page and line of the mode in effect when the HELP key was originally pressed. The ACTUAL VALUES and SET POINTS keys may also be pressed to exit HELP mode.

3.6 TRIP/ALARM Mode

TRIP/ALARM mode can only be entered when an actual motor value exceeds a setpoint value or an alarm becomes active. Every trip and alarm condition has a separate message so that the exact nature of the problem can be easily identified.

TRIP/ALARM mode will be entered whenever a setpoint is exceeded or an alarm condition arises regardless of whether an output relay activation occurs. For example, if the "STATOR RTD ALARM LEVEL" setpoint is exceeded, but this function is assigned to "NO" output relay, the 169 will enter TRIP/ALARM mode but no output relay activation will occur.

To leave TRIP/ALARM mode the ACTUAL VALUES, SET POINTS, or HELP keys can be pressed. Doing this will not change the state of the output relays but will allow the user to access other motor and relay information to determine the cause of the trip. The active TRIP/ALARM messages are found in ACTUAL VALUES mode, page 5, immediately in front of the pre-trip motor data. If any trip/alarm function is active and no key is pressed for a time of 20 seconds, the 169 relay display will return to the appropriate TRIP/ALARM message.

Only one type of relay trip can occur at any one time. However, a trip and an alarm or multiple alarms can occur at the same time. If this is the case the 169 relay display will show the TRIP/ALARM message for the trip or alarm with the highest priority. Any other active messages can be examined by using the LINE DOWN key. The complete set of TRIP/ALARM messages is shown in Table 3-4 together with a description of the conditions causing the relay to enter TRIP/ALARM mode. The messages are shown in order of display priority.

Note: Only one TRIP function can occur at any one time. TRIP functions <u>must</u> therefore be used to trip out the motor. Once one TRIP function is active no other TRIPs can occur. If multiple ALARMs occur, the other ALARM messages may be viewed by pressing the LINE DOWN key.

Table 3-4: TRIP/ALARM MESSAGES AND FAULT DIAGNOSIS

LEVEL	INFORMATION LINE	EXPLANATION	DIAGNOSIS	REF.
1	**SELF-TEST ALARM A/D H/W FAIL**	Problem in A/D circuit detected by internal self-test. Service required.	Return relay for service.	3.23
	SELF-TEST ALARM RTD H/W FAIL	Problem in RTD circuit detected by internal self-test. Service required.	Return relay for service.	
	SELF-TEST ALARM RAM FAIL	Problem in RAM detected by internal self-test. Service required.	Return relay for service.	
	SELF-TEST ALARM FACTORY SETPOINTS LOADED	Problem in NOVRAM detected by internal self-test. Service required.	Return relay for service.	
2	**PHASE S/C TRIP**	Short Circuit Trip Level exceeded for a time greater than the Short Circuit Time Delay.	Check for motor winding shorts.	3.14
3	**RAPID TRIP**	Rapid trip / Mech. Jam Trip Level exceeded for a time greater than the Rapid Trip Time Delay.	Check system for jams / excessive load.	3.13
4	**SINGLE PHASE TRIP**	Unbalance of over 30% present for a time greater than 4 seconds.	Check continuity of incoming three phase supply.	3.10
5	**G/F TRIP**	Ground Fault Trip Level exceeded for a time greater than the Ground Fault Trip Time Delay.	Check for motor winding to case or ground shorts. Check motor for moisture or conductive particles.	3.11
	OVERLOAD TRIP LOCKOUT TIME = XXX MIN.	Motor thermal capacity exceeded. Motor lock-out time is also shown.	Excessive load with motor running or locked rotor on start. Wait for motor to cool.	3.18
7	**START INHIBITED LOCKOUT TIME = XXX MIN**	Insufficient thermal capacity available for motor to start (i.e. capacity remaining is less than Learned Start Capacity).	Wait for motor to cool.	3.20
8	**U/B TRIP**	Unbalance Trip Level exceeded for a time greater than the Unbalance Trip Time Delay (all phases > 0.1 XFLC).	Check incoming supply phases for unbalance. Check for motor winding shorts. Increase Trip Level if required.	3.10
9	**STATOR RTD TRIP RTD # X = XXX C**	Stator RTD Trip Level temperature exceeded on at least one stator RTD.	Check motor ventilation and ambient temperature. Allow motor to cool.	3.16
10	**RTD TRIP RTD # XX = XXX C**	RTD Trip Level temperature exceeded.		3.17

LEVEL	INFORMATION LINE	EXPLANATION	DIAGNOSIS	REF.
11	STARTS/HOUR TRIP LOCKOUT TIME = XXX MIN.	Total number of motor starts over the past hour greater than Number of Starts / Hour setpoint.	Reduce number of starts during normal motor operation.	3.9
12	ACCEL. TIME TRIP	Motor did not enter a normal running state (i.e. phase current < FLC) within Acceleration Time setpoint.	Excessive load or locked rotor on start.	3.8
13	PHASE REVERSAL TRIP	Phases not connected to motor in proper sequence.	Check incoming phase sequence and CT polarity.	3.19
14	SPEED SWITCH TRIP	Non-closure of speed switch contacts within Speed Switch Time Delay.	Locked rotor on start.	2.16
15	DIFFERENTIAL INPUT TRIP	Closure of differential relay contacts.	Differential relay trip.	2.15
16	SPARE INPUT TRIP	Spare Input contact closure.	Check device connected to Spare Input terminals.	2.21
17	OVERLOAD WARNING TIME TO TRIP = XXXXX	Phase current greater than Immediate O/L Level setpoint.	Reduce motor load.	3.15
18	G/F ALARMS G/F = XX.X AMPS	Ground Fault Alarm Level exceeded for a time greater than the Ground Fault Time Delay.	Check motor windings for shorts, moisture, or conductive particles.	3.11
19	U/B ALARM U/B = XX PERCENT	Unbalance Alarm Level exceeded for a time greater than the Unbalance Time Delay.	Check incoming phases for unbalance.	3.10
20	U/C ALARM I(3 ph avg) = XXXX A RMS	Phase current less than Undercurrent Alarm Level for a time greater than the Undercurrent Time Delay.	Check system for loss of load.	3.12
21	STATOR RTD ALARM RTD # X = XXX C	Stator RTD Alarm Level temperature exceeded on at least one stator RTD.	Check motor ventilation and ambient temperature.	3.16
22	RTD ALARM RTD # XX = XXX C	RTD Alarm Level temperature exceeded.		3.17
23	BROKEN RTD LINE see RTD ACTUAL VALUES	Open circuit on RTD.	Check continuity of RTDs.	3.16, 3.17
24	SPARE INPUT ALARM	Spare Input contact closure.	Check device connected to Spare Input terminals.	2.21
25	SLAVE NUMBER XXX NOT CONNECTED	Indicated relay SLAVE number is not connected or not responding.	Check indicated relay SLAVE. Check communication link wiring	2.18

3.7 Phase CT and Motor Full Load Current Setpoints

The "PHASE CT RATIO" is entered into the 169 relay in SETPOINTS mode, page 1. This value must be entered correctly in order for the relay to read the actual motor phase currents (this setpoint should be in a range from 50% to 95% of FLC).

The "MOTOR FULL LOAD CURRENT" setpoint is used by the relay as the maximum continuous current that the motor can draw without overheating and should be taken from the motor nameplate or data sheets. It is entered into the relay in SETPOINTS mode, page 1.

If the motor has a service factor, this should be multiplied by the nameplate full load current and the result entered into the 169 as the motor full load current.

When the relay detects a current greater than the full load current, the time/overload curve will come into effect, and the Trip relay will activate after a time determined by the overload curve shape, the amount of phase current unbalance present and the RTD bias (when enabled), and the thermal memory contents.

3.8 Acceleration Time Setpoint

The acceleration time of the drive system is entered into the 169 relay in SETPOINTS mode, page 1. This feature is strictly a timer that can be used to protect the equipment driven by the motor. This time does not affect the thermal memory calculated by the relay.

The acceleration time is used by the relay as the maximum allowable time between a motor start attempt and the beginning of normal running operation. A motor start attempt is detected by the 169 when an average phase current greater than one full load current is detected following a motor stop condition. A normal running condition will be detected by the relay when the phase current drops to below one full load current for any length of time following a start. When the phase current drops to below 5% of CT primary rated amps a motor stop will be detected.

To protect against a locked rotor condition the 169 relay allows its thermal memory (see section 3.20) to fill during a start. Thus if the heat produced by a locked rotor condition causes the thermal capacity of the motor to be exceeded an overload trip will be initiated. The acceleration time setpoint can only be used for driven load protection, not locked rotor protection.

If the Acceleration Time function is not required the setpoint should be set to "OFF".

3.9 Number of Starts/Hour Setpoint

The allowable number of motor starts per hour is entered into the 169 relay in SETPOINTS mode, page 1.

The relay keeps a record of the number of motor starts over the past hour and will cause an output relay activation when this value is equal to the setpoint value. A trip will occur only after the motor is stopped. This setpoint should be obtained from the motor manufacturer's data sheets. If more than 5 starts/hour are allowed this setpoint should be stored as "OFF". The relay starts/hour counter will be **saved** if power is lost to the unit. Note that the 169 relay must detect all motor start attempts (see section 3.8) in order for this function to operate correctly.

The "ENABLE AUTO-RESET OF START TRIPS?" setpoint, when enabled, will automatically reset a STARTS/HOUR trip once the lockout time has elapsed.

3.10 Unbalance Setpoints

Unbalanced three phase supply voltages are a major cause of induction motor thermal damage. Unbalance can be caused by a variety of factors and is common in industrial environments. Causes can include increased resistance in one phase due to pitted or faulty contactors, transformer faults and unequal tap settings, or non-uniformly distributed three phase loads. The incoming supply to a plant may be balanced but varying single phase loads within the plant can cause voltage unbalance at the motor terminals. The most serious case of unbalance is single phasing which is the complete loss of one phase of the incoming supply. This can be caused by a utility supply problem or by a blown fuse in one phase and can seriously damage a three phase motor.

Unbalance at the motor terminals means an increase in the applied negative sequence voltage. This results in a large increase in the negative sequence current drawn by the motor due to the relatively small negative sequence impedance of the rotor. This current is normally at about twice the power supply frequency and produces a torque in the opposite direction to the desired motor output. For small unbalances the overall output torque will remain constant, but the motor will be developing a large positive torque to overcome the negative sequence torque. These opposing torques and the high negative sequence current produce much higher rotor losses and consequently greatly increased rotor heating effects. Stator heating is increased as well, but to a much smaller extent. The amount of unbalance that a given motor can tolerate is therefore dependent on the rotor design and heat dissipation characteristics.

Persistent, minor voltage unbalance can thus lead to rotor thermal damage while severe unbalance such as single phasing can very quickly lead to a motor burnout.

For phase currents above 100% FLC, the 169 relay calculates the ratio of the negative to positive sequence currents (In/Ip) and uses this ratio in two separate protective functions . It is used to bias the thermal memory of the relay which represents the thermal capacity of the motor as a whole (this can be enabled in SETPOINTS mode, page 5, 169 Plus only), and it is used for separate unbalance protection. The method of determining In/Ip is independent of actual line frequency or phase current lead/lag characteristics, and when enabled is used with the In/Ip ratio to bias the thermal memory (see section 3.20). This negative sequence unbalance method provides readings similar to the NEMA unbalance calculation but gives more realistic results for the thermal effect of unbalance on the motor. For phase currents below 100% FLC, the relay calculates the ratio of In to full load current (In/IFLC) and uses this to provide protection. This avoids nuisance trips due to relatively high levels of In with lower levels of Ip that may create high U/B levels at low loads.

For separate unbalance protection, trip and alarm In/Ip ratios may be chosen along with appropriate persistence times (time delays) in SETPOINTS mode, page 1. If no separate unbalance protection is desired the trip and alarm levels should be set to "OFF". The delay times will then be disregarded by the relay. Above 100% FLC, if an unbalance of more than 30% persists for more than 4 seconds, a "SINGLE PHASE TRIP" will result. Below 100% FLC, if motor load is >25%, and any one phase reads zero, this will also be considered a single phase condition.

Note: If the "UNBALANCE TRIP LEVEL" is set to "OFF" single phase protection will be turned off.

3.11 Ground Fault (Earth Leakage) Setpoints

Aging and thermal cycling can eventually cause a lowering of the dielectric strength of the insulation in the stator winding. This can produce a low impedance path from the supply to ground resulting in ground fault currents which can be quite high in solidly grounded systems. In resistance grounded systems there is a resistance in series with the supply source to limit ground fault current and allow the system to continue operating for a short time under fault conditions. The fault should be located and corrected as soon as possible, however, since a second fault on another phase would result in a very high current flow. In addition to damaging the motor, a ground fault can place the motor casing above ground potential thus presenting a safety hazard to personnel.

On the occurrence of a ground fault caused by insulation breakdown, an unprotected motor will commonly suffer severe structural damage and have to be replaced. The fault could also shut down the power supply bus to which the faulty motor is connected.

Ground faults can occur in otherwise good motors because of environmental conditions. Moisture or conductive dust, which are often present in mines, can provide an electrical path to ground thus allowing ground fault current to flow. In this case, ground fault protection should shut down the motor immediately so that it can be dried or cleaned before being restarted.

For ground fault protection by the 169 relay, all three of the motor conductors must pass through a separate ground fault CT (see section 2.6). The CT ratio may be either 2000:1 or 50:5 up to 250:5 (in increments of 50) and is chosen in SETPOINTS mode, page 1. Separate ground fault trip and alarm levels (entered in actual ground fault amps), and persistence times (time delays) may also be set. The ground fault trip can be instantaneous, or up to 20.0 seconds of time delay can be chosen to allow the 169 relay to be coordinated with other protective devices and switchgear.

The amount of current that will flow due to a fault depends on where the fault occurs in the motor winding. A high current flow will result if a short to ground occurs near the end of the stator winding nearest the terminal voltage. A low ground fault current will flow if a fault occurs at the neutral end of the winding since this end should be a virtual ground. Thus a low level of ground fault pickup is desirable to protect as much of the stator winding as possible and to prevent the motor casing from becoming a shock hazard. In resistance grounded systems the ground fault trip level must be set below the maximum current limited by the ground resistor or else the relay will not see a large enough ground fault current to cause a trip.

The ground fault trip level should be set as low as possible, although too sensitive a setting may cause nuisance trips due to capacitive current flow. If nuisance trips occur with no apparent cause the trip level should be increased; conversely if no nuisance trips occur a lower fault setpoint may be desirable.

3.12 Undercurrent Setpoints

These setpoints are found in SETPOINTS mode, page 1 and are normally used to detect a decrease in motor current flow caused by a loss of, or decrease in, motor load. This is especially useful for indication of loss of suction for pumps, loss of airflow for fans, or a broken belt for conveyors. When the current falls below the setpoint value for the setpoint time, the relay assigned to this alarm function will become active.

If this feature is used for loss of load detection, the "UNDERCURRENT ALARM LEVEL" setpoint should be chosen to be just above the motor current level for the anticipated reduced load condition. If the feature is not desired, the alarm level should be set to "OFF". The delay time setpoint will then be ignored by the relay.

If the motor is normally operated at a current level below its rated full load current, this feature may be used for a pre-overload warning. This is accomplished by setting the "UNDERCURRENT ALARM LEVEL" to be above the normal operating current of the motor but below the rated full load current. In this way the undercurrent function will cause the relay assigned to it to become inactive if the motor current increases above the Undercurrent setpoint level. This would indicate an abnormal loading condition prior to an actual motor overload.

The output relay assigned to this function will automatically reset itself when the motor stops (i.e. when the phase current becomes zero) unless this relay is programmed as latched (see "RELAY ALARM LATCHCODE", SETPOINTS, page 5).

3.13 Rapid Trip / Mechanical Jam Setpoints

These setpoints are found in SETPOINTS mode, page 1 and are used to protect the driven mechanical system from jams. If used, this feature is active only after the motor has successfully started, and will cause relay activation in the event of a stall while the motor is running.

A current surge of 150% to 450% of motor full load for from 0.5 to 125.0 seconds during motor operation, depending on the setpoints chosen, will cause the relay assigned to the Rapid Trip / Mechanical Jam function to become active. To disable the Rapid Trip / Mechanical Jam function the "RAPID TRIP/MECH. JAM TRIP LEVEL" setpoint should be set to "OFF". The "RAPID TRIP TIME DELAY" setpoint will then be disregarded by the relay.

Note: This feature is not recommended for use with systems that experience overloads as part of normal operation.

3.14 Short Circuit Setpoints

The Short Circuit protective function provides overriding protection for any large phase current. Complete protection from phase-to-phase and phase-to-ground faults is provided with this feature. This feature is active at all times, including during motor starts, unless the "SHORT CIRCUIT TRIP LEVEL" is set to OFF. The setpoints are in SETPOINTS mode, page 1.

The phase current short circuit trip level can be set from 4 to 12 times motor full load current. The trip can be instantaneous or can be delayed by up to 20.5 seconds to facilitate coordination with system switchgear. If this feature is not desired the "SHORT CIRCUIT TRIP LEVEL" setpoint should be set to "OFF". If this is done the relay will disregard the "SHORT CIRCUIT TIME DELAY" setpoint.

3.15 Immediate Overload Alarm Level Setpoint

The Immediate Overload Alarm Level setpoint is found in SETPOINTS mode, page 1. It is adjustable from 1.01 XFLC to 1.50 XFLC. An output relay activation will occur immediately when the average phase current goes over the setpoint value. This function can never cause latched (manual reset) relay operation.

3.16 Stator RTD Setpoints

The 169 relay has 6 sets of 4 terminals available for the connection of RTDs to monitor the temperature of the stator windings. If fewer than 6 RTDs are to be used they should be connected to the lowest numbered RTD connections on the rear of the relay. The stator RTD setpoints are found in SETPOINTS mode, page 2. The "# OF STATOR RTDS USED" setpoint should be chosen to represent the number of RTDs actually connected to the motor stator windings. Thus if 3 RTDs are connected to the stator, the "# OF STATOR RTDS USED" setpoint should be set to 3, and the 3 RTDs should be connected to the terminals for RTD1, RTD2, and RTD3 (terminals #1-12).

There are individual trip and alarm setpoints for each RTD. A relay activation will occur when any one of the RTD temperatures goes over its corresponding setpoint value. The maximum stator RTD temperature at any time will be used for relay thermal calculations.

When the relay is in ACTUAL VALUES mode the temperature readings from all of the RTDs may be displayed. If no connection has been made to any RTD terminals the display for that RTD will be "noRTD". If the "# OF STATOR RTDS USED" setpoint is stored as 3, only the maximum temperature from RTD1, RTD2, and RTD3 will be used for motor temperature calculations. Thus, in this case, RTD4, RTD5, and RTD6 may be used for any other RTD temperature monitoring function desired.

If a stator RTD becomes open circuited during use, the ACTUAL VALUES display for that RTD will be "noRTD". Readings from the disconnected RTD will then be ignored. The 169 relay will enter TRIP/ALARM mode to warn the user of the faulty RTD if the "No Sensor Alarm" is enabled (SETPOINTS, page 5). After a stator RTD temperature trip or alarm setpoint is exceeded the 169 relay will not allow the active output relays to be reset until the temperature has fallen 4 C below the exceeded setpoint.

3.17 Other RTD Setpoints

A total of 8 RTD inputs is provided on the model 169 with 10 on the 169 Plus. Any RTD inputs not used for stator RTD protection can be used for other temperature monitoring functions. These will commonly be used for motor and load bearings. Separate alarm and trip level temperatures can be selected for each RTD in SETPOINTS mode, page 2.

Trip and alarm level setpoints should be set to "OFF" for any unused RTD terminals. When no connection is made to a set of RTD terminals or if a sensor becomes damaged, the ACTUAL VALUES display for that RTD will be "noRTD". If the "No Sensor Alarm" is enabled (SETPOINTS, page 5) the relay will enter TRIP/ALARM mode to warn the user of any open RTD connection that does not have its trip and alarm level setpoints stored as "OFF".

RTDs connected to the RTD terminals of the 169 relay must all be of the same type. After an RTD temperature trip or alarm setpoint is exceeded, the 169 relay will not allow the activated output relays to be reset until the temperature has fallen 4 C below the exceeded setpoint.

To use RTD #8 (RTD #10 on the 169 Plus) for ambient air temperature sensing a setpoint in page 5 of SETPOINTS mode must be changed (see sections 3.4, 3.20).

3.18 Overload Curve Setpoints

The running overload curve is chosen in SETPOINTS mode, page 3. The curve will come into effect when the motor phase current goes over the full load value. When this is true the motor thermal capacity will be decreased accordingly; the output relay assigned to the OVERLOAD TRIP function will activate when this capacity has been exhausted. Thermal capacity may be reduced by the presence of unbalance and RTD bias as well as overload (if the U/B and RTD inputs to TC are enabled). Thus the times on the overload curve may be reduced due to phase current unbalance (see section 3.20). A choice of eight standard curves, as shown in figure 3-2, is available on both the model 169 and 169 Plus.

If one of the standard curves shown in figure 3-2 is desired for the given application, the answer to the SETPOINTS question, "CUSTOM CURVE?", should be "NO". In this case the desired curve can be chosen from the 8 standard curves available. If it is required to have a different curve the answer to the "CUSTOM CURVE?" question should be "YES". In this case the following lines in SETPOINTS mode will be the choice of breakpoints as shown in section 3.4. These points should be entered carefully and checked since motor overload protection is based largely on this curve. After a standard curve has been chosen, the numerical values for the breakpoints can be viewed by storing a "YES" for the "CUSTOM CURVE?" question and then examining the next few lines of setpoint values. The overload levels and trip times for the standard overload curves are as shown in Table 3-5.

If none of the standard curves match the motor data well enough the model 169 Plus relay allows the formation of a custom overload curve. Motors with non-standard overload characteristics can be fully protected since almost any shape of curve can be entered into the relay. The 169 Plus will accept 22 points and will internally form a curve through these points.

If it is required to have a discontinuity in a custom overload curve, as shown in figure 3-3 (b), the 169 Plus will insert it at the appropriate place. A discontinuity will occur when a time is entered that is greater than the time entered for the previous overload level. Examples of custom curves formed by the 169 Plus relay with the breakpoints given are shown in figure 3-3.

Note: If a new standard curve number or a custom curve point is stored when the motor is running the new curve or point will not come into effect until the motor stops.

Table 3-5 Standard Overload Curve Trip Times (in seconds)

Overload Level	MULTILIN STANDARD CURVE NUMBERS							
	1	2	3	4*	5	6	7	8
1.05	853	1707	2560	3414	5975	7682	10243	12804
1.10	416	833	1250	1666	2916	3750	5000	6250
1.20	198	397	596	795	1392	1789	2386	2982
1.30	126	253	380	507	887	1141	1521	1902
1.40	91	182	273	364	638	820	1093	1367
1.50	70	140	210	280	490	630	840	1050
1.75	42	84	127	169	297	381	509	636
2.00	29	58	87	116	204	262	350	437
2.25	21	43	64	86	150	193	258	323
2.50	16	33	50	66	116	150	200	250
2.75	13	26	39	53	93	119	159	199
3.00	10	21	32	43	76	98	131	164
3.50	7	15	23	31	54	69	93	116
4.00	5	11	17	23	40	52	69	87
4.50	4	9	13	18	31	40	54	68
5.00	3	7	10	14	25	32	43	54
5.50	2	5	8	11	20	26	35	44
6.00	2	5	7	10	17	22	30	37
6.50	2	4	6	8	14	19	25	31
7.00	1	3	5	7	12	16	21	27
7.50	1	3	4	6	11	14	19	23
8.00	1	2	4	5	9	12	16	20

* Factory preset value

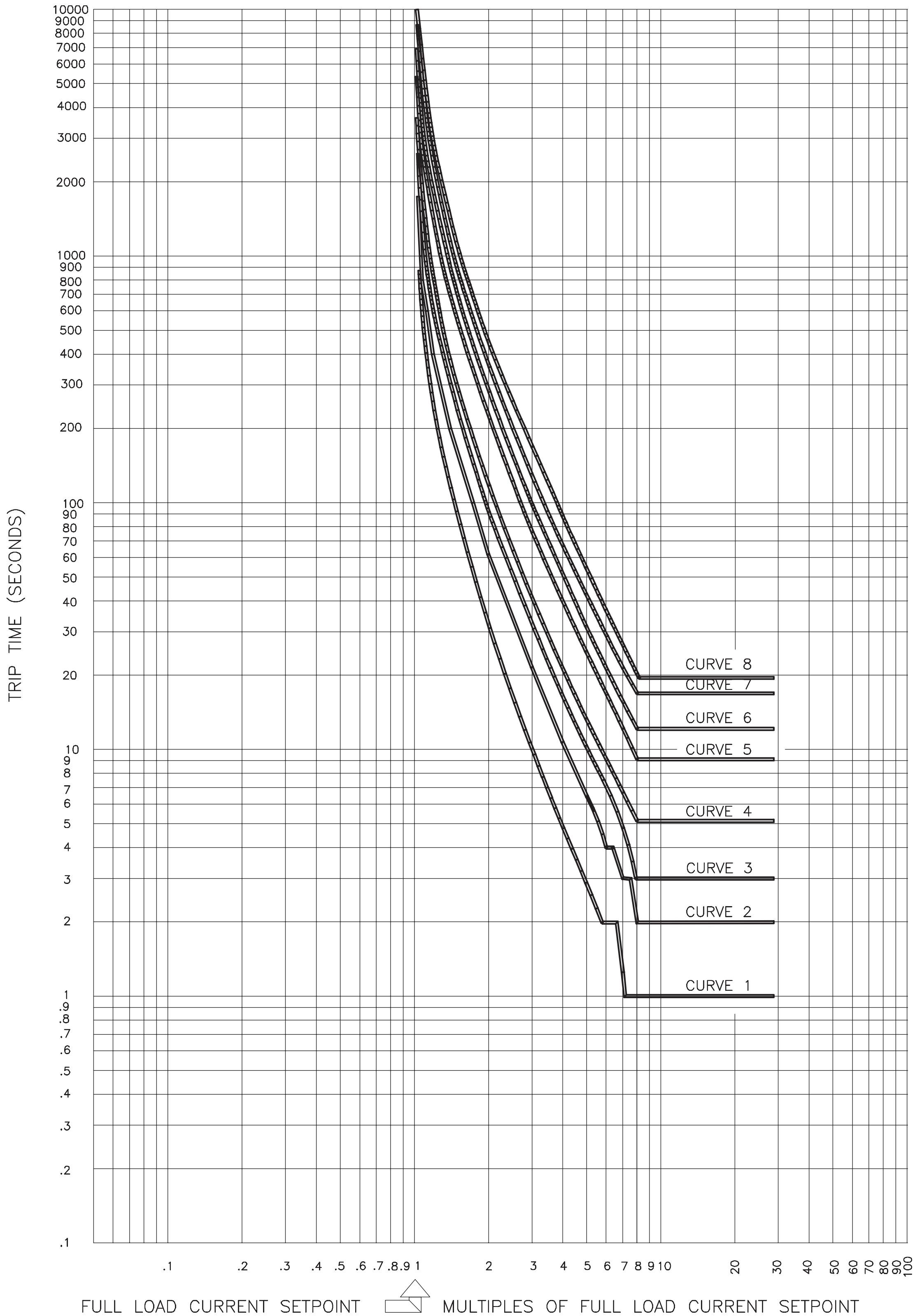
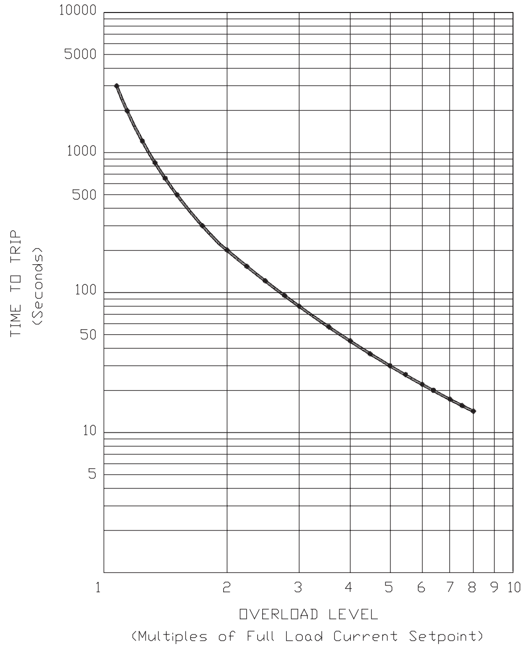


Figure 3-2 Standard Overload Curves

A

OVERLOAD LEVEL	TIME TO TRIP SETPOINT
1.05	3000
1.10	2000
1.20	1200
1.30	850
1.40	650
1.50	500
1.75	300
2.00	200
2.25	160
2.50	120
2.75	95
3.00	80
3.50	58
4.00	45
4.50	38
5.00	32
5.50	28
6.00	23
6.50	21
7.00	18
7.50	17
8.00	15



B

OVERLOAD LEVEL	TIME TO TRIP SETPOINT
1.05	3000
1.10	2000
1.20	1200
1.30	850
1.40	650
1.50	500
1.75	300
2.00	200
2.25	150
2.50	115
2.75	95
3.00	75
3.50	55
4.00	40
4.50	400
5.00	120
5.50	65
6.00	35
6.50	22
7.00	16
7.50	12
8.00	10

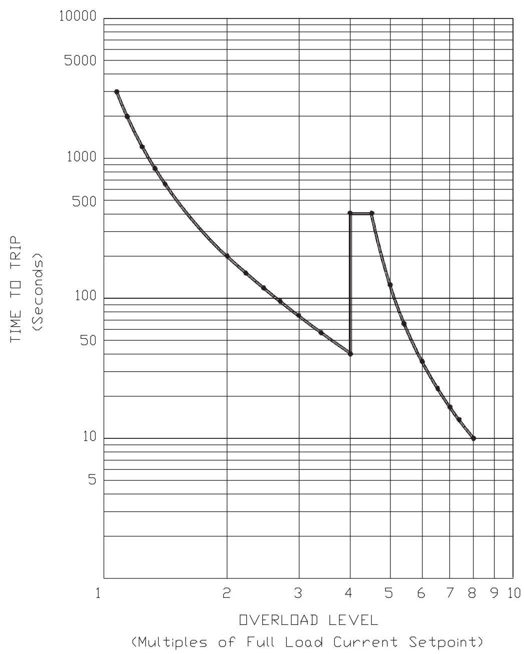


Figure 3-3 Custom Curve Examples

3.19 Phase Reversal Protection

Phase reversal protection is provided on the 169 to detect improper connection of incoming phases. The order of the incoming phases must be as shown in figure 2-4 in order for the proper sequence to be detected. This feature can be enabled or disabled by a setpoint in page 5 of SETPOINTS mode. A phase reversal trip will occur when the motor is started, if the phases are out of sequence, within 3.5 seconds.

3.20 Thermal Memory

The 169 relay uses an internal thermal memory register to represent the thermal capacity of the motor. To "fill" this register, the square of the equivalent motor heating current is integrated over time. This equivalent current is a biased average of the 3 phase currents. The biasing factor is derived from the amount of negative sequence current flowing in the motor (on a 169 Plus if the U/B input to TC is enabled). The rate at which the memory fills is thus dependent on the amount of overload, unbalance present, as well as RTD bias. The unbalance input to thermal memory as well as RTD bias can be defeated using a setpoint in page 5 of SETPOINTS mode. When the thermal memory register fills to a value corresponding to 100% motor thermal capacity used, an OVERLOAD TRIP will be initiated. This value is determined from the overload curve.

Thermal memory is emptied in certain situations. If the motor is in a stopped state the memory will discharge within the motor STOPPED COOL TIME (factory value = 30 min.). If the motor is running at less than full load, thermal memory will discharge at a programmed rate to a certain value. This value is determined by the "FLC Thermal Capacity Reduction" setpoint. For example, a value of 25% may be chosen for this setpoint. If the current being drawn by the motor drops below full load current to 80%, then the thermal memory will empty to 80% of the FLC Thermal Capacity Reduction setpoint, namely, 20% (0.8 x 25%). In this way the thermal memory will discharge to an amount related to the present motor current in order to represent the actual temperature of the motor closely. Thermal memory will discharge at the correct rate which is approximately exponential, even if control power is removed from the 169. Thermal memory can be cleared to 0% by using the Emergency Restart feature (see section 3.21).

U/B INPUT TO THERMAL MEMORY - When U/B input to thermal memory is defeated the 169 Plus relay will use the average of the three phase currents for all overload calculations (i.e. any time the overload curve is active). When U/B input to thermal memory is enabled the 169 Plus relay will use the equivalent motor heating current calculated as shown:

$I_{eq} = I_{avg}$ (with U/B input to thermal memory disabled; factory preset)

$I_{eq} = \sqrt{I_p^2 + KI_n^2}$ (with U/B input to thermal memory enabled)

where: $K = (\text{Istart}/\text{Iflc})^2 / 7.41$ or user entered value (negative sequence current heating factor; see below)
I_{eq} = equivalent motor heating current
I_{avg} = average of three phase currents
I_p = positive sequence component of phase current
I_n = negative sequence component of phase current

Thus the larger the value for K the greater the effect of current unbalance on the thermal memory of the 169 relay.

RTD INPUT TO THERMAL MEMORY - The RTD Input to Thermal Memory may be used to protect against loss of motor cooling and also to serve as a double check for the thermal model. For example, the thermal model is based on motor running currents. This model does not take into account loss of motor cooling, therefore the RTD bias may be used for this function.

When the hottest stator RTD temperature is included in the thermal memory (SETPOINTS mode, page 5; factory preset disabled) the maximum measured stator RTD temperature is used to bias the thermal memory. The thermal capacity available in the relay is reduced proportional to the RTD stator temperature. When the stator temperature is at the RTD bias curve maximum value (SETPOINTS mode, page 5) the remaining thermal capacity available will be reduced to 0%. The capacity will not be reduced at all when the RTD stator temperature is at the RTD bias curve minimum value or below (SETPOINTS mode, page 5). Between these extremes thermal capacity reduction increases linearly with the maximum stator temperature, as shown in Figure 3-4. The RTD temperature input to thermal memory can be enabled in SETPOINTS mode, page 5.

An example of how the RTD input to thermal memory affects the thermal capacity available is described below and illustrated in Figure 3-4. If curve 1 is used (i.e. factory preset values) and the stator temperature is 130 C, the available thermal capacity will be reduced to 59%. If the RTD bias curve minimum and maximum values are changed to correspond to curve 2 in Figure 3-4 the result will be somewhat different. The thermal capacity available will be approximately 71% at 130 C. The thermal capacity available at any temperature between the RTD bias curve minimum and maximum values can be determined from the graph or calculated as follows:

$$\text{Average Thermal Capacity} = 100 - 100 \times \frac{\text{Temp} - \text{RTD Min.}}{\text{RTD Max} - \text{RTD Min.}}$$

where: Temp.= Hottest Stator RTD temperature
RTD Min. = RTD bias curve minimum value
RTD Max. = RTD bias curve maximum value

If the hottest stator RTD temperature is below the RTD bias curve minimum value the total thermal capacity available will be 100%.

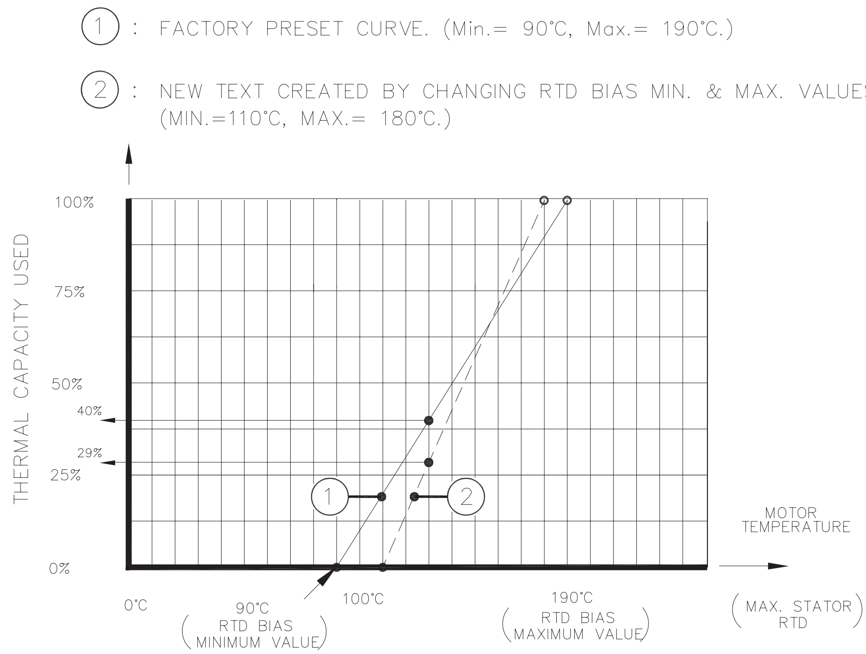


Figure 3-4 Hot Motor Thermal Capacity Reduction

The effect of reducing the thermal capacity available when the motor is hot is equivalent to shifting the overload curve down resulting in a shorter time to trip. Using the example above when the total thermal capacity available is reduced to 59% the trip time at any overload level will also be reduced to 59% of its original value.

LEARNED COOLING TIMES - Through various measurement and averaging techniques the 169 relay "learns" a number of motor parameters. All learned values can be examined in page 6 of ACTUAL VALUES mode. If RTDs are used to monitor the temperature of the motor stator the relay will learn the running and stopped cooling times of the motor. In this way the 169 provides increased accuracy in the thermal modeling of the protected motor. When RTD #8 (RTD #10 on the 169 Plus) is used for ambient air temperature monitoring even greater thermal protection is provided since the cooling air temperature is known. In this case the learned cool times are based on the difference between the ambient temperature and the average stator RTD temperature. When no ambient sensing is used the learned cool times are based only on the average stator RTD temperature. If no stator RTDs are used, or if the DEFEAT LEARNED COOL TIME setpoint (SETPOINTS mode, page 5) is left as "YES", the relay will use the default times as described above.

Note: The learned cooling times should not be enabled until the 169 Plus relay has had sufficient time to learn the actual motor cooling times. The time required will vary between motors, however several start/stop cycles will be necessary.

The 169 Plus relay learns the motor cooling times over various temperature ranges. Thus the times shown in page 6 of ACTUAL VALUES mode (LEARNED RUNNING COOL TIME, LEARNED STOPPED COOL TIME) will reflect the total cooling time as a combination of the cooling times over each temperature range.

LEARNED START CAPACITY - An OVERLOAD TRIP caused by the exhaustion of motor thermal capacity will cause a lock-out. A relay reset will not be allowed until the memory has discharged to 15% thermal capacity used. At this point the relay can be reset.

If the Start Inhibit feature is enabled (SETPOINTS, page 5) a motor start will not be allowed until the thermal memory has discharged sufficiently to make the start possible. The 169 relay uses the "LEARNED Start Capacity required" (ACTUAL VALUES, page 6) to determine if a start is possible. If sufficient thermal capacity is available for a start, the start will be successful. Thus the START INHIBIT lock-out time is adjusted to allow for optimum motor usage. To override a START INHIBIT or OVERLOAD TRIP lock-out condition the Emergency Restart feature can be used. If the Start Inhibit feature is disabled the OVERLOAD TRIP lock-out time will not be adjusted by the learned starting capacity value and will represent the time for the thermal memory to discharge to 15% thermal capacity used. Thus the lockout time will equal 85% of the STOPPED COOL TIME when Start Inhibit is disabled. When Start Inhibit is enabled the OVERLOAD TRIP lock-out time will represent the time for the thermal memory to discharge to the "LEARNED Start Capacity required" value.

If the "ENABLE AUTO-RESET OF START TRIPS?" setpoint is enabled then the relay will automatically reset once the lockout time has elapsed.

Before the 169 Plus relay has learned the actual Start Capacity required by the motor this value will default to 40%.

3.21 Emergency Restart

When production or safety considerations become more important than motor protection requirements it may be necessary to restart a faulted motor. Momentarily shorting together the Emergency Restart terminals will discharge the thermal memory to 0% so that the relay can be reset after an OVERLOAD TRIP. In this way the lock-out is avoided. The Emergency Restart feature will also reduce the relay's starts/hour counter by one each time to terminals are shorted together, so that a STARTS/HOUR TRIP can be defeated.

When RTD input to thermal memory (SETPOINTS, page 5) is enabled and the Emergency Restart feature is used, thermal capacity will be reduced to 0% only for as long as the Emergency Restart terminals are held shorted (note: it may take up to 11 seconds for the "Thermal Capacity Used" display to change to 0%). When the Emergency Restart terminals are opened again the thermal capacity will change to what is used according to the maximum stator RTD temperature and Figure 3-4. Thus, momentarily shorting the Emergency Restart terminals with RTD input to thermal memory enabled may not reduce the thermal capacity used to 0% when the motor is hot.

Shorting the Emergency Restart terminals together will have no effect unless the motor is stopped. Thus having these terminals permanently shorted together will cause the memory to be cleared when the motor stops. This will allow for an immediate restart after an OVERLOAD TRIP.

Caution is recommended in the use of this feature since the 169 relay's thermal protective functions will be overridden and it is possible to damage the motor if Emergency Restart is used.

3.22 Resetting The 169 Relay

Resetting the 169 relay after a trip must be done manually by pressing the RESET key, or by shorting together the External Reset terminals. Alarm functions can cause latched (manual reset) or unlatched (automatic reset) output relay operation depending on the RELAY ALARM LATCHCODE (SETPOINTS mode, page 5). A latched relay will stay activated until the RESET key is pressed or the External Reset feature is used.

If a trip/alarm condition persists (e.g. a high RTD temperature), or if the relay has locked out the motor, pressing the RESET key will cause the flash message,

RESET NOT POSSIBLE -
Condition still present.

to be displayed. However, shorting the Emergency Restart terminals together will reduce the lock-out time, allowing the relay to be reset immediately.

Note: If RTD input to thermal memory is enabled (SETPOINTS, page 5) the lock-out time may not be reduced to 0 minutes since the thermal capacity available is dependent on the RTD bias curve (Figure 3-4) and the maximum stator RTD temperature (see section 3.21).

If the External Reset terminals are permanently shorted together the relay will be reset immediately when motor conditions allow (e.g. when the lock-out time runs out). The 169 relay cannot be reset after a Differential Input Trip or Spare Input Trip until the contacts connected across the Differential or Spare Input terminals have been opened.

The 169 Plus relay has a selectable single-shot restart feature which will allow the motor to be restarted immediately after an overload trip. To allow the motor to be restarted the relay decreases its internal value for motor thermal capacity used. However if two overload trips occur within a lock-out time delay, the 169 Plus will not allow an immediate restart. The displayed lock-out time must be allowed to run out before the motor can be restarted. This feature can be selected in page 5 of SETPOINTS mode and is factory preset as disabled.

The 169 Plus also has a special external reset feature which can be selected in page 5 of SETPOINTS mode. When this feature is enabled, shorting the External Reset terminals together causes all output relays to reset, while pressing the reset key causes all relays except AUX. 1 to reset. This feature is factory preset as disabled.

Note: This feature works for 169 Plus relay trip functions only. Trip functions assigned to the TRIP & AUX. 1 output relays cannot be reset using the reset key.

If the 169 relay trips and then loses control power, the trip function will become active again once control power is re-applied. For example, if a GROUND FAULT TRIP occurs and then control power for the relay is removed and later returned, the message "GROUND FAULT TRIP" will appear on the display and the output relay assigned to the Ground Fault Trip function will become active.

Note: If control power is removed for more than one hour after a trip the 169 relay will be reset when power is re-applied (only on O/L trips).

3.23 169 Relay Self-Test

The 169 relay's internal circuitry self-test consists of three separate tests. A/D, RTD, and memory circuitry tests are continually performed. The A/D test involves sending a known, precise voltage level through the A/D circuitry and seeing if it is converted correctly. The RTD test involves reading a known, internal resistance and checking to see if the correct temperature is determined. To test the memory circuitry, test data is stored in the 169 relay's non-volatile RAM and is then read and compared with the original data.

Should any of these tests indicate an internal circuitry failure, the "SERVICE" LED will start to flash and the output relay programmed for the self-test feature will activate.

Note: When a relay A/D or memory self-test failure occurs all metering and protective functions will be suspended. The ACTUAL VALUES display for all parameters will be zero in order to avoid nuisance tripping. When in this state the relay will <u>not</u> provide motor protection. If a memory failure occurs the factory setpoints will be reloaded into the 169. If an RTD hardware failure occurs the "# OF STATOR RTDS USED" setpoint will be automatically set to 0 and the RTD ALARM and TRIP levels will be automatically set to OFF; however all current-related functions will continue to operate.

3.24 Statistical Data Features

The model 169 relay offers a record of maximum RTD temperatures and pre-trip current and RTD values while the model 169 Plus relay offers, in addition, a full range of motor statistical data. The maximum RTD temperature data is found on page 2 of ACTUAL VALUES mode and can be cleared to zero by storing a YES in response to the "CLEAR LAST ACCESS DATA?" question at the end of page 2. Pre-trip motor current and temperature values are found in ACTUAL VALUES mode, page 5. These values will be updated only when a relay trip occurs. Note that if a trip function setpoint is set to INST. (instantaneous) and this type of trip occurs, the values for pre-trip current will not be recorded exactly. This is because the relay has tripped instantaneously and thus did not have enough time to update the registers holding this information.

On the model 169 Plus statistical data is found on page 4 of ACTUAL VALUES mode. All of this data can be cleared to zero by storing a value of YES in response to the "START NEW COMMISSIONING?" question at the end of page 4.

All of the statistics in this page will reset to zero after reaching 255. The running hours data will reset to zero after 65535 hours.

3.25 Factory Setpoints

When the 169 relay is shipped it will have all setpoints stored in its non-volatile memory. The factory setpoints represent values for an average large three phase motor. The preset Relay and System Configurations represent the most common output relay configurations and attributes. These values are meant to be used as a starting point for programming the relay and should be changed as each application requires.

In the event of a non-volatile memory failure, which will be detected by the self-test feature (see section 3.23), the 169 relay will reload the factory setpoints but will not provide motor protection.

A list of the motor current, RTD, and overload curve setpoints is given in Table 3-6. For other factory setpoints see Tables 3-7 and 3-3.

Table 3-6 Pre-stored Factory Setpoints (169 Setpoint pages 1 to 3)

INFORMATION LINE	FACTORY VALUE	INFORMATION LINE	FACTORY VALUE	INFORMATION LINE	FACTORY VALUE
PAGE 1: SETPOINT VALUES MOTOR AMPS SETPOINTS		IMMEDIATE OVERLOAD LEVEL = X.XX X FLC		RTD #10 TRIP LEVEL = XXX DEGREES C	
PHASE CT RATIO SECONDARY = X AMP	5	PAGE 2: SETPOINT VALUES RTD SETPOINTS		PAGE 3: SETPOINT VALUES O/L CURVE SETPOINTS	
PHASE CT RATIO CT RATIO = XXX:5	100	# OF STATOR RTDS USED # OF RTDs = X		CUSTOM CURVE? XXX YES voids selected curve	
MOTOR FULL LOAD CURRENT FLC = XXXX AMPS	90 A	STATOR #1 ALARM LEVEL = XXX DEGREES C		SELECTED CURVE NUMBER CURVE # = XX	
ACCEL.TIME= XX.X SECONDS Consult motor data sheet	10 s	STATOR #1 TRIP LEVEL = XXX DEGREES C			
STARTS/HOUR= X Consult motor data sheet	3	STATOR #2 ALARM LEVEL = XXX DEGREES C			
UNBALANCE ALARM LEVEL U/B ALARM= XX PERCENT	10%	STATOR #2 TRIP LEVEL = XXX DEGREES C			
U/B ALARM TIME DELAY TIME DELAY = XXX SEC	5 s	STATOR #3 ALARM LEVEL = XXX DEGREES C			
UNBALANCE TRIP LEVEL U/B TRIP= XX PERCENT		STATOR #3 TRIP LEVEL = XXX DEGREES C			
U/B TRIP TIME DELAY U/B DELAY= XXX SECONDS		STATOR #4 ALARM LEVEL = XXX DEGREES C			
G/F CT RATIO :5 ? XXX (No indicates 2000:1)		STATOR #4 TRIP LEVEL = XXX DEGREES C			
G/F CT RATIO G/F C.T XXX :5		STATOR #5 ALARM LEVEL = XXX DEGREES C			
GROUND FAULT ALARM LEVEL G/F ALARM= XXX AMPS		STATOR #5 TRIP LEVEL = XXX DEGREES C			
G/F ALARM TIME DELAY TIME DELAY = XXX SEC		STATOR #6 ALARM LEVEL = XXX DEGREES C			
GROUND FAULT TRIP LEVEL G/F TRIP = XXX AMPS		STATOR #6 TRIP LEVEL = XXX DEGREES C			
G/F TRIP TIME DELAY G/F DELAY= XX.X SECONDS		RTD #7 ALARM LEVEL = XXX DEGREES C			
UNDERCURRENT ALARM LEVEL U/C ALARM= XXX AMPS		RTD #7 TRIP LEVEL = XXX DEGREES C			
UNDERCURRENT TIME DELAY U/C DELAY= XXX SECONDS		RTD #8 ALARM LEVEL = XXX DEGREES C			
RAPID TRIP / MECH. JAM TRIP LEVEL= X.X X FLC		RTD #8 TRIP LEVEL = XXX DEGREES C			
RAPID TRIP TIME DELAY DELAY= X.X X FLC		RTD #9 ALARM LEVEL = XXX DEGREES C			
SHORT CIRCUIT TRIP LEVEL S/C TRIP= XX X FLC		RTD #9 TRIP LEVEL = XXX DEGREES C			

Table 3-7 Preset Factory Relay Configurations and Functions

CONFIGURATION/FUNCTION	OUTPUT RELAY TRIP	ALARM	AUX. 1	AUX. 2
CONFIGURATION				
Latched (Manual Reset)	X			X [+]
Unlatched (Automatic Reset)		X	X [+]	
Fail-safe	X			X [+]
Non-fail-safe		X	X [+]	
ALARM SIGNALS				
Immediate O/L Warning		#		
G/F Alarm		X		
U/B Alarm		X		
U/C Alarm		#		
Stator RTD Alarm		X [*]	X [+]	
RTD Alarm		X [*]	X [+]	
Broken Sensor Alarm		# [*]	# [+]	
Self Test Alarm		X [*]		X [+]
Spare Input Alarm				
TRIP SIGNALS				
O/L Trip	X			
U/B Trip	X			
Single Phase Trip	X			
S/C Trip	#			
Rapid Trip	X			
Stator RTD Trip	X			
RTD Trip	X			
G/F Trip	X			
Phase Reversal Trip	#			
Acceleration Time Trip	X			
Starts/Hour Trip	X			
Speed Switch Trip	#			
Differential Relay Trip	#			
Spare Input Trip	#			
Start Inhibit	#			

[*] Model 169 only — X Function programmed ON
[+] Model 169 Plus only — # Function programmed OFF

4.1 Primary Injection Testing

Prior to relay commissioning at an installation, complete system operation can be verified by injecting current through the phase and ground fault CTs. To do this a primary (high current) injection test set is required.

Operation of the entire relay system, except the phase CTs can be checked by applying input signals to the 169 relay from a secondary injection test set as described in the following sections.

4.2 Secondary Injection Testing

Single phase secondary injection testing can be performed using the test set up shown in figure 4-1. Tests should be performed to verify correct operation of relay input (A/D), output, memory, and RTD circuitry. 169 relay functions are firmware driven and thus testing is required only to verify correct firmware/hardware interaction.

All tests described in the following sections will be applicable with factory setpoints and configurations left unchanged. Similar tests can be performed after new setpoints have been stored in the 169 relay.

NOTE: A three phase test set or an actual installation test is required to test the phase reversal function.

4.3 Phase Current Input Functions

All phase current functions use digital current information converted from the analog phase CT inputs. Functions that use phase current readings are overload, unbalance, short circuit, rapid trip, and phase reversal. The 169 must read the injected phase currents correctly in order for these functions to operate correctly. To determine if the relay is reading the proper current values inject a phase current into the relay and view the three current readings in ACTUAL VALUES mode, page 1. With factory setpoints stored in the relay the displayed current should be:

displayed current = actual injected current X 100/5 (phase CT ratio)

Various trip and alarm conditions can be simulated by adjusting the injected phase currents. All trip/alarm conditions using phase current readings will operate as described in Section 3 providing the 169 relay reads the correct phase current.

To simulate an overload condition turn to "ACCEL. TIME=" to "off" (SETPOINTS, page 1) and inject a current of 9 Amps in all three phases. This will be read by the relay as:

displayed current = 9 Amps X 100/5 = 180 Amps

which is two times the Full Load Current setpoint of 90 Amps. The trip output relay should activate after a time of 117 seconds which is the time to trip for a 200% overload using curve #4. This time may be less due to the charging of thermal memory because of the presence of unbalance or previous overloads. Thermal memory may be discharged to 0% by shorting together the Emergency Restart terminals (54, 55) momentarily.

To check the displayed negative to positive sequence unbalance ratio inject currents of 5.0 Amps, 5.0 Amps and 3.9 Amps into the relay and examine the "UNBALANCE RATIO (In/Ip)". The reading should be 15%. Other unbalance conditions can be checked by calculating the negative to positive sequence current ratio for the injected phase currents and comparing this to the ACTUAL VALUES display.

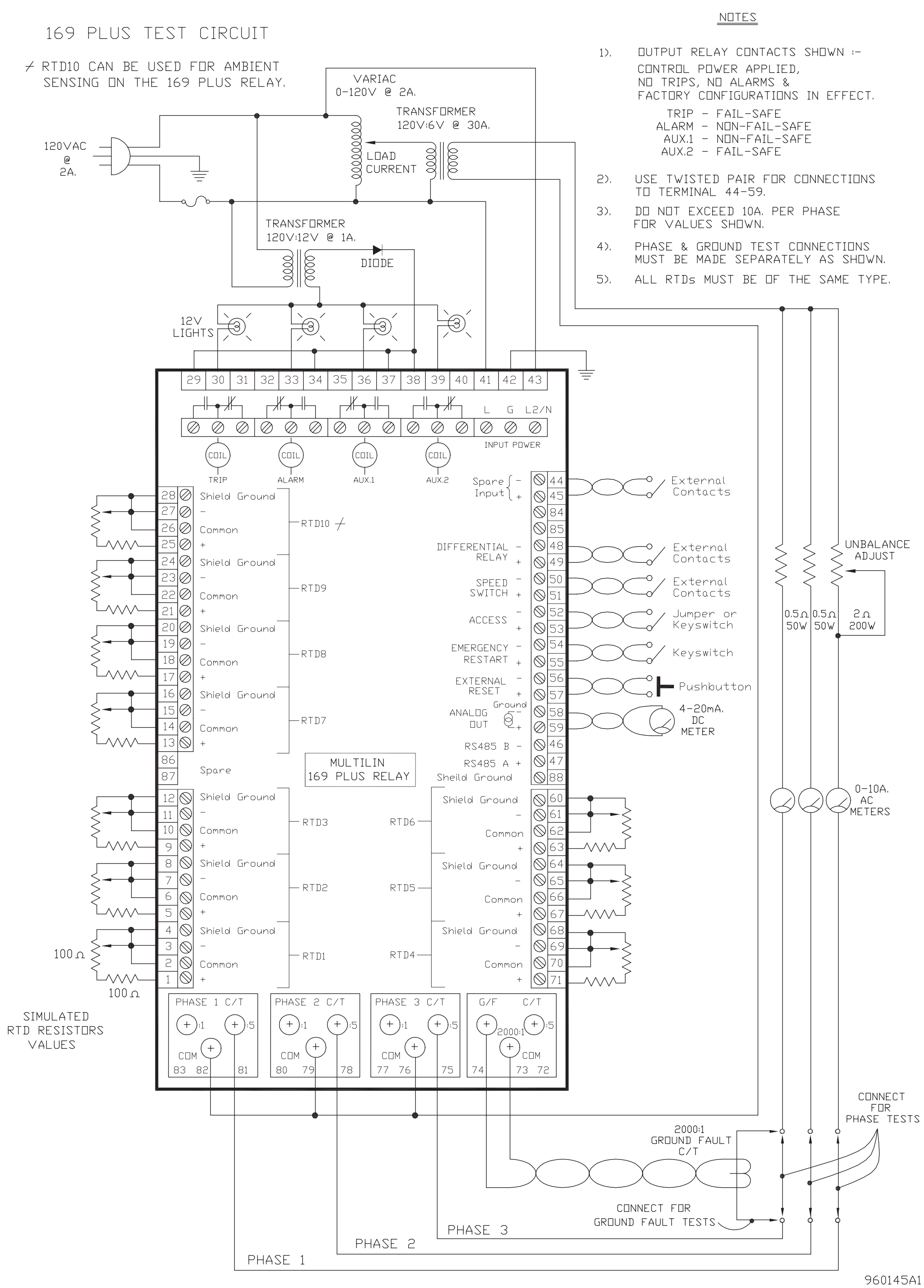


Figure 4-1 Secondary Injection Test Set (AC input to 169 relay)

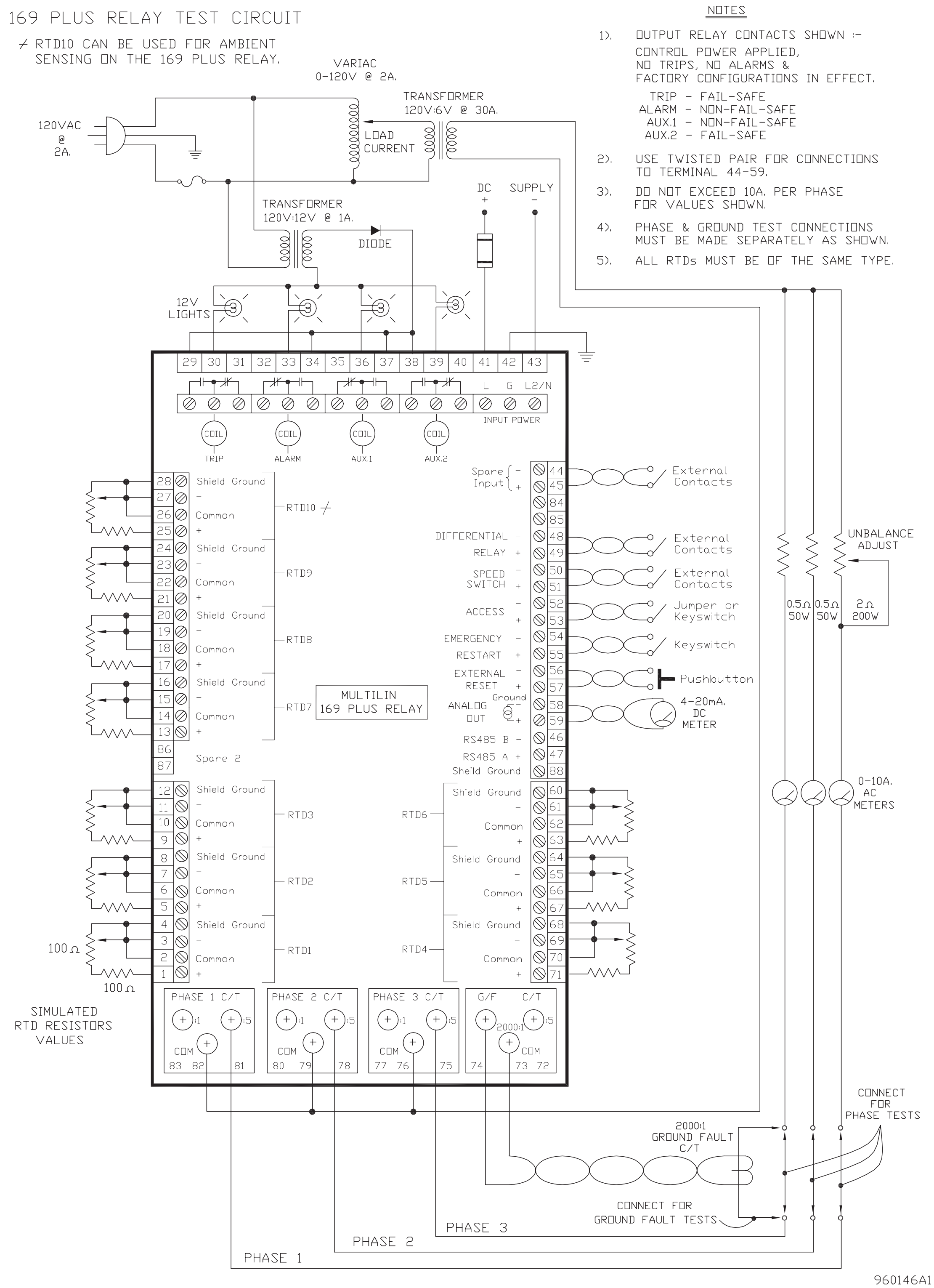


Figure 4-2 Secondary Injection Test Set (DC input to 169 relay)

4.4 Ground Fault Current Functions

The ground fault current function uses digital current information converted from the analog ground fault CT input. The 169 relay must read the injected ground fault current correctly in order for the ground fault function to operate properly. Using factory default setpoints to test the ground fault input circuitry, pass a phase current conductor through the ground fault CT window as shown in figure 4-1. The actual injected current should then be the same as the "GROUND FAULT CURRENT" display in ACTUAL VALUES mode. If the injected current is adjusted to over 4.0 Amps for longer than 10.0 seconds the ground fault alarm should become active. If over 8.0 Amps is injected for more than 50 msec. a ground fault trip should occur. These tests can be performed for other CT ratios and setpoints.

4.5 RTD Measurement Tests

The correct operation of each of the RTD inputs can be tested by simulating RTDs with potentiometers. To test a 169 relay configured for use with 100 Ω platinum RTDs, 100 Ω potentiometers and resistors can be used. These should be connected to each RTD as shown in figure 4-1.

Table 4-1 shows RTD resistances for various temperatures. Individual, actual stator and bearing RTD temperatures can be viewed in ACTUAL VALUES mode, page 2.

To test overtemperature trip/alarm functions the simulated RTD potentiometers should be adjusted to correspond to high RTD temperatures.

Table 4-1 RTD Resistance vs. Temperature

TEMP °C	RESISTANCE (IN OHMS)			
	100 Ω Pt	120 Ω Ni	100 Ω Ni	100 Ω Cu
0	100.00	120.00	100.00	9.04
10	103.90	127.17	105.97	9.42
20	107.79	134.52	112.10	9.81
30	111.67	142.06	118.38	10.19
40	115.54	149.79	124.82	10.58
50	119.39	157.74	131.45	10.97
60	123.24	165.90	138.25	11.35
70	127.07	174.25	145.20	11.74
80	130.89	182.84	152.37	12.12
90	134.70	191.64	159.70	12.51
100	138.50	200.64	167.20	12.90
110	142.29	209.85	174.87	13.28
120	146.06	219.29	182.75	13.67
130	149.82	228.96	190.80	14.06
140	153.58	238.85	199.04	14.44
150	157.32	248.95	207.45	14.83
160	161.04	259.30	216.08	15.22
170	164.76	269.91	224.92	15.61
180	168.47	280.77	233.97	16.00
190	172.46	291.96	243.30	16.39
200	175.84	303.46	252.88	16.78

4.6 Power Failure Testing

When the AC voltage applied to the 169 relay decreases to below about 90 V the relay SERVICE L.E.D. should become illuminated. All output relays will also go to their power down states. To test the memory circuitry of the relay, remove and then re-apply control power. All stored setpoints and statistical data should be unchanged. The displayed lock-out time after an overload trip should continue to decrease even when control power is removed.

4.7 Analog Current Output

Using the factory default setpoints to test the analog current output, a 4-20 mA DC ammeter should be connected between terminals 58 and 59. While viewing the "HOTTEST STATOR RTD" actual value adjust the resistance of the simulated stator RTD potentiometers shown in figure 4-1. A displayed reading of 0 C should correspond to a 4 mA output. A reading of 200 C should correspond to an output of 20 mA. The output should be a linear function of temperature between these extremes. Similar tests can be performed for the other output options (thermal capacity used, motor load as a percentage of full load).

4.8 Routine Maintenance Verification

Once a relay has been properly installed, periodic tests can be performed to check correct operation of the protection system. Many conditions can be simulated without creating the actual trip/alarm conditions themselves. This is done by changing relay setpoints to values that will initiate trips and alarms during normal motor operation. Changed setpoints should be returned to their proper values when tests have been completed. The Access terminals must be shorted together to allow setpoint changes. The Emergency Restart terminals should be shorted together momentarily 5 times before each test to ensure that the relay thermal memory is fully discharged and starts per hour counter is fully cleared.

To test relay functions using phase current data, with the motor running, change the "MOTOR FULL LOAD CURRENT" setpoint to a value under the actual motor current. Stop the motor and short the Emergency Restart terminals together momentarily to discharge the thermal memory in the relay. The trip relay should activate after a time determined from the overload curve, amount of unbalance present, and motor RTD temperature. The time to trip at a given overload level should never be greater than the time on the overload curve. Current unbalance and high stator RTD temperatures will cause this time to be shorter (if the RTD bias and/or U/B bias functions are enabled).

Larger overloads, representing short circuits or mechanical jams, can be simulated by changing the "MOTOR FULL LOAD CURRENT" setpoint to a value much lower than the actual motor phase current.

Unbalance trip or alarm conditions can be simulated by changing the Unbalance Trip or Alarm Level setpoints to values below the actual unbalance present at the motor terminals.

Other trip or alarm conditions using ground fault current data and RTD temperature data can be simulated using the procedures outlined in the previous sections.

To test the operation of the 169 output relays and the switchgear connected to them the "EXERCISE: XXXXX RELAY" setpoint in page 6 of SETPOINTS mode can be used. The motor must be stopped in order for this function to operate. Any or all of the output relays can be toggled using this setpoint.

To test the analog output current hardware the "ANALOG OUT FORCED TO: XXXXXX SCALE" setpoint can be used. The output current can be forced to "ZERO", "MID", or "FULL" scale. This feature can be used to test the calibration of the 169 as well as the operation of any device through which the current is flowing.

The motor must be stopped in order for this function to operate.

To test the operation of devices connected to the Differential Input, Speed Switch Input, Access terminals, Emergency Restart terminals, and External Reset terminals the "STATUS" setpoint can be used. This is in page 6 of SETPOINTS mode. This line will give the status of each pair of terminals as either "OPEN" or "SHORT".

5.1 Hardware

All relay functions are controlled by an 8031 8-bit microcomputer. This IC contains internal RAM and timers, but all firmware and display messages are stored in an external EPROM IC. A 12 key keypad and a 2 row X 24 character display are used to enter relay setpoints and display all values and messages. A hardware block diagram is shown in figure 5-1.

The power supply uses a dual primary / triple secondary transformer for connection to 120/240 VAC. A 24/48/125/250 VDC input switching power supply is also available as an option. Regulated +/-5 V supplies are created for use by logic and analog ICs. An unregulated +10 V supply is used to drive the RTD selection relays and L.E.D. indicators, and an isolated +10 V supply is used on the AC input versions to drive the output relays and read the contact inputs. +2.5 V reference voltages are derived from temperature compensated precision voltage reference diodes to provide stable, drift-free references for the analog circuitry. A power fail detector circuit is used to reset the relay whenever the supply voltage goes out of the proper operational range. This hardware watchdog circuit must be signaled regularly by a firmware-generated voltage or else the microcomputer will be reset.

Three phase CTs are used to scale the incoming current signals to the 169 relay. The currents are then rectified and fed through fixed burdens to produce a voltage signal of 430 mV peak / FLC. This signal is then multiplexed. The multiplexed signal is buffered and fed to an A/D converter. The digital signal is then fed to the microcomputer for analysis. A separate ground fault CT is provided on the 169 relay to scale the input ground fault current. This current signal is rectified and fed through a resistive burden to convert it to 1.25 V peak / secondary amps rating. This is then fed to the same multiplexer as the phase input signals.

The temperature monitoring circuitry of the 169 relay consists of 10 RTD connections multiplexed by miniature relays and a 4 to 10 decoder. Mechanical relays are used because of their excellent isolation, transient immunity, and almost zero on-resistance. A stable current source feeds each of the RTDs in turn, and 128 readings are taken over a period of one second for each RTD. This provides for stable averaging and good 50/60 Hz noise rejection. An RTD lead compensation circuit subtracts the RTD lead resistance and then the analog RTD voltage is multiplexed along with the phase and ground fault signals. A no sensor detector circuit indicates when no current flows in an RTD in order to distinguish a faulty sensor from a high temperature reading.

The 8031 microcomputer interfaces with an 8155H I/O port and static RAM to drive an intelligent display module and provide a digital output signal for a D/A converter. The analog output signal from the DAC is then converted to a current and scaled to be 4-20 mA. The microcomputer also drives an 8255A I/O port which handles keypad inputs, L.E.D. drivers, and external switch inputs. The data lines from the 8031 are latched before being passed to the address lines of the EPROM and NOVRAM. NOVRAM store cycles are initiated every time control power goes out of the recommended operating range. The output relays are controlled by the microcomputer through optoisolators and are powered by a separate, isolated +10 V supply. A SN 75176 transceiver is used to provide an RS 422 communications interface for programmable controllers and computers for the 169 Plus.

All connections to the 169 relay are made on the I/O circuit board; transient protection and filtering are provided on all inputs.

Figure 5-1 Hardware Block Diagram

5.2 Firmware

All mathematical, logic and control functions are performed on an 8031 microcomputer by a program stored on a separate EPROM. The program execution flow is shown in the firmware block diagram of figure 5-2.

Every 2 ms the system clock generates an interrupt. At this time all timers are updated, the keypad is read and debounced, and five A/D conversions are performed by the A/D module. These conversions are the ground fault current reading, three phase current readings, and a single RTD, voltage reference, or power fail circuit reading. At this point the RMS values of the currents are calculated, and short circuit and ground fault tests are made. The EOC interrupt routine checks for a motor start condition and if this is true the phase sequence is checked, a start timer is initiated, and the start register is updated.

The INITIALIZE module is performed whenever the relay is powered on to ensure that the system comes up in a known state. Parts of this module are executed whenever the relay is reset as well. The SYSTEM EXECUTIVE then causes execution to loop through a series of modules which perform most of the relay functions.

The O/L module uses the positive to negative sequence current ratio calculated by the U/B module, the learned K factor, and the RMS phase currents to fill a thermal memory register. The O/L module discharges this register at either a learned or preset cooling rate when no overload is present. The average stator RTD temperature calculated in the RTD module is used to bias the thermal memory. This module also compares the RMS phase current values to the Undercurrent and Rapid Trip / Mechanical Jam trip and alarm levels, and starts appropriate timers if the current levels are out of range.

The U/B module computes the phase current ratios Ib/Ia and Ic/Ia, and uses them in conjunction with a look-up table to determine the negative to positive sequence current unbalance ratio In/Ip. This value is compared to the Unbalance trip and alarm levels and appropriate timers are initiated if trip/alarm conditions are met.

The RTD module uses the RTD voltage reading from each of the 10 RTD inputs and computes the average stator RTD temperature. This is then used to bias the thermal memory. The RTD readings are compared to the trip and alarm levels and relay activation is initiated if conditions are met. Each RTD is read 128 times over a one second scan interval.

The KEYSERVICE/EXTERNAL SWITCH module takes in all of the data associated with the keypad and executes the function of each key. Timers for the closure times of the VALUE UP/DOWN, PAGE UP/DOWN, and LINE UP/DOWN keys are initiated and the display is updated accordingly. This module also reads the Emergency Restart, External Reset, Differential Relay, and Speed Switch inputs and initiates appropriate action.

The MESSAGE module handles all of the message look-up functions and sends the message data to the display. The displayed messages are made up of individual messages, common message strings, and variable data. Non-displayed control bytes are used to indicate the message type, variable data type, decimal point placement, and other control information.

The D/A module gives the DAC the current digital value for the selected option output for conversion to an analog value. This analog voltage is then fed to a voltage-to-current converter circuit.

The SELF-TEST module causes the 8031 to send out regular voltage signals to indicate to the power supply watchdog circuit that the system is operating properly. This module also performs all of the self-test features outlined in section 3.23.

The TRIP/ALARM module is executed when any relay trip or alarm setpoint has been exceeded. This module handles output relay activation and TRIP/ALARM message output.

Statistical data is updated whenever a statistical value changes. For example, the total number of motor starts value is updated every time a motor start is detected.

Figure 5-2 Firmware Block Diagram

6 APPLICATION EXAMPLES

6.1 169 Relay Powered from One of Motor Phase Inputs

If a 169 relay is powered from one of the three motor phase inputs, a single-phase condition could cause control power to be removed from the relay. In order to ensure that the motor is taken off-line if this condition arises, the 169 output relay (e.g. TRIP, AUX. 1) used to trip the motor must change state when control power is removed from the 169. This is accomplished by making this output relay fail-safe. Factory defaults are:

- TRIP: Fail-Safe
- ALARM: Non-fail-safe
- AUX. 1: Non-fail-safe
- AUX. 2: Non-fail-safe

These can be changed using the RELAY FAILSAFE CODE in page 5 of SETPOINTS mode.

6.2 Loss of Control Power Due to Short Circuit or Ground Fault

If the input voltage (terminals 41-43) to a 169 relay drops below the low-end specification (90 VAC on 120 VAC units), the 169 output relays will return to their power down states. If the input voltage drops due to a short circuit or ground fault on a motor, the 169 relay protecting the motor may or may not be able to trip out the motor. For example, if a 120 VAC 169 relay is set to trip after 0.5 seconds of an 8.0 XFLC short circuit current, the input voltage must remain above 90 VAC for at least 0.5 seconds after the short circuit has occurred or else the 169 relay will not be able to trip. As explained in section 6.1 above, in order to trip the motor when control power for the 169 is lost, the 169 output relay used to trip the motor must be configured as fail-safe.

6.3 Example Using FLC Thermal Capacity Reduction Setpoint

The purpose of the FLC Thermal Capacity Reduction Setpoint is to accurately reflect the reduction of thermal capacity available (increase the thermal capacity used) in a motor that is running normally (100% of FLC or less). This setpoint allows the user to define the amount of thermal capacity used by their motor running at 1 FLC. A motor that is running at 10% of FLC will obviously use less thermal capacity than a motor at 100% FLC.

For example, if the FLC Thermal Capacity Reduction Setpoint is set at 30%, then with the motor running at 1 FLC, the thermal capacity used will settle at 30%. Using the same example, with the motor running at 50% FLC, the thermal capacity used will settle at 15% (50% of 30%). A practical example of implementation of this setpoint to coordinate hot/cold damage curves is illustrated below.

Assume the motor manufacturer has provided the following information:

1. Maximum permissible locked rotor time (hot motor) = 15.4 seconds.
2. Maximum permissible locked rotor time (cold motor) = 22 seconds.
3. Recommended thermal limit curves are as shown in Figure 6-1.

Note: Hot motor is defined as a motor that has been running at 1 FLC, but not in an overload, for a period of time such that the temperature remains constant (typical 90 C). Cold motor is defined as a motor which has been stopped for a period of time such that the temperature remains constant (ambient temperature is defined by NEMA standard as 40 C).

The hot motor locked rotor time is 30% less than the cold motor locked rotor time. Therefore the FLC Thermal Capacity Reduction Setpoint should be set to 30%. The overload curve selected should lie below the cold thermal damage curve. Once the motor has been running for a period of time at 1 FLC the thermal capacity used will remain constant at 30%. The time to trip at any overload value will correspondingly be 30% less.

Once a motor comes out of an overload condition, the thermal capacity used will discharge at the correct rate which is approximately exponential and settle at a value defined by the FLC Thermal Capacity Reduction Setpoint and the present current value. Using the example above if the motor came out of an overload and the present current value was 50% FLC the thermal capacity used would discharge to a value of 15% (50% of 30%).

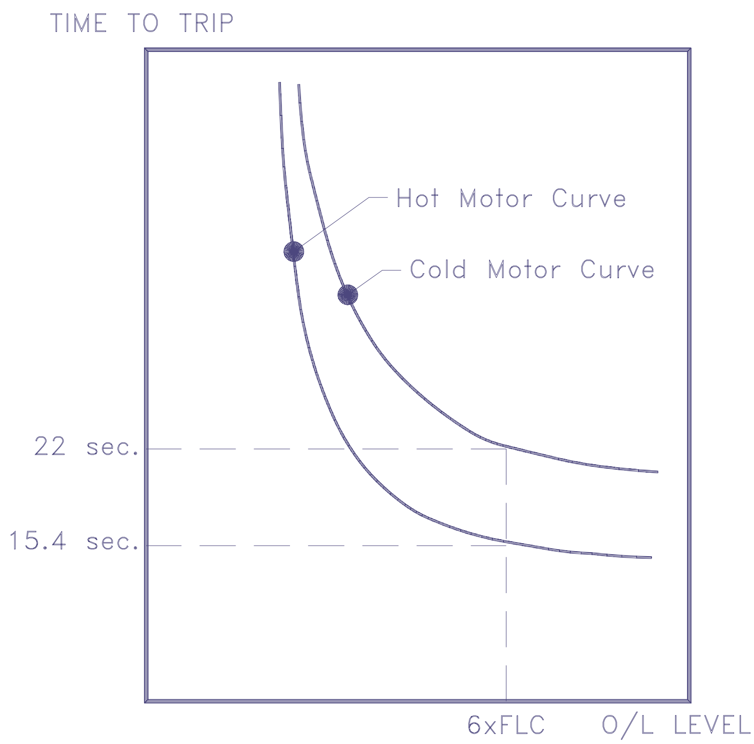


Figure 6-1 Thermal Limit Curves

GLOSSARY

Active - Refers to the state of an output relay. An output relay will become active (activate) when any of the functions assigned to that relay indicate a trip/alarm condition.

Inactive - Refers to the state of an output relay. An output relay will be inactive whenever none of the conditions assigned to that relay indicate trip/alarm conditions.

Latched - Refers to the configuration of an output relay. Latched relays must be manually reset after activation. This can be done by using the Reset key or the External Reset terminals. Trip and Aux. 2 relays are always latched.

Unlatched - Refers to the configuration of an output relay. An unlatched relay will be automatically reset after the conditions causing its activation are removed.

Fail-safe - Refers to the configuration of an output relay. When a fail-safe relay is in the no trip/no alarm (inactive) state its coil will be energized (i.e. have a voltage across it). Thus when control power is removed from the 169 all fail-safe output relays will go to the active state. Aux. 2 relay is always fail-safe.

Non-fail-safe - Refers to the configuration of an output relay. When a non-fail-safe relay is in the no trip/no alarm state its coil will be de-energized (i.e. have no voltage across it). Thus when control power is removed from the 169 relay all non-fail-safe output relays will go to the inactive state.

Tripped - Refers to the state of the motor controller, starter, or system circuit breaker. When one of these devices is tripped the power to the motor will be removed. Normally the Trip relay of the 169 is used to control this operation.

Mode - The large amount of information that can be viewed on the 169 relay display is divided into four modes: ACTUAL VALUES, SETPOINTS, HELP, and TRIP/ALARM. The relay can be put into any one of these modes for viewing specific information. The ACTUAL VALUES and SETPOINTS modes each contain many pages of data while all four modes contain many lines.

Page - The ACTUAL VALUES and SETPOINTS modes are divided into a number of pages containing different sets of information. Each page contains many lines, only one of which can be viewed on the display at any one time.

Line - Each relay display mode is divided into a number of lines of data. Each line consists of 2 rows X 24 characters. One line will always be visible on the 169 relay display.

Flash Message - Flash messages are one-line messages that appear on the display in response to certain key closures or timer indications. Flash messages stay on the display for 2 seconds.

Thermal Memory - This is an internal 169 relay register which is used to thermally model the motor being protected. When this register reaches a value of 100% the entire thermal capacity of the motor has been used and an OVERLOAD TRIP is initiated.

MULTILIN RELAY WARRANTY

Multilin warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a Multilin authorized factory outlet.

Multilin is not liable for contingent or consequential damages or expenses sustained as a result of a relay malfunction, incorrect application or adjustment.