POWER CONTROLLER
MODEL 664D AND 664E
USER'S MANUAL

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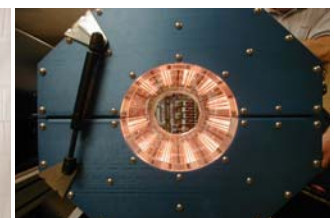

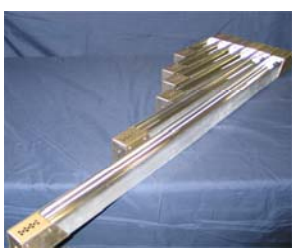

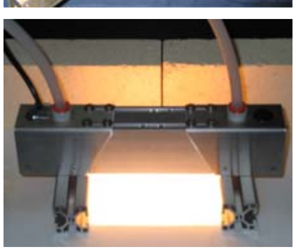

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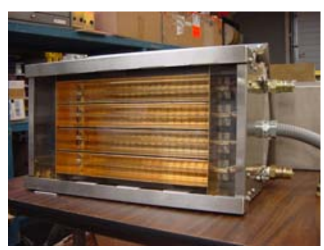

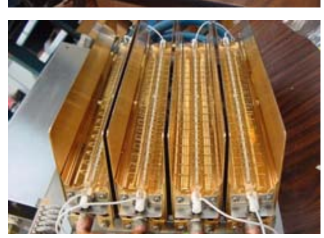

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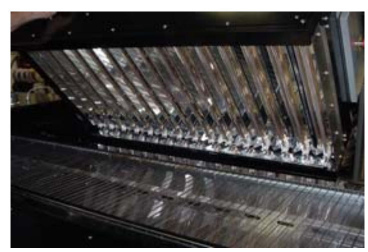

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SECTION 1.

INTRODUCTION

1.1 GENERAL DESCRIPTION

Model 664D and 664E power controllers (figure 1–1) are compact, versatile, and highly reliable SCR-type, distributed, zero crossover controllers *suitable for use with resistive loads only.*

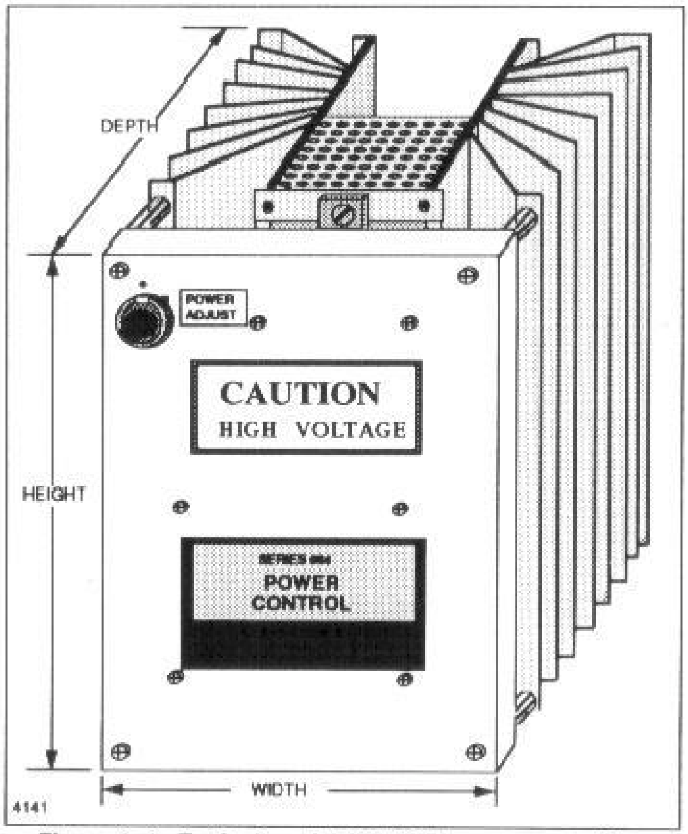

Figure 1–1. Typical model 664 SCR power controller.

The 664D is a single-phase controller. The 664E is a three-phase controller. Both controllers operate on 208 VAC to 600 VAC, 47 Hz to 63 Hz power. Controller current capacity ranges from 35 amperes through 300 amperes, depending on the version.

Standard model 664 controllers are controlled automatically by means of a 4–20 mA signal. If the optional input module is used, they can be controlled manually with a potentiometer, or automatically by either a 0–5 VDC or 0–20 mA signal.

1.2 STANDARD FEATURES

Each standard model 664D or 664E controller includes:

1. One or two pairs of SCRs the conduction of which controls the load power.
2. A firing circuit module, which controls the conduction of the SCRs.
3. A dv/dt circuit, which is connected across each SCR module to prevent the firing circuit from being activated by voltage transients on the AC line.
4. A metal oxide varister (MOV) connected across each SCR module to protect the SCRs from being damaged by high-voltage AC line transients.
5. Jumpers for using different line voltages to power the controller.
6. A cooling fan (on 175 A, 250 A, and 300 A versions only).
7. A thermostat (standard on all 175 A, 250 A, and 300 A versions and optional on all others).
8. On/off control of the controller from a remote location.
9. Firing circuit fuses to protect critical portions of the firing circuit module in case an SCR fails or does not fire properly.

1.3 OPTIONAL FEATURES

SCR Alarm

Operates a set of form C relay contacts if an SCR short circuits (the most common way an SCR fails).

Input Module

Permits the 664D and 664E to be controlled manually with a 1000 ohm potentiometer, or automatically by either a 0–5 VDC or 0–20 mA signal.

Subcycle Fuses

Protect the SCRs from current overloads (for 70–300 A controllers only).

Current module

Permits the use of instantaneous current trip (an alternative to subcycle fuses).

1.4 MODEL NUMBER INTERPRETATION

Table 1–1 shows how to interpret a model 664 controller's model number (located on the top panel of the controller). Table 1–1 also lists all options available for the 664D and 664E controllers.

Table 1–1. Model 664 Power Controller Model Number Interpretation

MODEL 664	POWER CONTROLLER

CODE	CONTROL TYPE
B	Single Phase Time Proportioned Zero Cross (TPZC)
C	Three Phase 2 Leg Time Proportioned Zero Cross (TPZC)
D	Single Phase Distributed Zero Cross (DZC)
E	Three Phase 2 Leg Distributed Zero Cross (DZC)
F	Single Phase, Phase Angle (PA)
G	Three Phase (Hybrid) Phase Angle (PA) – Inductive Loads Only
K	Three Phase (Hybrid) Phase Angle (PA) – Resistive Loads Only
L	Single Phase Peak Fire Zero Cross (PFZC)
M	Three Phase 2 Leg Peak Fire Zero Cross (PFZC)

CODE	VOLTAGE
2	208V
3	240V
4	277V
5	380V
6	415V
7	480V
8	600V

CODE	CURRENT
1	35A
2	50A
3	70A
4	90A
5	125A
6	175A
7	250A
8	300A

CODE	CIRCUIT OPTION #1
0	None
1	Input Module
2	Input Module w/1 Turn Pot (pot mounted on Power Cont. Top Plate)
3	Input Module w/10 Turn Pot & Dial (pot mounted on Pwr Cont Top Plate)

CODE	CIRCUIT OPTION #2
0	None
2	ICT
3	ICT w/Current Limiting (phase angle controllers only)
4	ICT w/Current Feedback (phase angle controllers only)

CODE	COVER OPTION
0	No Cover
1	Cover

CODE	OPTIONS
00	None
11	Thermostat
22	Failed SCR Detector
XX	Custom Feature

664 D – 4 4 – 3 2 1 – 11 – 22 ←TYPICAL MODEL NUMBER

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1.5 DIMENSIONS AND WEIGHT

See tables 1–2 and 1–3.

Table 1–2. Dimensions* and Weight—664D

CURRENT RATING	MOUNTED HEIGHT	WIDTH	DEPTH	WEIGHT	
				LBS	KG.
35–125 A	7.50 (190.5)	6.25 (158.8)	10.20 (259.1)	6	2.8
175 A	11.37 (288.8)	6.25 (158.8)	10.20 (259.1)	10	4.6
250–300 A	21.87 (555.5)	6.25 (158.8)	10.20 (259.1)	18	8.3

*Dimensions in inches (millimeters)

Table 1–3. Dimensions* and Weight—664E

CURRENT RATING	MOUNTED HEIGHT	WIDTH	DEPTH	WEIGHT	
				LBS	KG.
35–70 A	7.50 (190.5)	6.25 (158.8)	10.20 (259.1)	6	2.8
90–125 A	18.00 (457.2)	6.25 (158.8)	10.20 (259.1)	15	6.9
175 A	21.87 (555.5)	6.25 (158.8)	10.20 (259.1)	16	7.4
250–300 A	21.87 (555.5)	6.25 (158.8)	10.20 (259.1)	20	9.2

*Dimensions in inches (millimeters)

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1.6 SPECIFICATIONS

NOTE

Unless stated otherwise each specification presented applies to both the 664D and 664E controller's.

1.6.1 Power Control Action

NOTE

The following specifications are applicable when standard average load voltage feedback is used.

Type

Distributed power control with zero crossover turn-on and turn-off. One-second cycle time (nominal) with one-cycle resolution.

Output Linearity

Average load voltage varies linearly with control signal within ± 2%.

Line Regulation

RMS load voltage is stable within ±3 percent for rms line voltage variations of –15 percent to +10 percent.

Load Regulation

Average load voltage is stable within ±1% for load impedance variations, up to current capacity limitation of AC line source.

Temperature Stability

Average load voltage varies by less than 0.2 VAC per degree C change in ambient temperature.

Controllable Range

When the control signal activates the SCRs, the controller's load voltage is controllable from zero to 97 percent of the controller's input line voltage.

1.6.2 SCR/Load Configuration

664D

Single-phase power control (one SCR pair) suitable for resistive loads.

664E

Three-phase, two-leg power control suitable for resistive loads in 3-wire closed delta or 3-wire wye configurations.

1.6.3 Control Signal

4 mA (–0, +0.5 mA) to 20 mA (–0.5, +0 mA). Minimum control signal compliance: 12 VDC. Input impedance is equivalent to 600 ohms for interconnection purposes (impedance varies inversely with control signal level).

1.6.4 Span Adjustment

User-adjustable, 20-turn potentiometer that adjusts the gain of the firing circuit's internal average load voltage feedback circuit. Matches the gain of the internal feedback circuit to the line voltage being used. When internal feedback is selected, the firing circuit **SPAN** potentiometer varies the control signal input span by changing the control signal value that produces full output from 15 mA to 20 mA. Adjusting the **SPAN** potentiometer also adjusts the span of the firing circuit 0–100 microampere load-voltage meter drive signal.

1.6.5 Line Voltage

208–600 VAC, +10% –15% (line voltage configuration required only for fan-cooled units).

1.6.6 Line Frequency

47 to 63 Hz (no line frequency configuration is required).

1.6.7 SCR V_{RRM} Rating

1200 V.

1.6.8 DV/DT

Circuit

RC network across each SCR pair.

DV/DT Rating

200 V/microsecond.

1.6.9 Current Capacity

See table 1–4.

Table 1–4. Model 664D and 664E Current Capacities

Continuous Current Rating	Maximum Current (Amperes) 10 Cycle Surge*	1/2 Cycle Surge	I^2T	Maximum Power (KW) @ 600 VAC
35	130	280	390	21.0
50	185	400	800	30.0
70	400	850	3,600	42.0
90	585	1250	8,000	54.0
125	820	1750	15,000	75.0
175 **	820	1750	15,000	105.0
250	1500	3400	58,000	150.0
300	1995	4250	90,000	180.0

*Typical current surge duration for start-up of incandescent loads.
**Continuous current derated to 135 A for loads with high current draw when cold, e.g., tungsten heaters and tungsten lamps.

1.6.10 Cooling

35 A to 125 A units: convection cooled.
175 A to 300 A units: fan cooled.

1.6.11 Line Transient Protection

MOV across each SCR pair.
Clamping voltage: 820 V peak at 1 mA.
Peak surge current: 1000 A.

1.6.12 Firing Circuit Fuse

0.25 A fuse. Fuse opens if an SCR fails to fire when activated.

1.6.13 Isolation

Control Signal to AC Line and Load

1500 VAC.

Heatsink to AC Line and Load

1500 VAC.

1.6.14 Environmental Limits

Operating

32°F to 122°F (0°C to 50°C) at up to 90 percent relative humidity (non-condensing).

Storage

–40°F to 158°F (–40°C to 70°C) at up to 90 percent relative humidity (non-condensing).

1.6.15 Thermostat

Non-latching, normally closed switch connected to firing circuit **ENABLE** terminals. Automatically shuts down power controller in case of overtemperature. Recloses to restart power controller when normal operating temperature is restored.

Switch Action	Degrees F	Degrees C
Opens at:	180 ± 5	82 ± 3
Recloses at:	140 ± 20	60 ± 11

1.6.16 Electrical Connections

Control Signal

Firing circuit + and – push-on terminals.*

Enable Switching

Two pairs of push-on terminals* on firing circuit module used for thermostat option, for customer-supplied enable/disable switch, and for optional instantaneous current trip (ICT), an electronic alternative to subcycle fusing.

Line

Two compression screw terminals.**

Load

Two compression screw terminals.**

Ground

Compression screw terminal.**

*The terminal lugs supplied with unit accept 22 to 18 ga. wire.
**Maximum wire capacities:

CONTINUOUS CURRENT RATING	MAXIMUM WIRE GAUGE LINE, LOAD	GROUND	SUBCYCLE FUSES
35–175 A	1/0 ga.	1/0 ga.	1/0 ga.
250–300 A	250 mcm	1/0 ga.	4/0 ga.

SECTION 2.

INSTALLATION, SETUP, AND CONFIGURATION

2.1 INTRODUCTION

This section describes how to install and wire the Model 664 SCR power controller.

The features and options mentioned here are identified in the model number found on the plate attached to the top cover of the controller. See table 1–1 for the interpretation of the model number.

WARNING

1. Hazardous voltages are present at the controller's LINE and LOAD terminals and within the controller's chassis. Disabling firing circuit operation or setting the control signal to minimum does not eliminate these hazardous voltages.

2. Always remove AC line voltage from the controller before making contact with internal assemblies, line or load wiring, or any other areas where hazardous voltages may be present. Also remove AC line voltage from the controller before making connections, equipment changes, or resistance measurements.

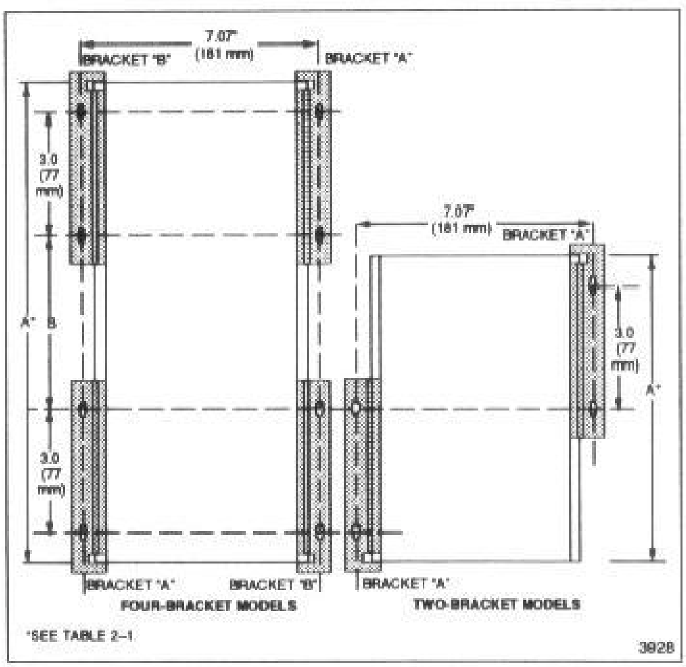

Figure 2–1. Mounting orientation for large (four-bracket) and small (two-bracket) Model 664 SCR controllers.

2.2 MOUNTING THE CONTROLLER

You can mount all models of the model 664 controller on a bench, but the preferred method is to mount them vertically on a bulkhead using two or four brackets (supplied) depending on the size of the controller. Figure 2–1 and table 2–1 give mounting dimensions for each model.

Table 2–1. Mounting Bracket Dimensions for Figure 2–1. Dimensions in inches (mm).

Controller Current Rating	664D	664E
35–70 A	A = 7.50 (192 mm) B = 0.00 (Uses two brackets only)	A = 12.00 (308 mm) B = 4.50 (115 mm)
90–175 A	A = 7.50 (192 mm) B = 0.00 (Uses two brackets only)	A = 18.00 (462 mm) B = 10.50 (269 mm)
250–300 A	A = 18.00 (462 mm) B = 10.50 (269 mm)	A = 18.00 (462 mm) B = 10.50 (269 mm)

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All model 664 controllers may be mounted either vertically or horizontally. If mounted vertically, fan-cooled units should be oriented so that the air flow is upward, not downward. If mounted horizontally, the controller's capacity must be derated 25 percent.

Allow at least 2 inches (50.8 mm) of space at the ends of the chassis for ventilation. If necessary, allow additional clearance if required by the wire gauge and routing methods used.

At least 0.75 inch (19.05 mm) clearance is required at each side for access to the mounting brackets.

If subcycle fuses are mounted on the heatsink, be sure to allow space for the fuse at the side of the power controller. If the subcycle fuse is not mounted on the heatsink, allow sufficient space for both the fuse and its associated wiring (see section 2.4).

To mount the controller on a bulkhead or bench:

1. Determine the location in which you wish to mount the controller.
2. Using figure 2–1 and table 2–1 as guides, mark the locations of the holes that must be drilled.
3. Drill holes for #10 screws.
4. Attach the lower mounting bracket(s) (one or two, depending on the size of the controller) to the mounting surface using #10 screws (not supplied). Orient the brackets as shown in figure 2–1. Do *not* tighten the screws yet.

5. Slide the bottom fins of the heat sink into the lower bracket(s) and have an assistant hold the controller in place, with the bottom edge of each fin resting against the lip of the bracket.
6. Tighten the screws for the top bracket(s) loosely. Do *not* tighten them yet.
7. Tighten the screws for the lower bracket(s), adjusting the screws in their holes so that they are equidistant from each end of the hole.
8. Slide the top bracket(s) down securely against the lip(s) of the fin(s) and tighten the screws for both the top and bottom brackets. Mounting is now complete.

2.3 POWER WIRING CONNECTIONS

After you have mounted the controller, wire the instrument to the load and power lines using the following procedure:

1. Loosen the protective side cover if the controller has one.
   A. Remove the screws that hold the side cover to the top cover.
   B. If conduit is connected to the protective side cover, you may wish to leave the cover in place after removing the screws.
2. Remove the top cover.
   A. Note the positions of the slotted holes in the long side of the top cover (see figure 2–2).

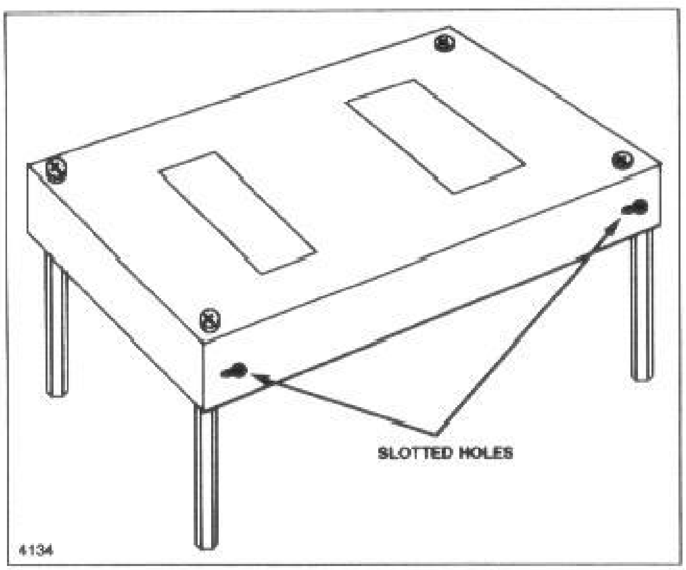

Figure 2–2. Slotted holes in controller cover.

   B. Remove the screws that hold the chassis cover to the standoffs.
   C. Lift the cover from its position as far as the wiring harness will permit.
   D. Replace the screws in the standoffs on the same side as the slotted holes in the cover, turning the screws until they are halfway into the standoffs.
   E. Position the top cover with the slotted holes aligned over the heads of the screws just replaced (figure 5–16). The top cover will now remain in place, "on edge," rotated 90 degrees from its original position. This provides complete access to all wiring connections and all internal components.
3. Attach the ground wire to the screw compression connector mounted at the end of the heat sink (figures 2–3 and 2–4).
4. Attach the external power lines to the **LINE** connectors on the printed circuit board(s) (see figure 2–3 for the 664D or figure 2–4 for the 664E). On the model 664E controller, connect the phase A power line to the **LINE 1** connector, the phase B power line to the **LINE 2** connector, and the phase C power line to the **LINE 3** connector.
5. Replace the chassis cover and tighten all cover mounting screws.

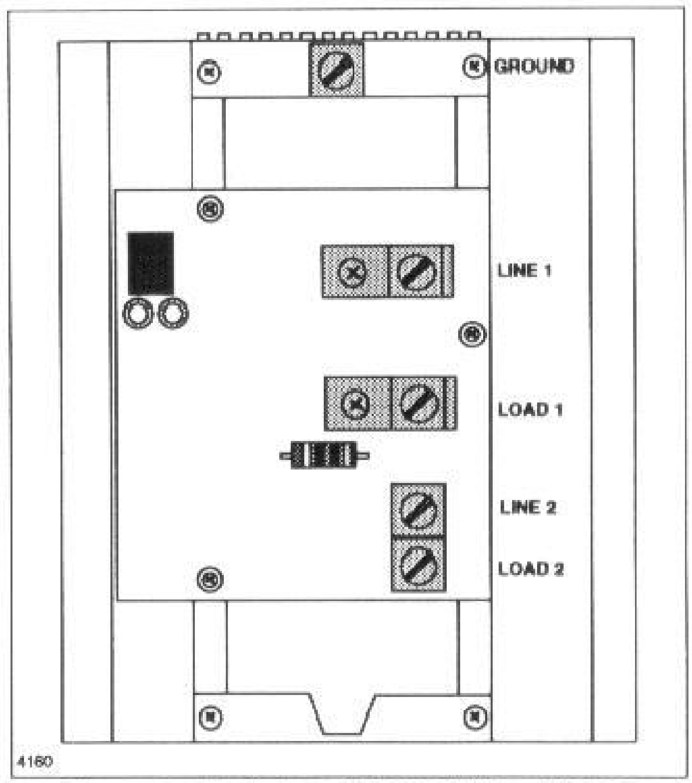

Figure 2–3. Typical model 664D LINE and LOAD connector locations.

2.4 OPTIONAL SUBCYCLE FUSE MOUNTING

Subcycle fuses (figure 2–5) for 70 A through 175 A controllers may be mounted on the side of the controller's heatsink, as shown in figure 2–6, or externally on a nearby bulkhead or bench. Subcycle fuses for 250 A and 300 A controllers must be mounted externally and should be located as close as possible to the controller.

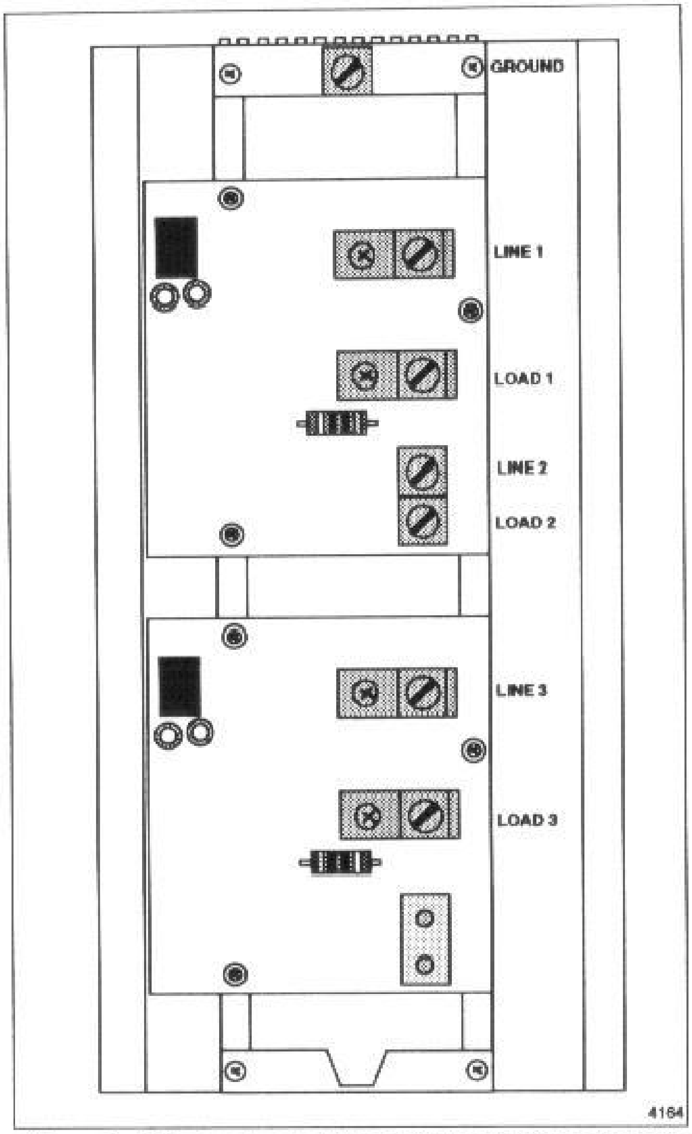

Figure 2–4. Typical model 664E LINE and LOAD connector locations.

Even if ordered with a controller, subcycle fuses are not mounted to the controller at the factory. The fuses and all mounting hardware are furnished in the form of a kit, which includes insulated standoffs and mounting hardware. The kit for 70 A through 175 A controllers also includes brackets for mounting the fuses on the side of the controller's chassis.

To install and connect the single subcycle fuse required for a model 664D controller:

1. Connect AC line 1 to one fuse terminal and connect the other fuse terminal to the **LINE 1** connector on the printed circuit board.
2. Connect the other AC line to the **LINE 2** connector on the printed circuit board.
3. Connect the load wires to the **LOAD 1** and **LOAD 2** connectors on the printed circuit board.

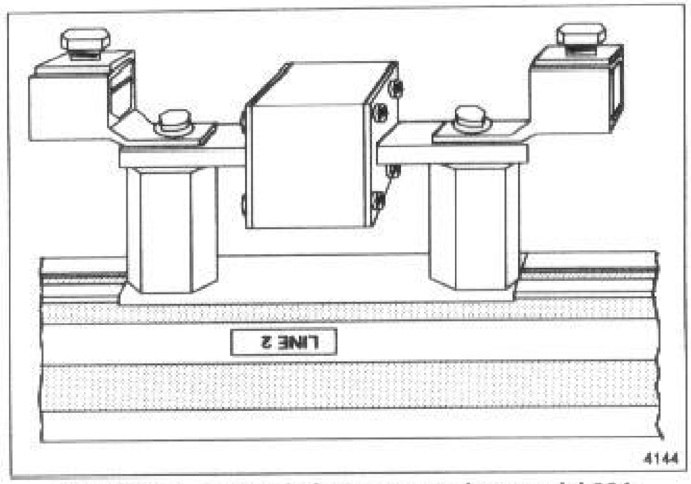

Figure 2–5. Subcycle fuse mounted on model 664 heatsink fins.

To install and connect the two subcycle fuses required for a model 664E controller:

1. Connect the phase A power line to one fuse terminal and connect the other fuse terminal to the **LINE 1** connector on the printed circuit board.
2. Connect the phase B power line to the **LINE 2** connector on the printed circuit board.
3. Connect the phase C power line to the second subcycle fuse and connect that fuse's other terminal to the **LINE 3** connector on the printed circuit board.
4. Connect the load wires to the **LOAD 1**, **LOAD 2**, and **LOAD 3** connectors on the printed circuit board.

CAUTION

1. Any control transformer used to monitor the power controller's output should have a rating sufficient to prevent damage to the transformer from saturation.

2. AC power connections should be made by a qualified electrician to ensure that all wiring is in accordance with National Electrical Code standard (within the United States) or equivalent standards (outside the United States).

2.5 SIGNAL WIRE CONNECTIONS

The standard 664 controller without options will accept only a 4–20 mA control signal with a 12-volt minimum compliance. The optional input module (if installed) allows you to use a 1000 ohm potentiometer, a 0–5 volt DC signal, or a 0–20 mA signal as a control input.

The accessory package supplied with the 664 controller contains push-on lugs for attachment to 18- to 22-gauge control signal wiring.

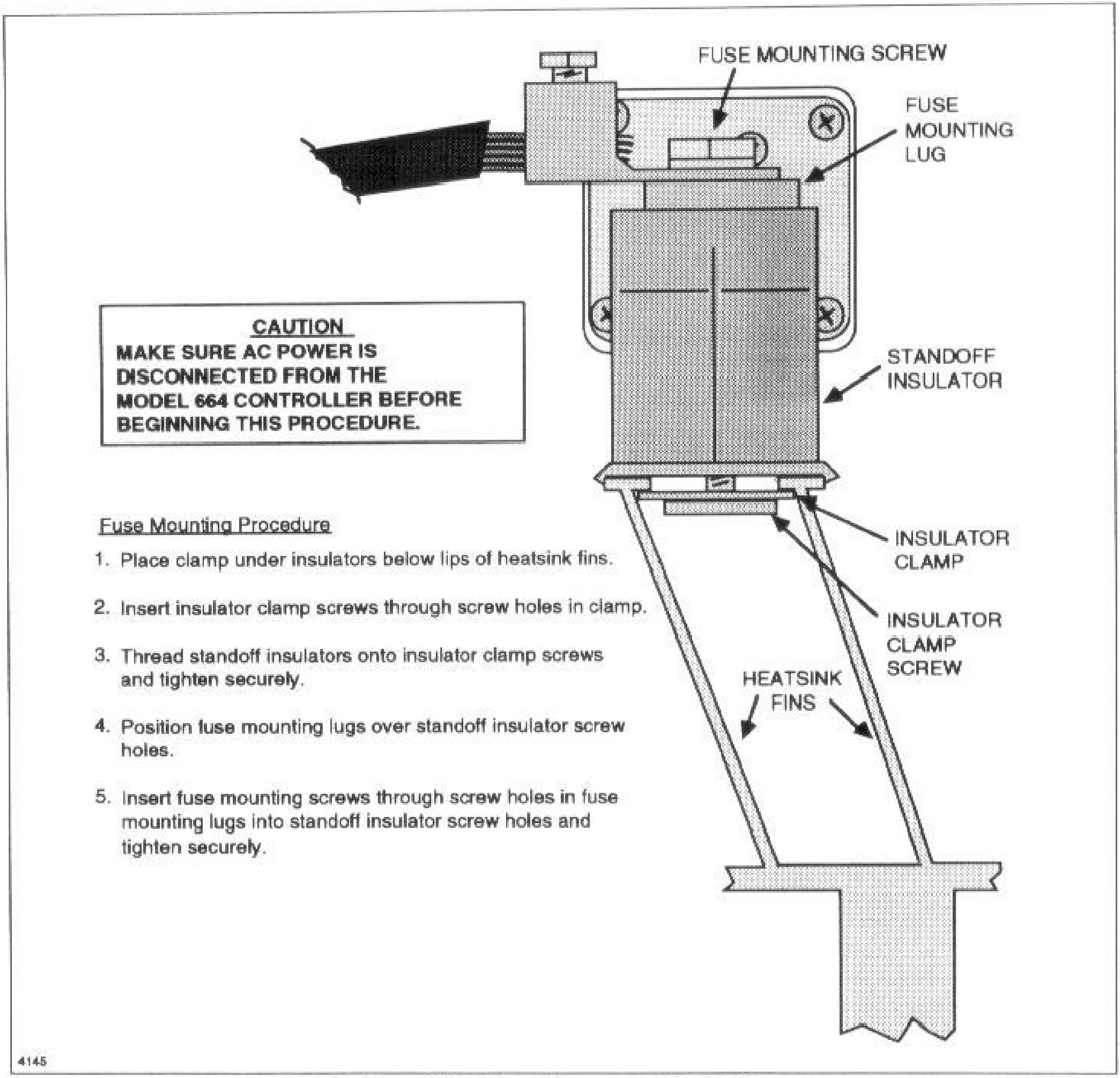

Figure 2–6. Subcycle fuse mounting details.

The firing circuit module is standard on all 664 controllers. The current module and input module are factory-installed options.

Connect the control signal wires as follows:

1. <u>If the controller does not have an input module or current module</u>, connect the 4–20 mA control-signal wires to the **INPUT** + and – terminals on the firing circuit module. See figures 3–8 and 3–10 (for the 664D) or figures 3–9 and 3–11 (for the 664E).
2. <u>If the controller has a current module (figure 3–14) but does not have an input module</u>, connect the 4–20 mA control-signal wires to the **4–20 IN** terminals of the current module. See figure 3–15 (for the 664D) or figure 3–16 (for the 664E).
3. <u>If the controller has an input module (figure 3–17)</u>, regardless of whether it also has a current module (see figures 3–18 and 3–20 for the 664D or figures 3–19 and 3–21 for the 664E):

A. If a 0–5 VDC control signal is being used:
   (1) Connect the positive control-signal wire to the **0–5 V** terminal of the input module.
   (2) Connect the negative control-signal wire to one of the **COM** terminals of the input module.
B. If a 0–20 mA control signal is being used:
   (1) Connect the positive control-signal wire to the **0–20 MA** terminal of the input module.
   (2) Connect the negative control-signal wire to one of the **COM** terminals of the input module.

4. If the controller has an input module and an installed 1000 ohm potentiometer, all wiring has been factory-installed on the input module.
5. If a remote 1000 ohm potentiometer is to be used:
   A. Connect its wiper to the **0–5 V** lug.
   B. Connect its **CW** end to the **POT** terminal.
   C. Connect its **CCW** end to a **COM** terminal.

NOTE

The potentiometer cannot normally be used concurrently with another control signal. The potentiometer wiper must be disconnected from the input module if a 0–5 VDC, 0–20 mA, or 4–20 mA input signal is to be used.

2.6 AUXILIARY CIRCUIT CONNECTIONS

2.6.1 Enable/Disable Switch or Relay

The controller can be enabled and disabled by means of an "enable/disable" switch (not supplied) the user installs and connects to the **ENABLE 3** and **4** terminals on the firing circuit module as shown in figure 5–14 (for 664D) or figure 5–15 (for 664E).

We recommend that you use a maintained-position, SPST switch for enable/disable switching. To avoid noise pickup, separate the switch wiring from all AC power wiring. If the wiring to the switch is long or if it passes through an electrically noisy environment, it may be necessary to use a local relay in conjunction with the enable/disable switch. In that case, install the relay as close as possible to the power controller. The switch then activates or deactivates the local relay, the contacts of which are connected to the **ENABLE 3** and **4** terminals on the firing circuit module.

To install and connect an enable/disable switch:

1. Move the thermostat connection on the firing circuit module from the **ENABLE 3** terminal (where it is shown in figure 2–7A) to the **ENABLE 1** terminal (where it is shown in figure 2–7B).
2. Install the enable/disable switch in a location of your choice. Route the switch or relay wiring through one of the two access holes in the top cover of the controller.
3. Crimp a push-on lug (supplied) on each switch or relay-contact wire.
4. Connect the lugs to the **ENABLE 3** and **4** terminals on the firing circuit module. There is no wiring polarity for these connections.

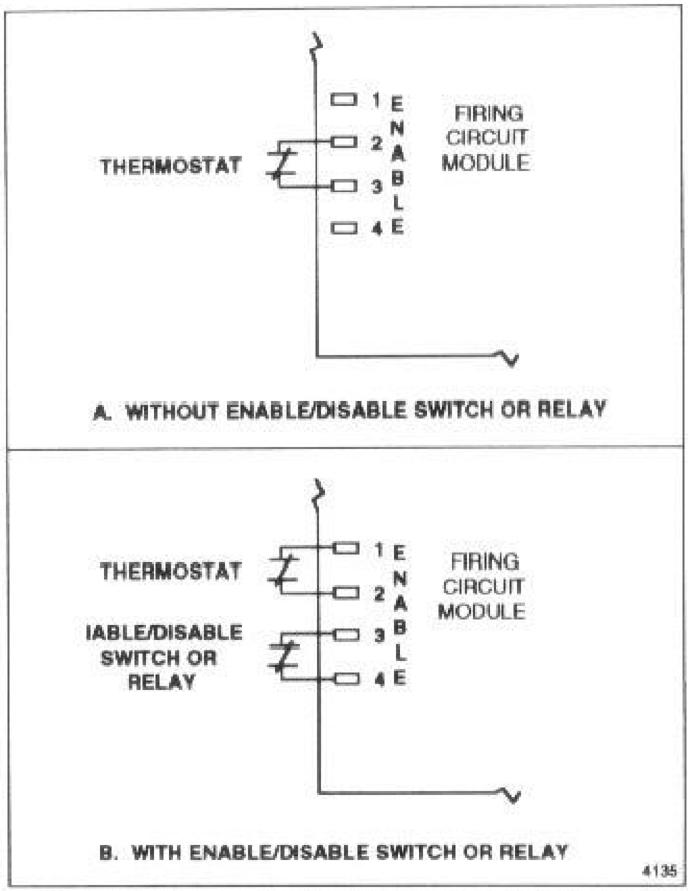

Figure 2–7. Connecting enable/disable switch to firing circuit module.

2.6.2 Optional SCR Alarm Circuit

The optional SCR alarm circuit, if installed, monitors SCR operations and operates a set of form C relay contacts if an SCR short circuits (a short circuit is the most common type of SCR failure).

Connect external indicators or devices that operate on contact *closures* between the **C** (common) terminal and the **NC** (normally closed) terminal (see figure 2–8). Connect external indicators or devices that operate on contact *openings* between the **C** (common) terminal and the **NO** (normally open) terminal (see figure 2–9 for wire-connection procedure).

2.6.3 ICT Function

2.6.3.1 ICT Reset Switch Wiring

Instantaneous current trip (ICT) is a function provided by the optional current module, if installed, which sends a

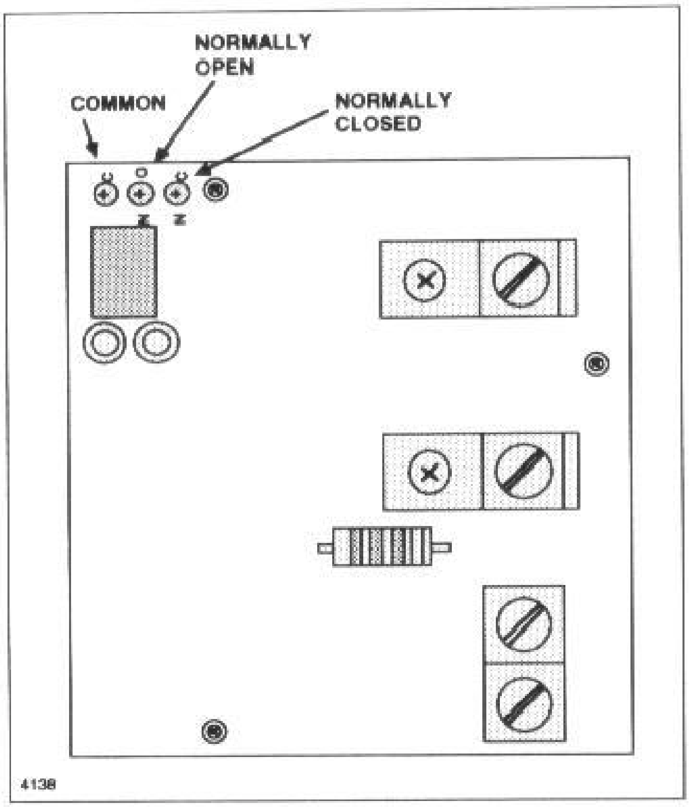

Figure 2–8. SCR alarm circuit terminal locations.

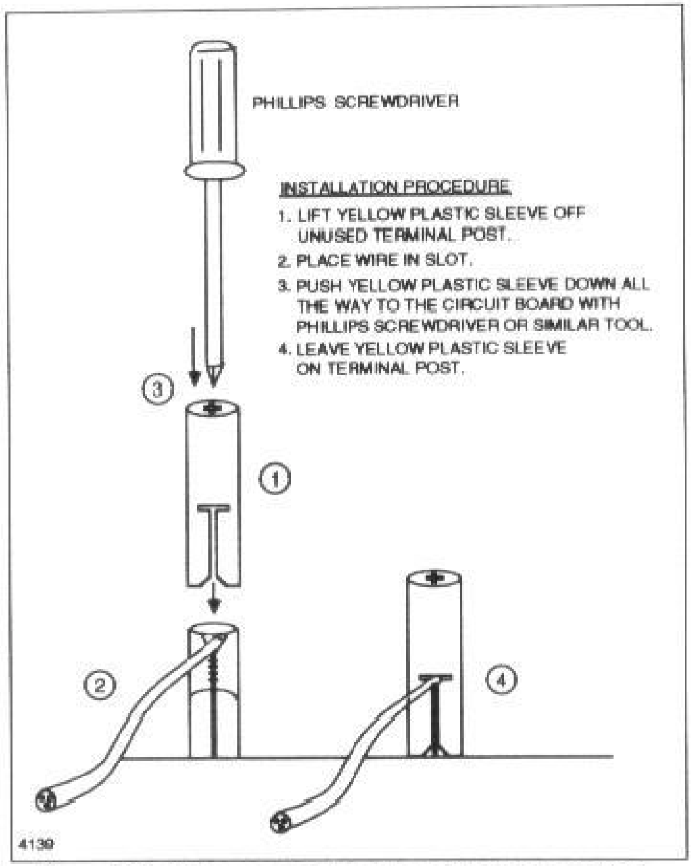

Figure 2–9. Wire connection procedure for insulation displacing terminals.

"trip"signal to the controller's firing circuit that disables controller operation within one AC cycle if the controller's output current exceeds a preset level. Once "tripped," the ICT circuit remains tripped until it is reset.

There are two ways to reset the ICT circuit:

1. Connect a customer-supplied single pole, normally *open*, momentary contact push-button switch between the two **RESET** terminals on the current module (see figure 5–6 and either figure 3–15 for the 664D or figure 3–16 for the 664E). Pressing the switch closes the switch contacts, which resets the ICT circuit.
2. Connect a customer-supplied single pole, normally *closed*, push-button switch in series with one of the control-signal wires that are connected to the **4–20 IN +** and – terminals of the current module. Pressing the switch opens the switch contacts, which resets the ICT circuit.

The current module (if supplied) is mounted under the controller's cover plate (see figure 5–16). Push-on lugs (part number KB067427-001) suitable for 18- to 22-gauge wire, are supplied with the power controller.

If installing a reset switch, crimp a push-on lug to each switch wire and install the lugs on the **RESET** terminals. There is no polarity to observe.

If installing a switch to interrupt the **4–20 IN +** or – signal, installation details will depend on where the switch is to be inserted in the signal wire.

2.6.3.2 Current Rating Configuration

The current at which the ICT circuit trips is determined by the settings of the eight **ICT SEL** switches on the current module (see figure 3–14). The switches are factory-set to correspond to the controller's current rating. Although they can be set so the ICT trips at a current lower than the controller's current rating, they should never be set to trip at a current higher than the controller's current rating.

Normally, the settings of the **ICT SEL** switches need not be checked or changed unless the current module is replaced.

The switch settings versus trip current are shown in table 2–2 (for the 664D) and table 2–3 (for the 664E).

2.6.3.3 ICT Indicator Wiring

A jumper wire is factory installed across the **ICT IND** terminals of the current module (see figure 5–6). If desired, this jumper can be removed and the **ICT IND** signal can be used to operate a remote indicator.

When the ICT circuit is tripped, the **ICT IND** terminals supply a DC current, ranging from approximately 4 to 20 mA, that is derived from the control signal received at the ICT module's **4–20 IN** terminals. This current may be used to drive an LED or operate a solid-state relay.

Table 2–2. ICT SEL Switch Settings, Model 664D

Amps	Switch Number 1	2	3	4	5	6	7	8
35 and 50	0	C	0	0	0	0	0	0
70 and 90	0	0	C	0	0	0	0	0
125	0	C	C	0	0	0	0	0
175	C	0	0	C	0	0	0	0
250	C	0	C	C	0	0	0	0
300	C	C	C	C	0	0	0	0

Note: C = Closed
0 = Open

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Table 2–3. ICT SEL Switch Settings, Model 664E

Amps	Switch Number 1	2	3	4	5	6	7	8
35 and 50	0	0	C	0	0	0	0	0
70 and 90	C	0	0	C	0	0	0	0
125	C	0	C	C	0	0	0	0
175	C	C	C	C	0	0	0	0
250	C	C	C	C	C	C	0	0
300	C	C	C	C	C	C	C	0

Note: C = Closed
0 = Open

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Push-on lugs (part number KB067427-001) suitable for 18- to 22-gauge wire are supplied with the power controller. Crimp a push-on lug to each indicator or relay wire and install the lugs on the **ICT IND** terminals in place of the **ICT IND** jumper. Be sure to observe the indicated signal polarity.

CAUTION

The ICT IND – terminal is not at common potential. The ICT IND signal must be connected to an isolated input or device.

Any LED or solid state relay that will operate on 4 mA of current may be connected to the **ICT IND** terminals. Some typical solid-state relays suitable for use in this application are listed in table 2–4.

Table 2–4. Typical Solid State Relays Suitable for Use with ICT IND Signal

Solid State Relay	Relay Application
OPTO 22 Model OAC5	12 to 140 VAC at up to 3A
OPTO 22 Model OAC5P	12 to 280 VAC at up to 3A

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2.7 LINE VOLTAGE CONFIGURATION

2.7.1 Input Module

The optional input module, if installed, uses AC power from the controller's **LINE** terminals and therefore must be configured to match the line voltage supplied to the controller.

The input module is configured for the line voltage specified at the time of purchase. If the controller is to be operated on a different line voltage, the input module must be reconfigured for the new voltage.

CAUTION

The input module may be damaged or may not operate correctly if it is not properly configured for the line voltage to which it is connected.

Voltage configuration consists of connecting one or two jumpers or a capacitor between the proper terminals on the input module. The terminals to which the jumper(s) or capacitor are connected depend on the line voltage in use. See table 2–5 and figure 2–10 for connection instructions.

Terminal lugs (part number KB067427-001) for making jumpers or for attaching to capacitor leads are supplied with the power controller.

Table 2–5. Input Module Line Voltage Configuration Connections

AC SUPPLY VOLTAGE	WHAT TO CONNECT	CONNECT BETWEEN THESE INPUT MODULE TERMINALS
208-277	Jumper	1 and 2
380-480	Jumper	2 and 3
600	Capacitor*	2 and 3

*Part Number 062864-002. Order from Research, Inc. Field Service Department

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2.7.2 Fan Assembly

The cooling fan (installed only on 175 A, 250 A, and 300 A controllers) is factory-configured for the line voltage specified at the time of purchase by installation of a capacitor. If the controller is to be operated on a different voltage, you must change the voltage-configuration capacitor. See figure 2–11 for the capacitor's location and the part number of the capacitor that must be used for each line voltage.

If you change the capacitor, check the voltage across the fan leads after the capacitor has been changed. It should be approximately 120 VAC if the proper capacitor is installed.

2.8 MODEL 664E LINE FREQUENCY CONFIGURATION

If the model 664E controller is to be connected to 50 Hz power, connect a jumper wire between the two **50 HZ JUMPER**

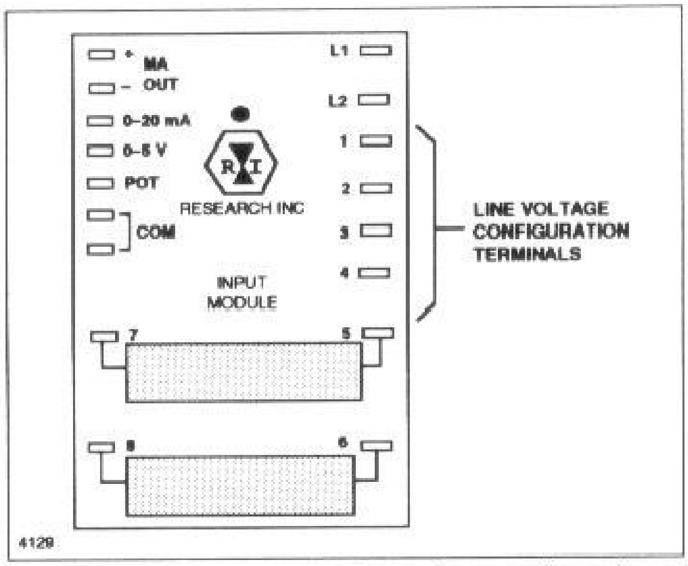
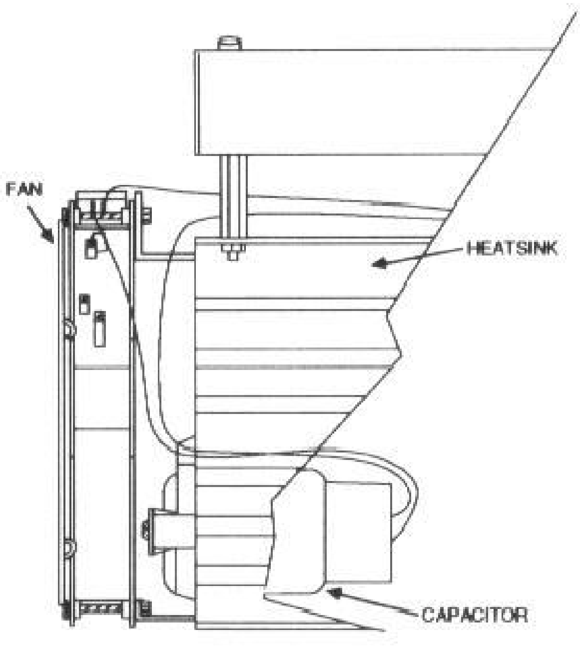


Figure 2–10. Input module line-voltage configuration terminals.

Line Voltage	Capacitor Part Number
208 VAC	KB062877-002
240 VAC	KB062877-001 and KB062865-001 *
277 VAC	KB062877-001
380 VAC	KB062878-002
415 or 480 VAC	KB062878-001
600 VAC	KB062878-003



* For 240 VAC operation, a second capacitor assembly (P/N KB062865-001) connects in parallel with the larger capacitor (P/N KB062877-001) by means of push-on connectors.

The second capacitor assembly consists of a capacitor (P/N KB062864-001), two push-on lugs (P/N KB055016-021), and lead sleeving (P/N KB055016-021).

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Figure 2–11. Fan assembly voltage configuration capacitor.

terminals on the firing circuit module (see figure 3–11). If the controller will be used on 60-Hz power, do not install the jumper.

To make a jumper, crimp two of the push-on lugs included with the controller onto the ends of a short piece of 18– to 22–gauge wire.

2.9 CONTROL SIGNAL INPUT SPAN ADJUSTMENT

CAUTION

Line frequency configuration is affected by the firing circuit module's phase calibration. Phase calibration (see section 2.9) is factory-set—user adjustment is not normally required or recommended.

WARNING

1. Hazardous voltage is present when performing the span adjustment. This adjustment should be made only by qualified service personnel.

2. Before performing the span adjustment, the controller must be completely mounted, configured, and connected as described in the preceding parts of section 2 of this manual.

A 20-turn **SPAN** potentiometer is located along the left side of the firing circuit module (see figure 3–10 for the 664D or figure 3–11 for the 664E). The **SPAN** potentiometer is factory set so that a 20 mA control signal produces full rated power output when the controller is connected to the line voltage specified in the customer order.

For most applications, no adjustment of the **SPAN** potentiometer is required. However, the user may wish to change the **SPAN** potentiometer's setting in order to:

1. Adjust the firing circuit module for a line voltage different from the value specified in the customer order.
2. Accommodate a control signal maximum value other than 20 mA.
3. Provide output limiting by adjusting the **SPAN** potentiometer's setting so the controller can deliver only the desired maximum output in response to the maximum control-signal value to be used.
4. Verify correct **SPAN** potentiometer adjustment.

The **SPAN** potentiometer adjustment procedure is as follows:

WARNING

Remove AC power from all affected equipment while making or breaking electrical connections.

1. Connect an AC voltmeter across the controller's **LOAD 1** and **LOAD 2** terminals.

2. Perform the general startup procedure described in section 5.3.
3. Connect a milliammeter as shown in figure 5–5.
4. Watching the milliammeter, set the control signal to the maximum value that will be used.
5. Adjust the **SPAN** potentiometer until the controller's output reaches the level desired for the control signal set in step 4. Turning the **SPAN** potentiometer *counterclockwise* increases the controller's output.
   A. For most applications, the desired maximum controller output level is 100 percent of the line voltage. The required control signal value for 100 percent output can be varied from 15 mA to 20 mA.
   B. To provide output limiting, set the **SPAN** potentiometer so the maximum control signal value produces less than 100 percent controller output—whatever output level is desired. When a 4–20 mA control signal is used, the controller's maximum output level can be varied from 100 percent to 80 percent.
6. Remove the milliammeter and AC voltmeter connections installed in steps 1 and 3.

NOTES

SECTION 3.

THEORY OF OPERATION

3.1 PRINCIPLES OF ZERO CROSSOVER SCR POWER CONTROL

SCR type power controllers control power by controlling when silicon controlled rectifiers (SCRs) conduct AC line current to the load

An SCR is a solid-state, electronic switching device that turns on (fires) very quickly when a low-level "gating" signal is applied its gate electrode. The timing of the gating signal, and therefore the length of time the SCRs conduct, is determined by the controller's firing circuitry in response to a control signal. The greater the percentage of time the SCRs are on, the greater the average power they allow to pass through them to the load.

During the positive half-cycle of the AC line voltage the SCR's anode is positive with respect to its cathode, so during that half-cycle the SCR will begin to conduct whenever a gating signal is applied to its gate electrode (see figure 3–1). Once turned on, an SCR will continue to conduct until its anode-to-cathode voltage drops to zero, so the SCR continues to conduct until the end of the half-cycle.

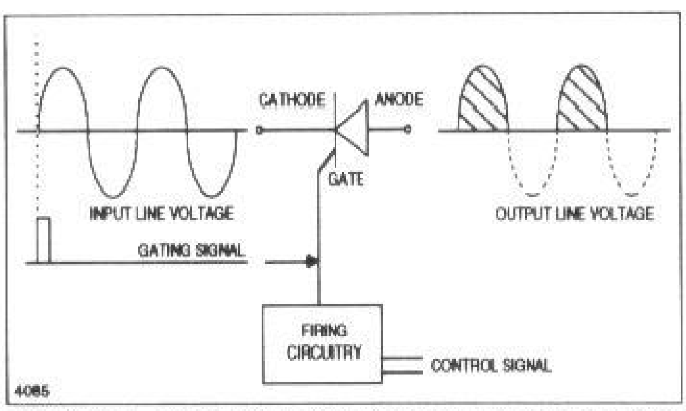

Figure 3–1. Conduction of one SCR when turned on at the beginning of a half cycle.

Because an SCR is a type of diode, it can conduct only during every other half-cycle of the applied voltage. Therefore, SCRs used to control AC power are usually installed in pairs, connected in reverse-parallel, as shown in figure 3–2. One of the SCRs then can be fired during the positive half-cycle and the other can be fired during the negative half-cycle.

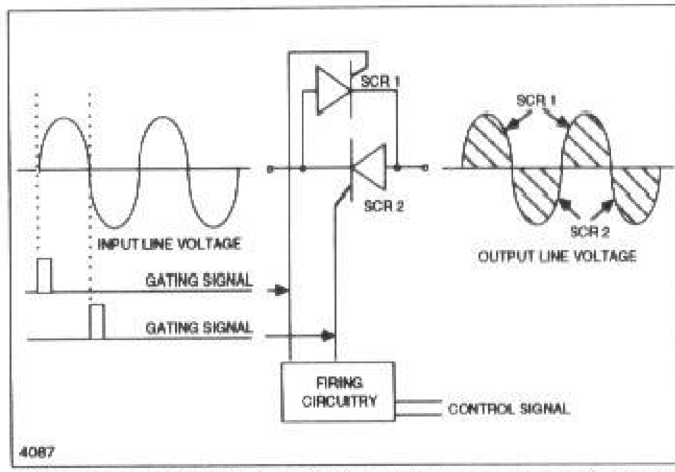

Figure 3–2. Conduction of two SCRs connected in reverse parallel when turned on at the beginning of half-cycles.

When a controller's SCRs are turned on precisely at the beginnings of the half-cycles during which it conducts, the controller is called a ***zero crossover*** type of controller, because the beginnings of the half-cycles are the times at which the voltage "crosses over" zero voltage. Use of zero crossover power control minimizes generation of electromagnetic and radio frequency interference (EMI and RFI) when the SCRs turn on.

3.2 PRINCIPLES OF DISTRIBUTED CONTROL

Model 664D and 664E power controllers control AC power by controlling the number of full cycles the controller's SCRs conduct AC line current to the load during a variable time base.

For example (see figure 3–3):

1. To deliver 25 percent power, each pair of SCRs conducts for one cycle and remains off for the next three cycles.
2. To deliver 50 percent power, each pair of SCRs conducts for one cycle and remains off for one cycle.
3. To deliver 75 percent power, each pair of SCRs conducts for three cycles and remains off for one cycle.
4. To deliver 100 percent power, each pair of SCRs conducts during all cycles.

Thus, SCR conduction is ***distributed*** as evenly as possible across time.

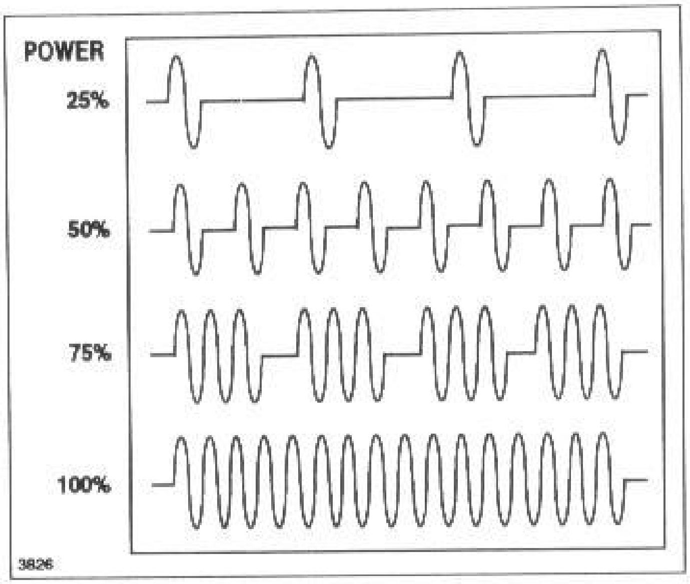

Figure 3–3. Distributed zero crossover power control.

The model 664D and 664E controllers can vary their percentage of on time over a range of 2 to 97 percent. As shown in figure 3–4, the model 664D and 664E average output voltage is linearly proportional to the level of the control signal.

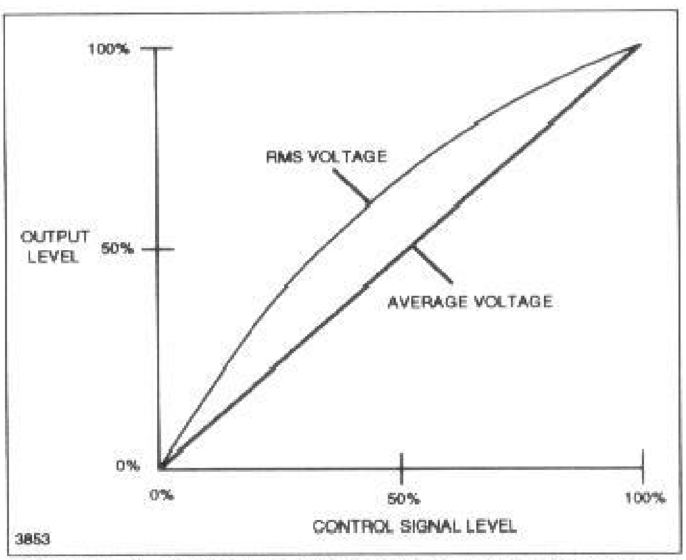

Figure 3–4. Controller output versus control signal input level.

3.3 CONTROLLER BASIC ELEMENTS

Although the 664D is a single-phase controller and the 664E is a three-phase controller, the general configuration of both units is very similar.

As shown in figure 3–5, the basic elements of a standard 664D or 664E controller consist of SCRs, which are turned on and off to control output power, and a firing circuit module, which generates the gating signals that turn the SCRs on and off. The timing of the gating signals is controlled by the level of the 4–20 mA control signal applied to the firing circuit module.

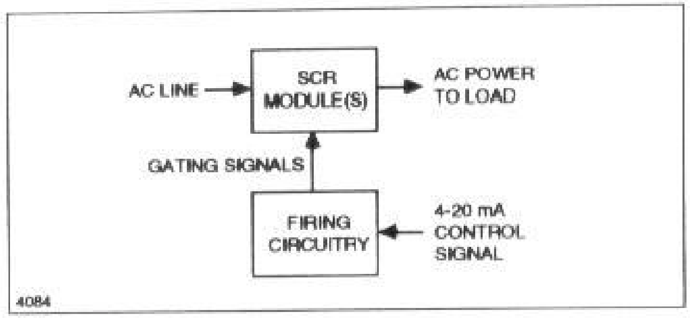

Figure 3–5. Basic elements of standard SCR controller. Firing circuit accepts only 4–20 mA control signals.

Some model 664D and 664E controllers have an optional current module (see figure 3–6), which permits use of instantaneous current trip (an alternative to subcycle fuses).

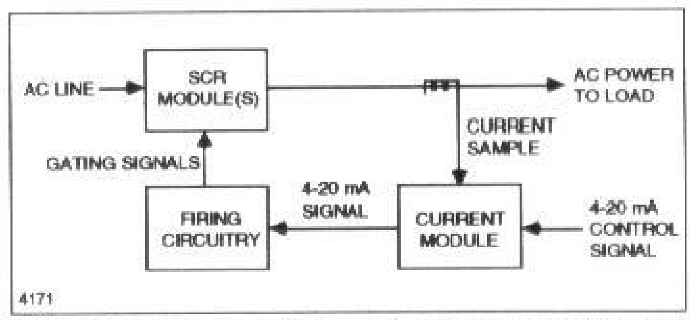

Figure 3–6. Use of current module permits use of instantaneous current trip. Current module accepts only 4–20 mA control signals.

The standard firing circuit module and the current module accept only 4–20 mA control signals. Some model 664D and 664E controllers have an optional input module (see figure 3–7), which permits manual control, by means of a potentiometer, or automatic control by either a 0–20 mA or 0–5 VDC control signal.

3.4 CONTROLLER FUNCTIONAL DESCRIPTIONS

3.4.1 SCR Modules

As shown in figures 3–8 and 3–9, the standard 664D and 664E controllers are functionally virtually identical except the 664D has only one SCR module whereas the 664E has two.

3.4.2 DV/DT Networks

A dv/dt network is connected across each SCR module to keep the firing circuit from being activated by voltage transients on the AC lines.

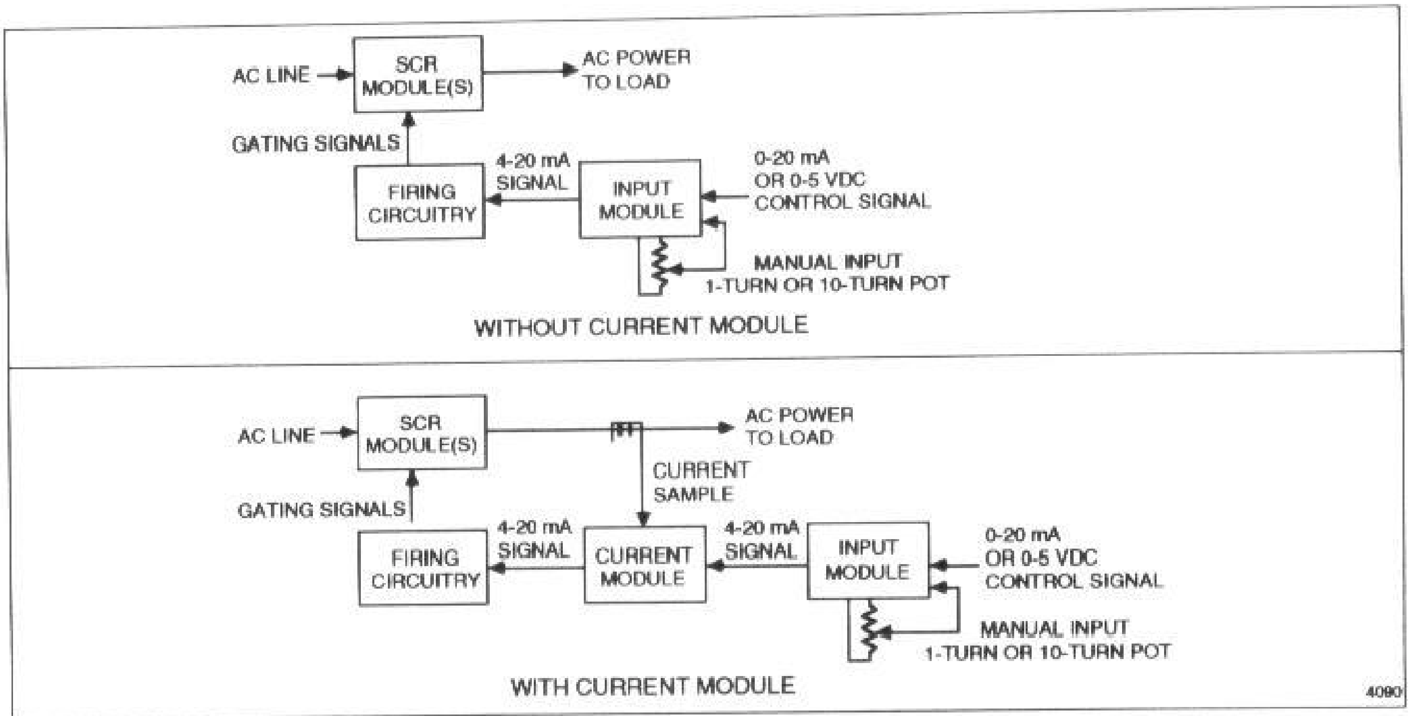

Figure 3–7. Input module permits use of 0–20 mA or 0–5 VDC control signals or manual control input from a potentiometer.

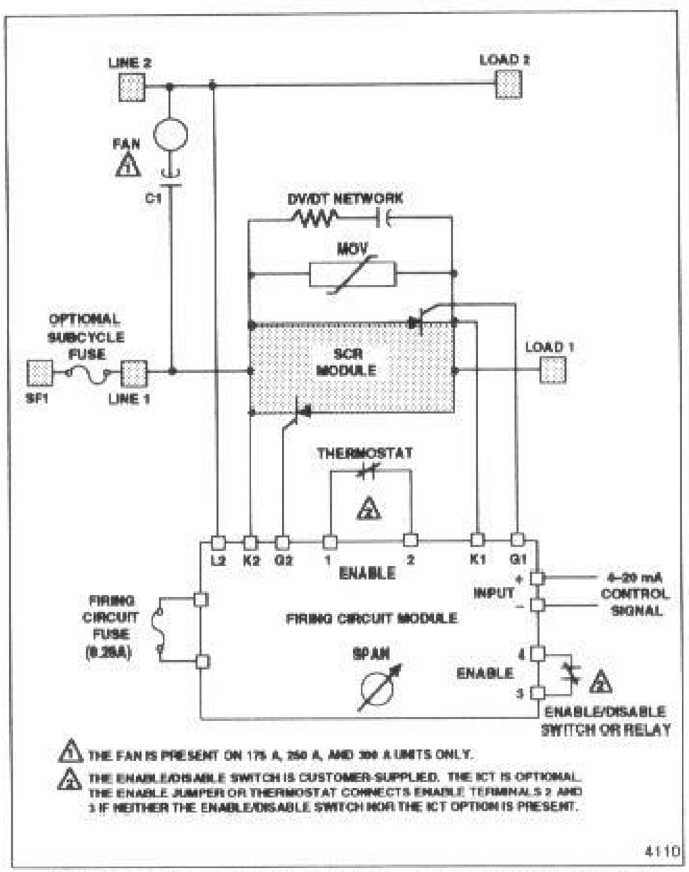

Figure 3–8. Functional diagram, standard model 664D power controller.

3.4.3 MOVs

A metal oxide varistor (MOV) also is connected across each SCR module to protect the SCRs from being damaged by high-voltage transients on the power line.

3.4.4 Optional Subcycle Fuses

The optional subcycle fuses protect the SCRs by opening within one AC cycle if excessive current is drawn by the load. Subcycle fuses are available for all model 664 controllers rated at 70 A or more. (Subcycle fuse ratings are presented in table 3–1.)

Table 3–1. Subcycle Fuse Ratings

CONTINUOUS CURRENT	I^2T
70 A	2,400
90 A	4,000
125 A	7,700
175 A	16,000
250 A	40,000
300 A	63,000

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3.4.5 Optional Failed SCR Alarm Circuit

An optional failed SCR alarm circuit is available for each SCR module in all model 664 power controllers. The SCR alarm circuit operates a set of form C relay contacts if an SCR module short-circuits or if AC line power is lost to that SCR module. Each contact pair is rated for 3 A (resistive) at 120 VAC.

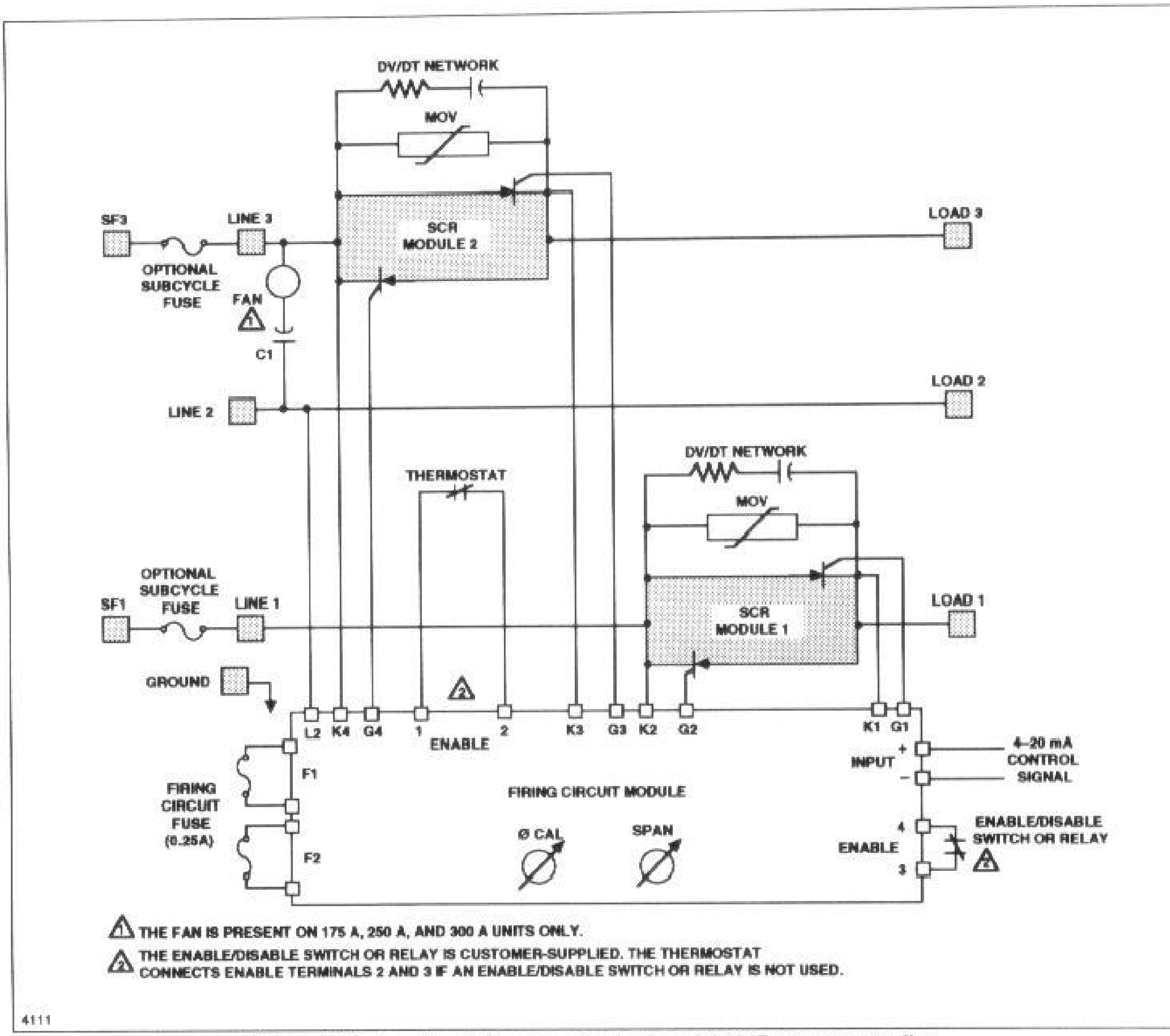

Figure 3–9. Functional diagram, standard model 664E power controller.

3.4.6 Firing Circuit Module

The SCR gating signals are generated by the controller's firing circuit module. The 664D firing circuit module (figure 3–10) provides only two gating signals (from terminals **G1/K1** and **G2/K2**), whereas the 664E firing circuit module (figure 3–11) supplies an additional pair of gating signals (from terminals **G3/K3** and **G4/K4**) to SCR module 2 (see figures 3–8 and 3–9).

The 664D firing circuit module contains a distributed zero crossover control circuit and an SCR driver circuit. The 664E firing circuit module contains a three-phase, two-leg distributed zero crossover control circuit and two SCR driver circuits (see figure 3–8 for the 664D and figure 3–9 for the 664E).

In both the 664D and 664E, the distributed zero crossover control circuit accepts a 4–20 mA control signal through the **INPUT +** and – terminals. The control circuit generates control pulses that activate the SCR driver circuit(s) (see figure 3–12 for the 664D and figure 3–13 for the 664E). Control pulses are initiated in pairs at the AC line zero crossover points, so SCR conduction is always for a full AC cycle. Each control pulse has a duration of 120 electrical degrees of the AC cycle to ensure reliable SCR firing.

The 664E firing circuit module has a **Ø CAL** potentiometer that is factory set so that the control pulses to SCR driver circuit 2 occur 120 degrees after the control pulses to SCR driver circuit 1. For 60 Hz operation (no 50 Hz jumper), the required

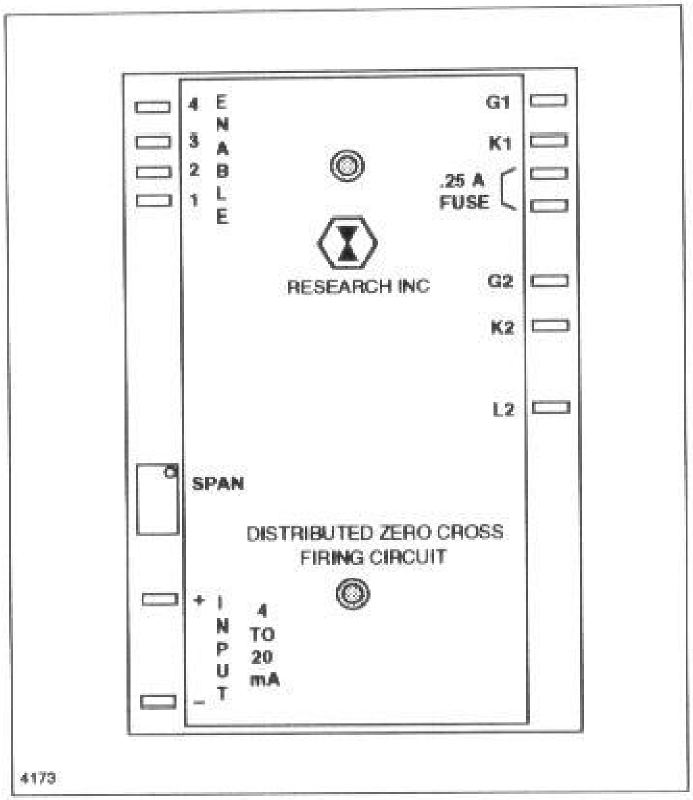

Figure 3–10. Firing circuit module, model 664D.

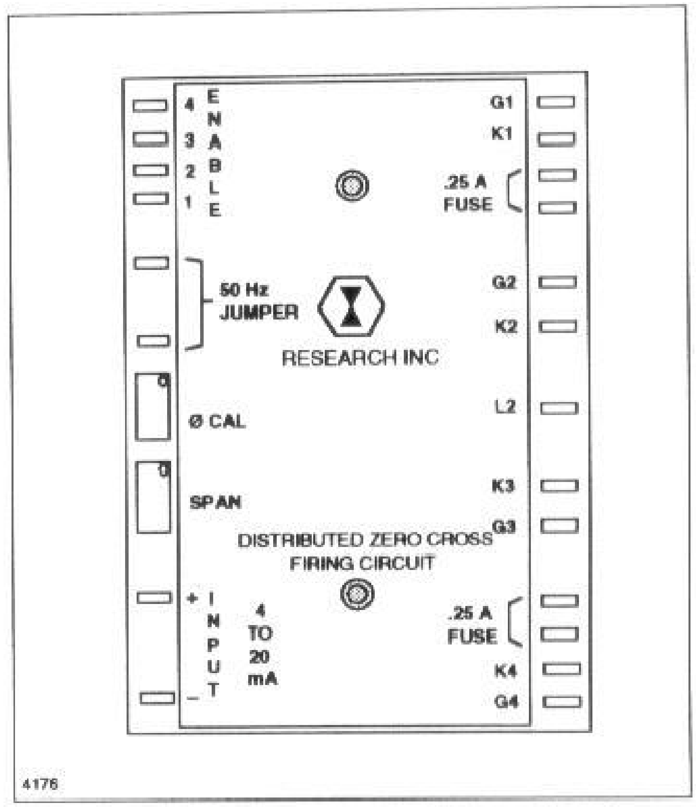

Figure 3–11. Firing circuit module, model 664E.

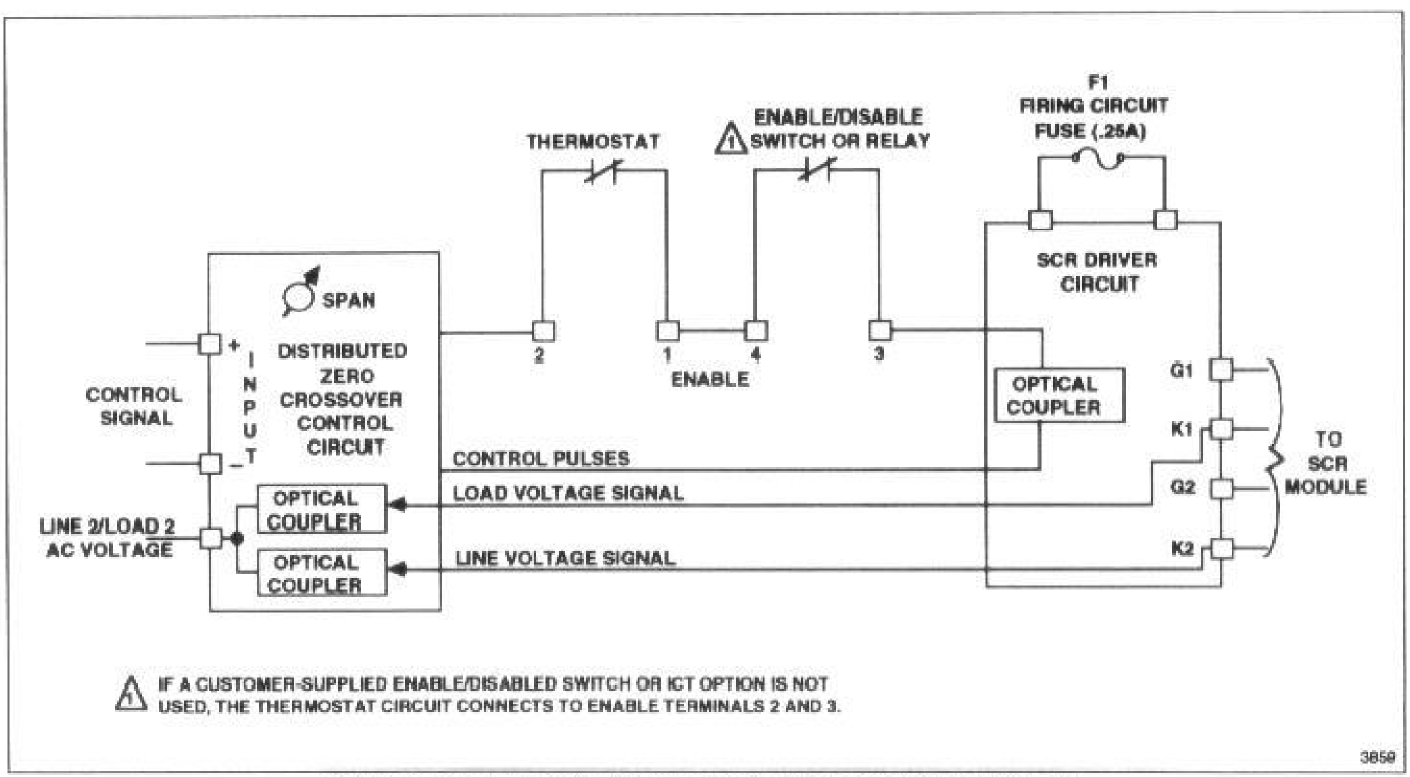

Figure 3–12. Model 664D firing circuit module functional diagram.

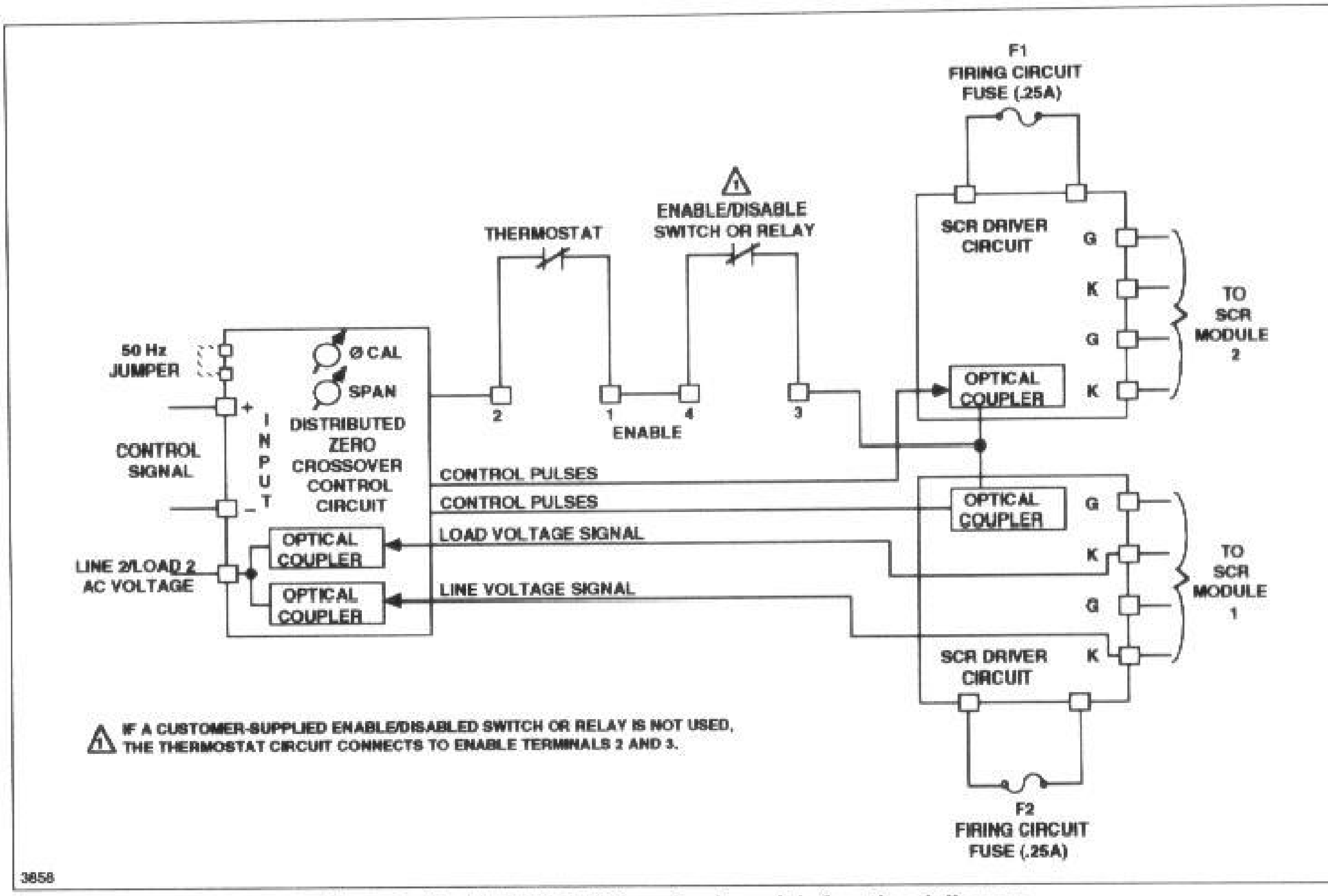

Figure 3–13. Model 664E firing circuit module functional diagram.

120-degree phase timing offset is 5.5 milliseconds. Installing a 50 Hz jumper (as described in section 2.8) lengthens the phase timing offset to 6.7 milliseconds, which corresponds to 120 degrees of a 50 Hz AC cycle.

In both the 664D and 664E, the distributed zero crossover control circuit includes a feedback circuit that monitors the average voltage across the power controller's load terminals. An optical coupler isolates the feedback circuit from the load voltage. The **SPAN** potentiometer matches the feedback circuit gain to the line voltage being used. The **SPAN** potentiometer also provides adjustment for the control signal input span by varying the control signal value that produces full output.

Operating power for the distributed zero crossover control circuit is derived from the 4–20 mA control signal through use of an internal shunt regulator. Because of the action of the shunt regulator, the converter's input impedance varies inversely with the level of the control signal, from 3000 ohms at 4 mA to 600 ohms at 20 mA. The control signal source compliance therefore must be at least 12 VDC.

An optical coupler transfers the control pulses to each SCR driver circuit. The control pulses also pass through two pairs of **ENABLE** terminals, **ENABLE 1** and **2**, and **ENABLE 3** and **4**. If used, the thermostat is factory-connected to **ENABLE** terminals **2** and **3**. If used, a customer-supplied enable/disable switch or relay is connected between **ENABLE** terminals **3** and **4** and the thermostat circuit is connected across **ENABLE** terminals **1** and **2**.

The SCR driver circuits provide gating signals for the SCR modules.

Operating power for each SCR driver circuit is derived from the AC line through the SCR cathode leads.

3.4.7 Thermostat

A normally closed, nonlatching thermostat is included with all 175 A, 250 A, and 300 A controllers. It is optional on all other controllers. If the temperature of the thermostat exceeds approximately 180°F (82°C), the thermostat opens and disables the firing circuit. When the thermostat's temperature drops to approximately 140°F (60°C), it recloses and re-enables the firing circuit. If a thermostat is factory-installed, it is connected between **ENABLE** terminals **2** and **3** of the firing circuit module. If a thermostat is not factory-installed, a jumper is factory-connected between those terminals.

3.4.8 Enable/Disable Switch or Relay

Standard 664D and 664E controllers can be turned on (enabled) and turned off (disabled) from a remote location by a switch or relay contact closure connected to terminals **3** and **4** of the firing circuit module. If the user wishes to use an enable/disable switch or relay, the thermostat or jumper connector connected to **ENABLE** terminal **3** is moved to **ENABLE** terminal **1**, and the enable/disable switch or relay is connected to **ENABLE** terminals **3** and **4** as described in section 2.6.1.

3.4.9 Cooling Fan

A cooling fan is standard on all 175 A, 250 A, and 300 A model 664 power controllers. The fan assembly is factory-configured to match the line voltage specified in the customer order but can be reconfigured for a different line voltage as described in section 2.7.2.

3.4.10 Firing Circuit Fuses

The firing circuit fuses protect circuitry in the firing circuit module against damage if an SCR fails or an SCR gate circuit opens.

3.4.11 Optional Current Module

The optional current module (see figures 3–14, 3–15, 3–16, 3–20, and 3–21) provides instantaneous current trip (ICT), which is a resettable electronic alternative to subcycle fusing. A controller that has a current module can also be equipped with subcycle fuses if desired, however.

If excessive current flows, the ICT circuit is activated and sends a signal to the firing circuit module that disables the power controller within one AC cycle.

While the ICT circuit is activated, an ICT indicator signal is also activated that can be used to operate a customer-supplied remote ICT indicator.

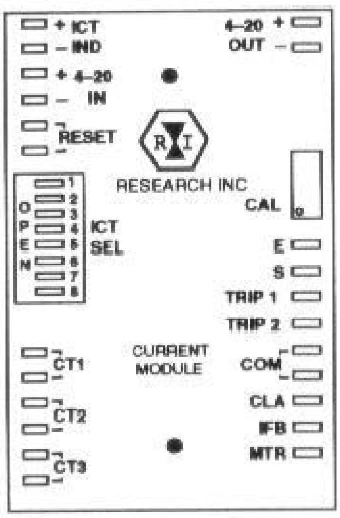

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Figure 3–14. Current module.

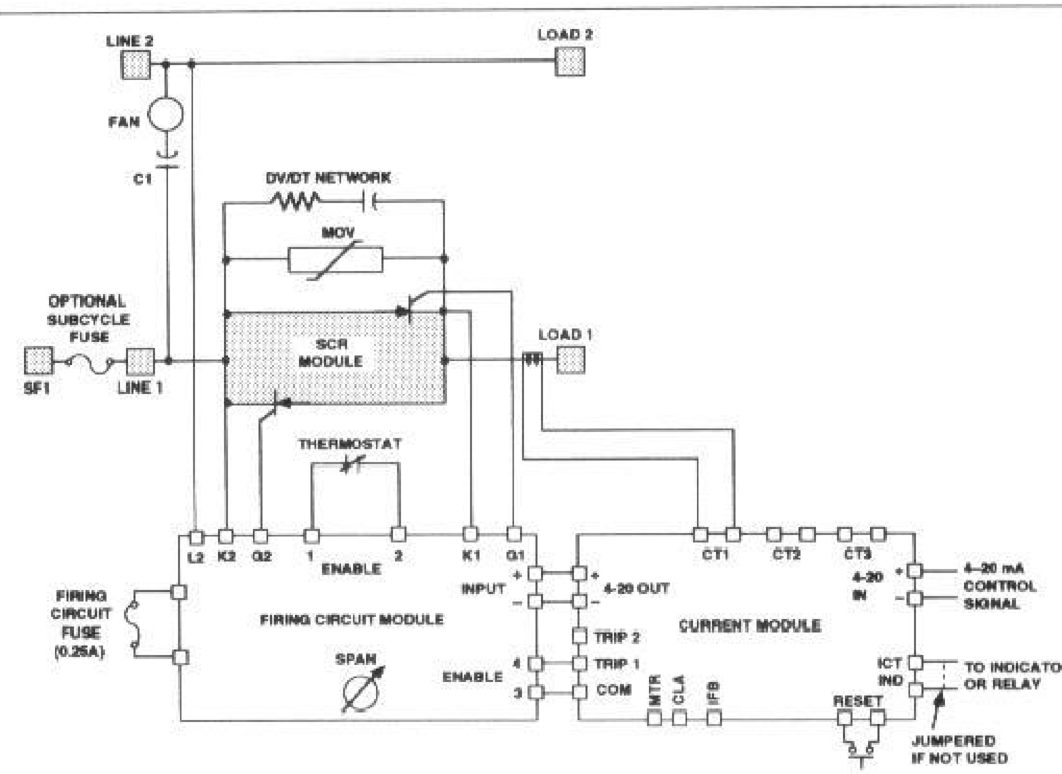

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Figure 3–15. Functional diagram, model 664D with current module.

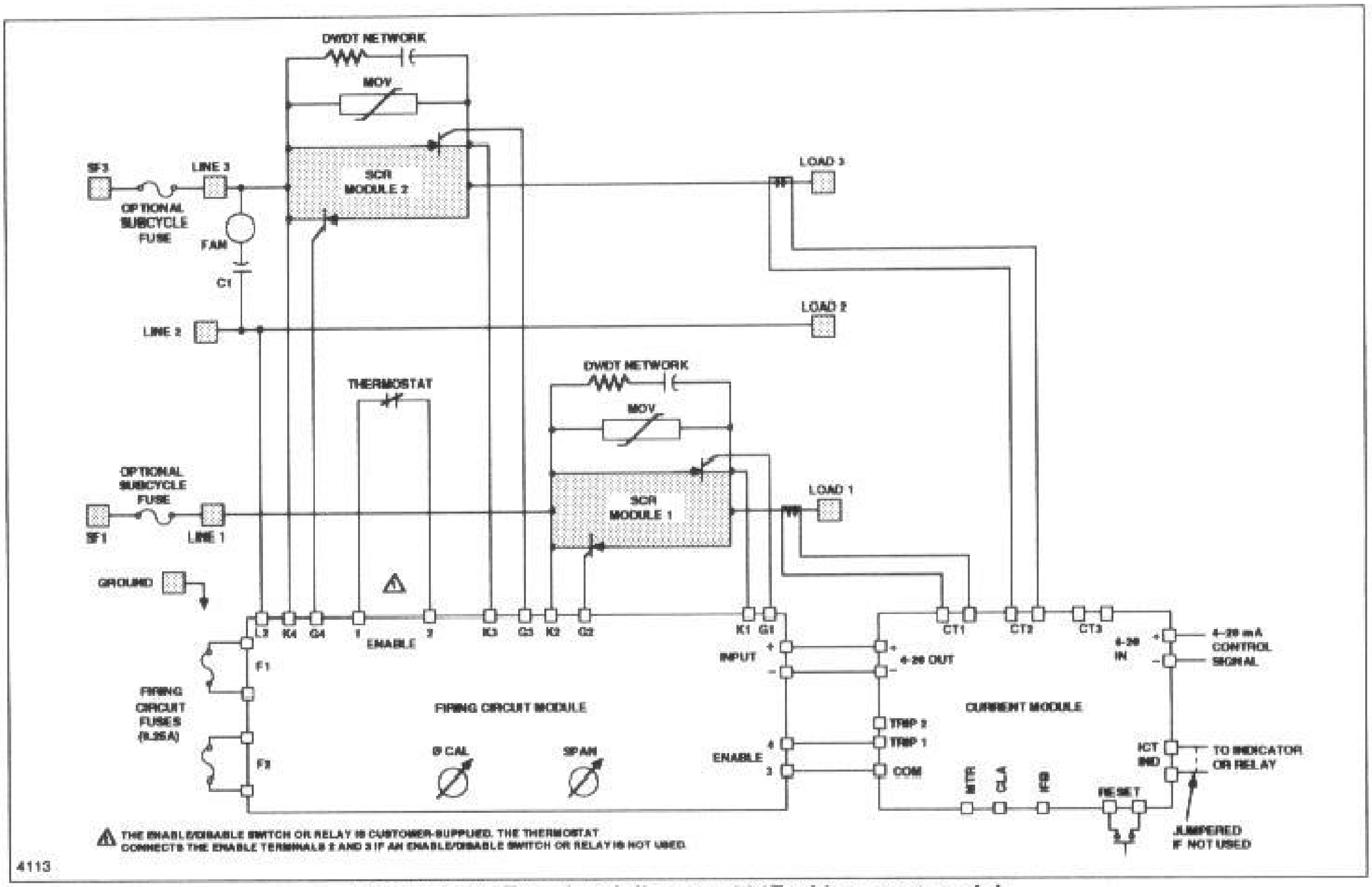

Figure 3–16. Functional diagram, 664E with current module.

Once disabled, the controller circuit remains disabled until the ICT circuit is reset. The ICT circuit is reset by closing a customer-supplied ICT reset switch or by interrupting the 4–20 mA control signal to the current module.

Procedures for using ICT are presented in section 2.6.3.

3.4.12 Optional Input Modules

The standard firing-circuit and current modules accept only 4–20 mA control signals. The optional input module (figure 3–17) makes it possible to control the model 664 controllers with a 1000 ohm, one- or 10-turn (specified when the controller is ordered) potentiometer; a 0–20 mA signal; or a 0–5 VDC signal.

The input module converts the potentiometer output or either the 0–20 mA or 0–5 VDC signal to a 4–20 mA signal, which is connected to the input terminals of the standard firing-circuit module or current module (whichever is used). See figures 3–18, 3–19, 3–20, and 3–21.

If a potentiometer is used, it is factory-installed on the controller's cover. The potentiometer's **CW** terminal is connected to the input module **POT** terminal; the **CCW** potentiometer terminal is connected to the input module **COM** terminal, and the potentiometer's wiper is connected to the input module **0–5 V** terminal. All connections are made with push-on terminals. In most circumstances, if a 4–20 mA, 0–20 mA, or 0–5 VDC signal is being used, the pot wiper must be disconnected from the **0–5 V** terminal.

Input module terminals **1**, **2**, **3**, and **4** are used to configure the input module for operation from different AC supply voltages. The configuration procedure is presented in section 2.7.1.

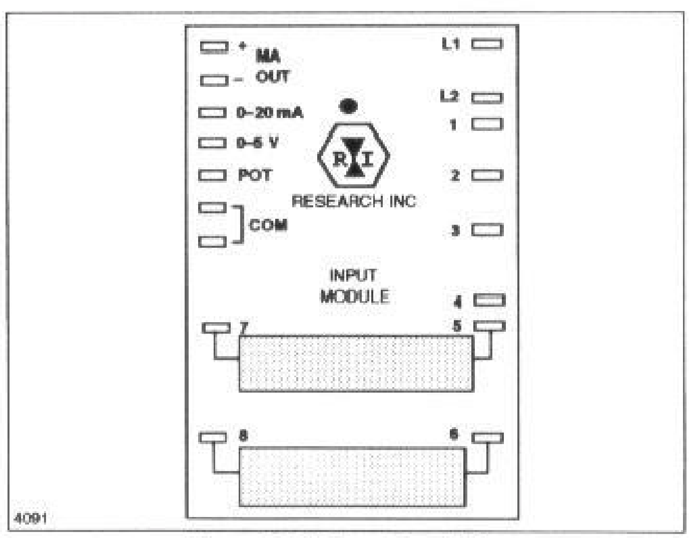

Figure 3–17. Input module.

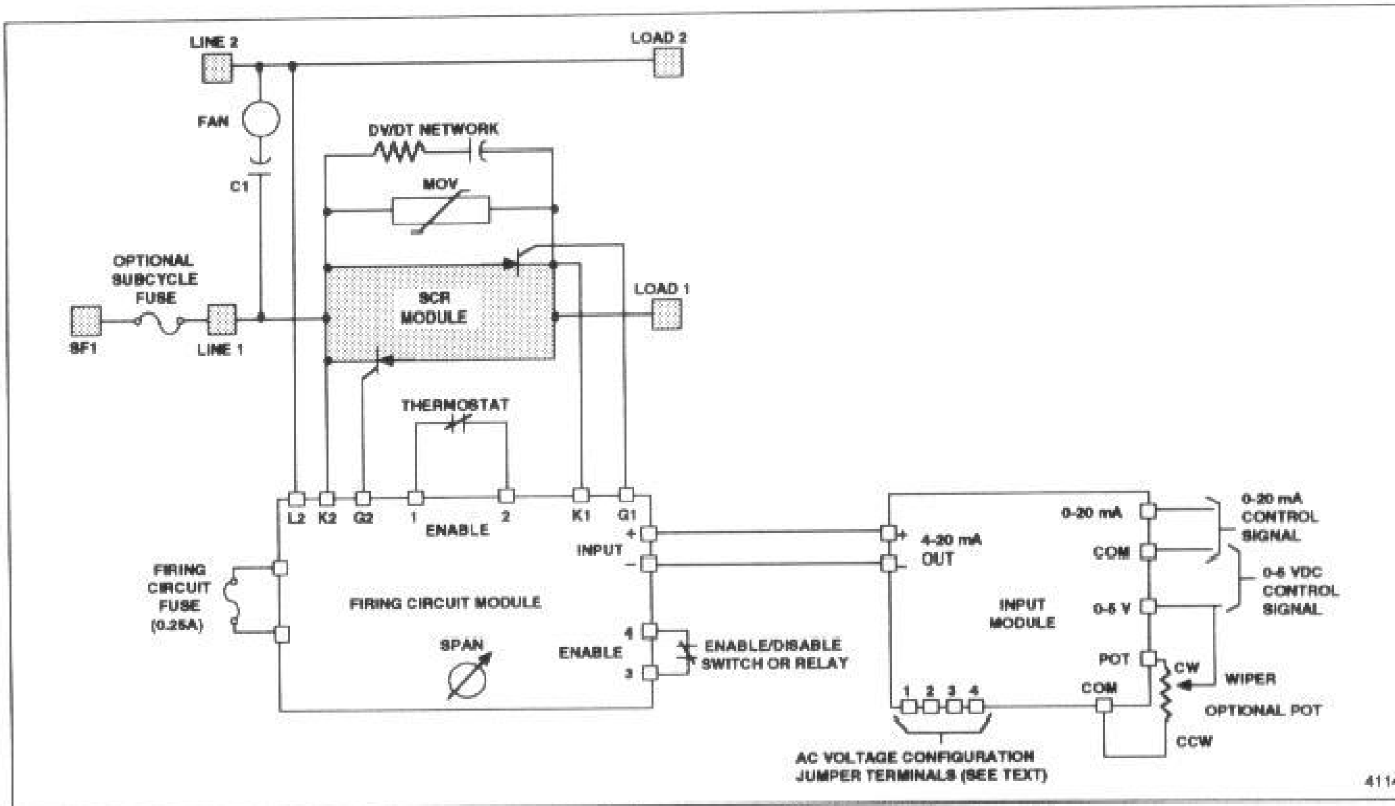

Figure 3–18. Functional diagram, model 664D with input module.

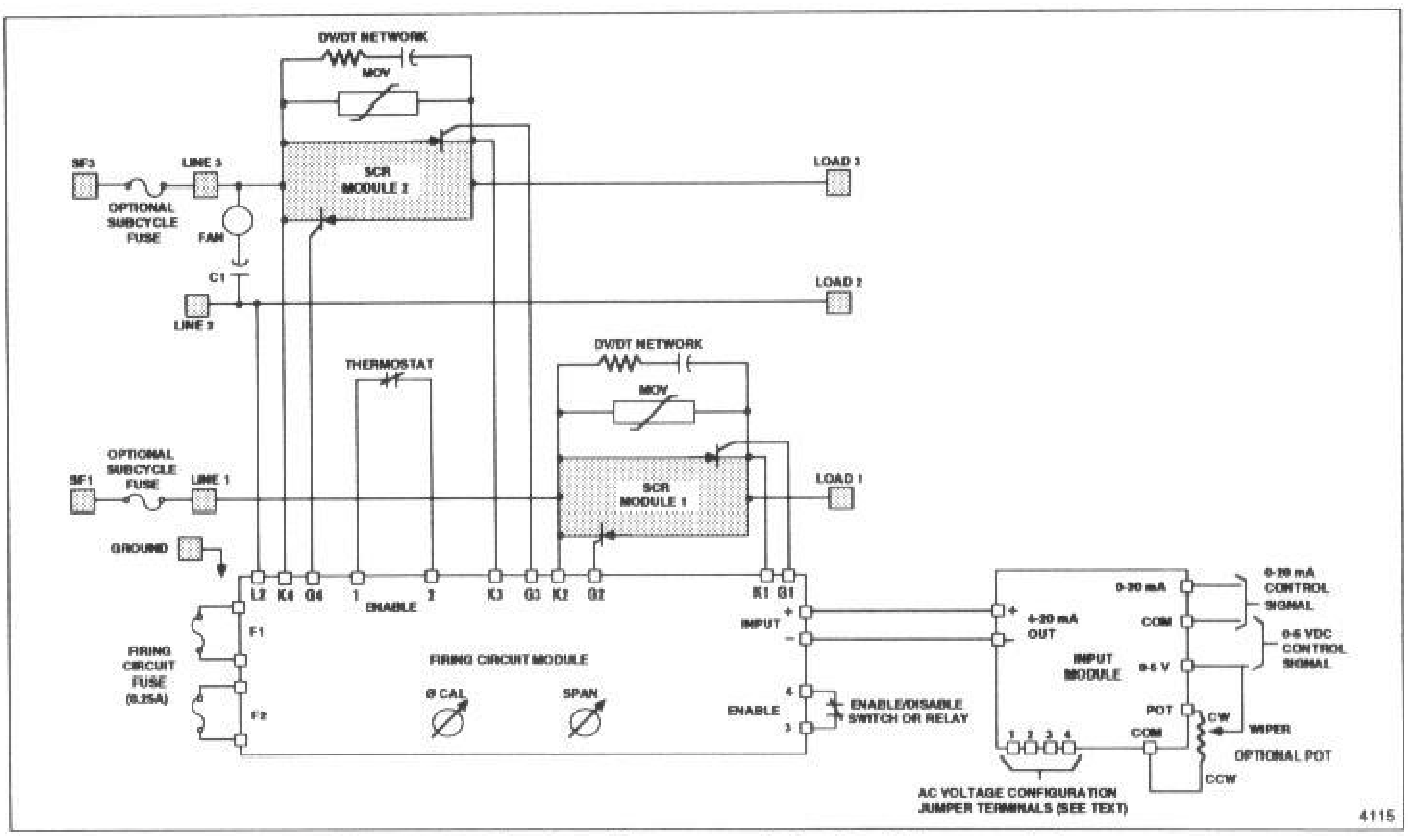

Figure 3–19. Functional diagram, model 664E with input module.

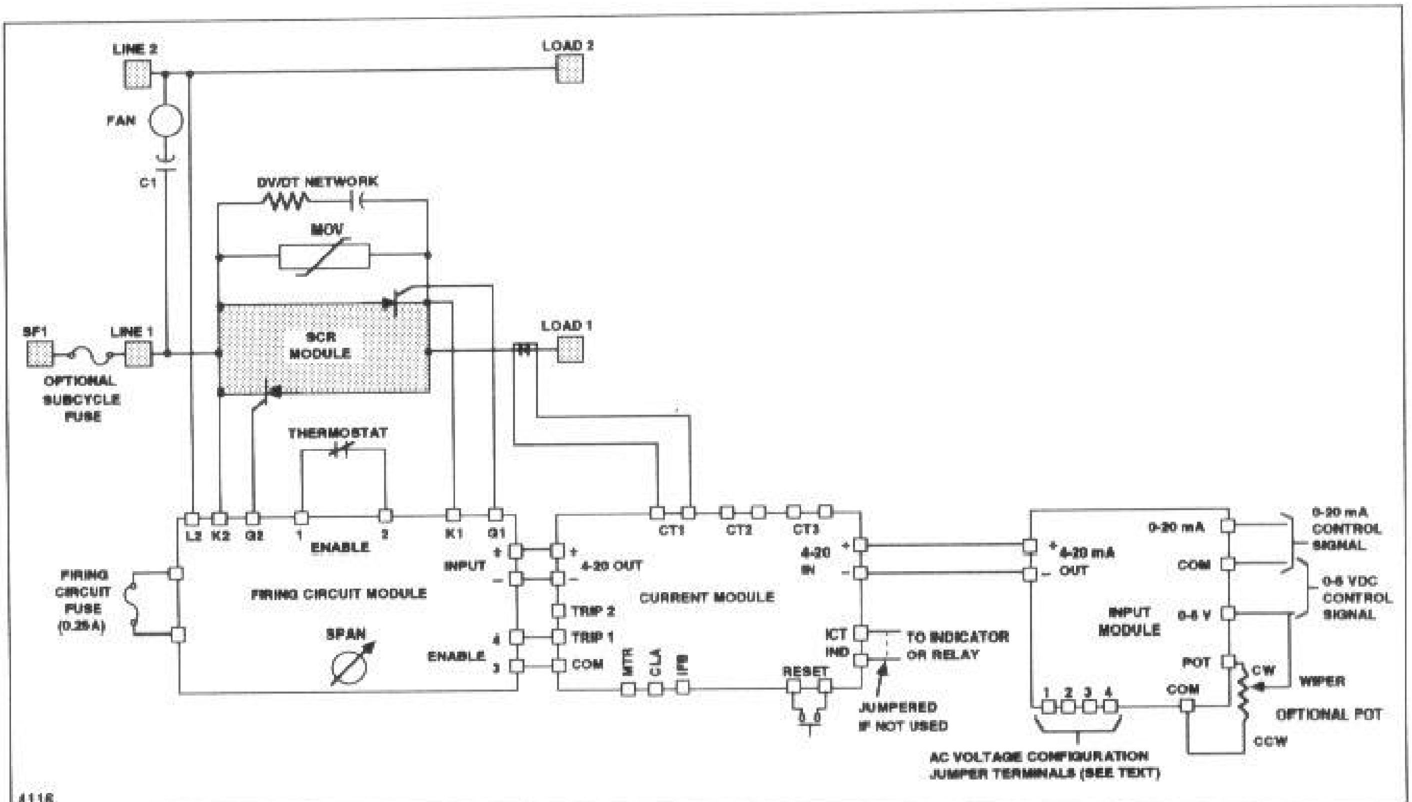

Figure 3–20. Functional diagram, model 664D with current module and input module.

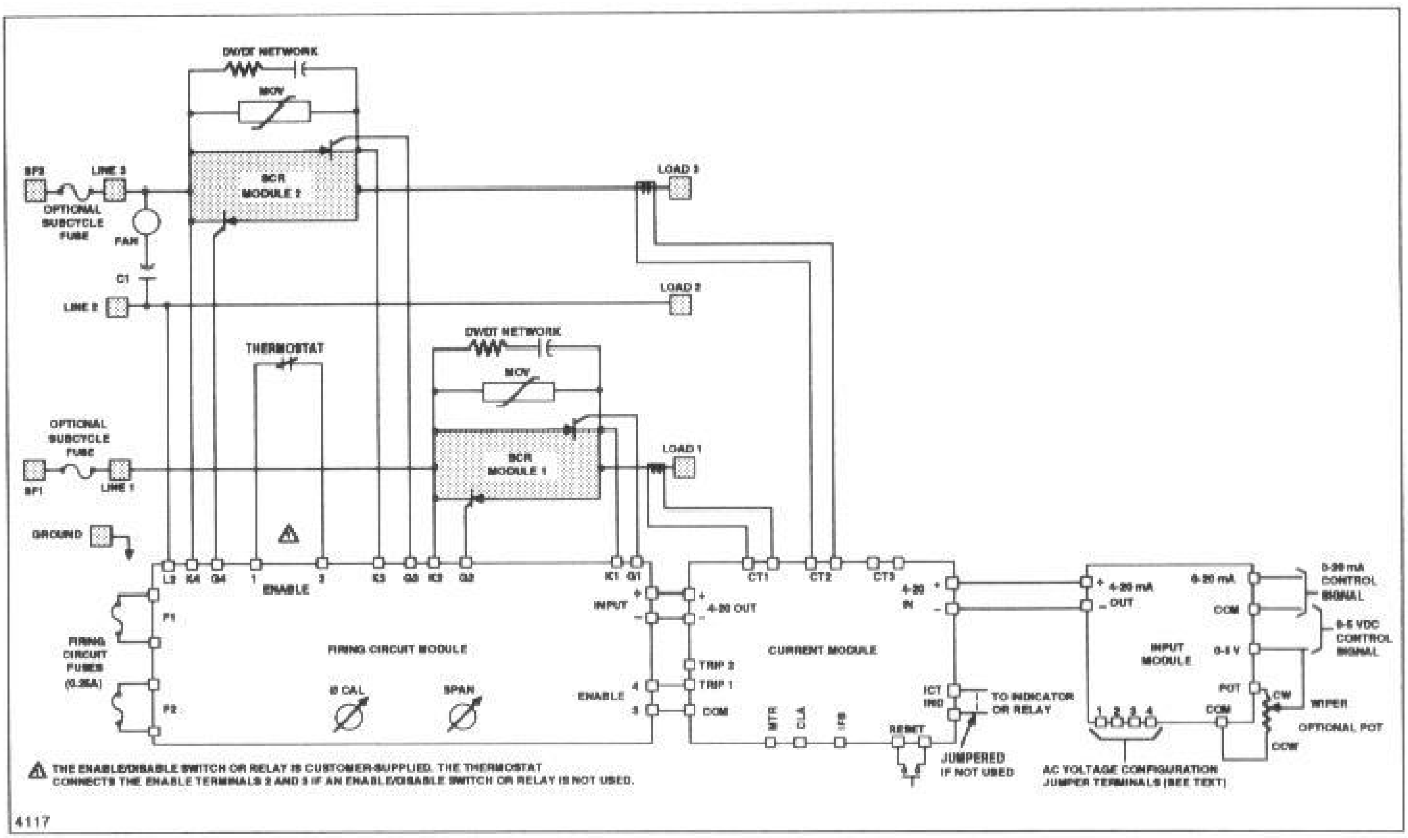

Figure 3–21. Functional diagram, model 664E with current module and input module.

SECTION 4.

OPERATION

4.1 NORMAL STARTUP

WARNING

To prevent personal injury, equipment damage, and operating problems, the model 664 power controller must be installed and configured as described in section 2, and you should read and understand all previous sections in this manual before attempting to operate the controller.

To turn on the controller:

1. Make sure line voltage is not applied to the controller's **LINE** terminals.
2. Ensure that the controller's cover is in place.
3. Set the control signal to its minimum value or set the control potentiometer (if used) to its most counterclockwise position.
4. Set the enable/disable switch (if used) to its enable position.
5. Apply AC line voltage to the controller's **LINE** terminals.

CAUTION

As long as line voltage is applied to the controller's LINE terminals, hazardous voltage remains at the Model 664 LOAD terminals even when the control signal is set to minimum or the firing circuit is disabled.

6. Gradually increase the level of the control signal or turn the control potentiometer knob clockwise from zero to the level desired. Increasing the control signal level or turning the potentiometer knob clockwise increases the controller's output level.

4.2 NORMAL SHUTDOWN

There are four ways to shut down the 664 controller normally:

1. Remove the line voltage from the controller's **LINE** terminals.
2. If the control potentiometer is in use, simply turn its knob fully counterclockwise.
3. If a control signal is used, decrease it to its minimum value.
4. If an enable/disable switch is in use, set it to its disable position.

4.3 AUTOMATIC SHUTDOWN

The 664 power controller will shut down automatically if:

1. It overheats to the temperature at which its thermostat opens.
2. The optional instantaneous current trip (ICT) circuit is installed and the controller's **LINE** current exceeds the ICT-circuit trip level.

4.4 RESTART FOLLOWING AUTOMATIC SHUTDOWN

If the controller was shut down automatically by action of the instantaneous current trip (ICT) circuit (if installed), you must press the **ICT RESET** switch to turn the controller back on again.

WARNING

If the controller shuts down automatically because overtemperature caused its thermostat to open, and if none of the four normal shutdown steps presented in section 4.2 was performed, the controller will turn on again automatically—*without warning*—when the thermostat's temperature falls to approximately 140°F (60°C).

NOTES

SECTION 5.

MAINTENANCE AND REPAIR

5.1 ROUTINE MAINTENANCE

The model 664D and 664E controllers require very little routine maintenance. The only moving part is the fan (present only on 175 A, 250 A, and 300 A controllers), and it is permanently lubricated. Remove dirt or dust accumulations frequently. Check for damaged wiring and loose connections occasionally and whenever any connections are changed. No other routine maintenance is required.

5.2 INTRODUCTION TO GENERAL CHECKOUT PROCEDURE

Use the checkout procedure to check the controller for proper operation before placing it in operation following initial installation and as an aid to troubleshooting the controller for maintenance purposes.

Before you perform the checkout procedure, the controller must be completely installed in its normal operating configuration. A multimeter providing AC voltmeter, DC ammeter, and ohmmeter functions is also required.

WARNING

1. Hazardous voltages are present at the controller's LINE and LOAD terminals and within the controller's chassis. Disabling firing circuit operation or setting the control signal to minimum does not eliminate these hazardous voltages.

2. Always remove AC line voltage from the controller before making contact with internal assemblies, line or load wiring, or any other areas where hazardous voltages may be present. Also remove AC line voltage from the controller before making connections, equipment changes, or resistance measurements.

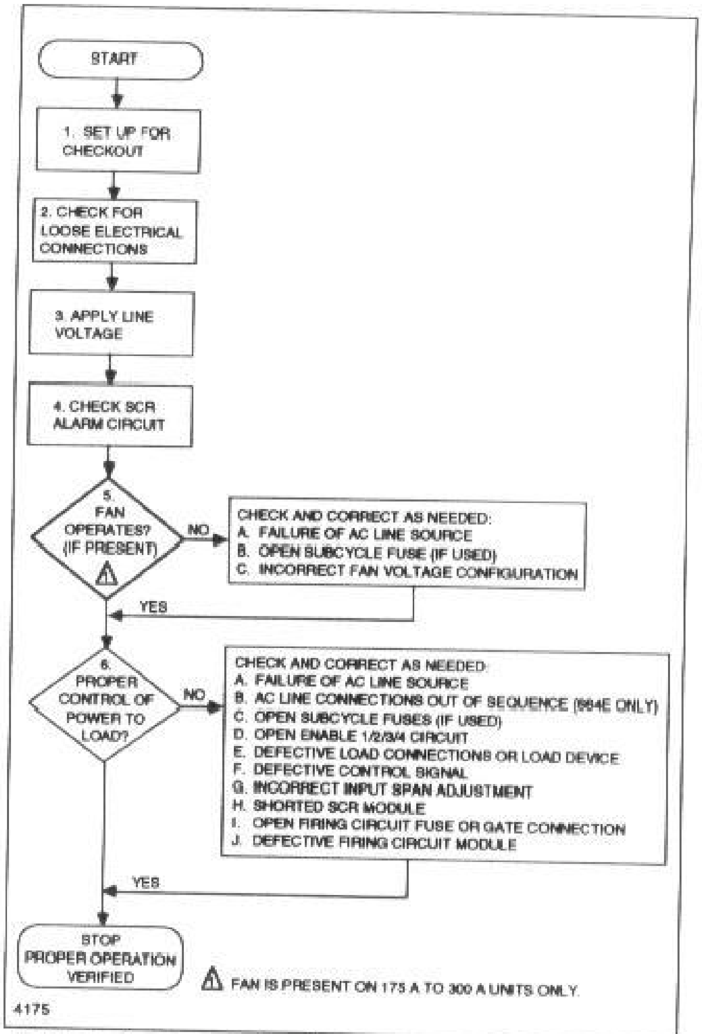

Figure 5–1. General checkout procedure, model 664D and 664E power controllers.

5.3 GENERAL CHECKOUT PROCEDURE

5.3.1 Step 1—Set Up Controller for Checkout

Set up the controller for checkout as follows (see figure 5–1):

1. Set the control signal to minimum.
2. Set the enable/disable switch (if used) to enable.

5.3.2 Step 2—Check for Loose Electrical Connections

1. Remove line voltage from the controller and check that all firing circuit and SCR module lugs are fully seated on their terminals.
2. Check that the line, load, and ground wiring is tightly fastened to the **LINE**, **LOAD**, and **GROUND** terminals.

5.3.3 Step 3—Apply AC Line Voltage to the Controller's LINE Terminals

Turn on the main power switch or circuit breaker to apply AC line voltage to the controller's **LINE** terminals.

5.3.4 Step 4—Check the Optional SCR Alarm Circuit

Check the optional SCR alarm circuit (if installed) as follows:

1. If an alarm indicator has been connected to the controller's SCR alarm circuit, check the indicator to determine whether the SCR has shorted.
2. If an alarm indicator has not been connected to the controller's SCR alarm circuit, measure the resistance between the main circuit board's **N/O** and **COMMON** terminals with an ohmmeter. If the measured resistance is zero (or approximately zero) ohms, the SCR is OK. If the measured resistance is higher than approximately zero ohms, the SCR is defective and should be replaced (see section 5.6.1 for replacement procedure).

5.3.5 Step 5—Check Fan Operation (175–300 Amp Controllers Only)

On 175 A, 250 A, and 300 A controllers, check the operation of the fan. The fan should start when line voltage is applied to the controller. If the fan does not start or if it seems to run too slow or fast, check for the following:

1. Failure of the AC line source(s). Measure the voltage across the **LINE 1** and **LINE 2** terminals if a 664D controller and across the **LINE 2** and **LINE 3** terminals if a 664E controller. If the correct voltage is not present, check the AC line source for a tripped circuit breaker or other fault.
2. Open subcycle fuse(s) (if installed):

WARNING

1. Remove the line voltage from the controller before making resistance checks.

2. Inspect for damaged wiring or components before replacing the fuse.

Measure the resistance across the subcycle fuse(s). Replace any fuse found to be open (see section 5.6.4 for replacement procedure).

3. Incorrect fan voltage configuration. Check the voltage across the fan leads. It should be approximately 120 VAC. If it is not approximately 120 VAC, check whether the correct voltage-configuration capacitor is installed on the fan assembly (see section 2.7.2).

5.3.6 Step 6—Check for Proper Control of Output to the Load

5.3.6.1 Introduction

Connect a load device across the controller **LOAD** terminals, as shown in figure 5–2 (for 664D) or 5–3 (for 664E).

Vary the level of the control signal while monitoring the controller's output to the load. Measure the voltage across each

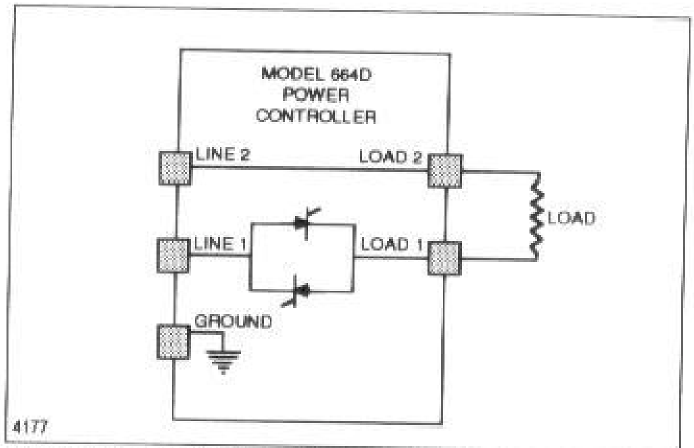

Figure 5–2. Load connections for 664D power controller.

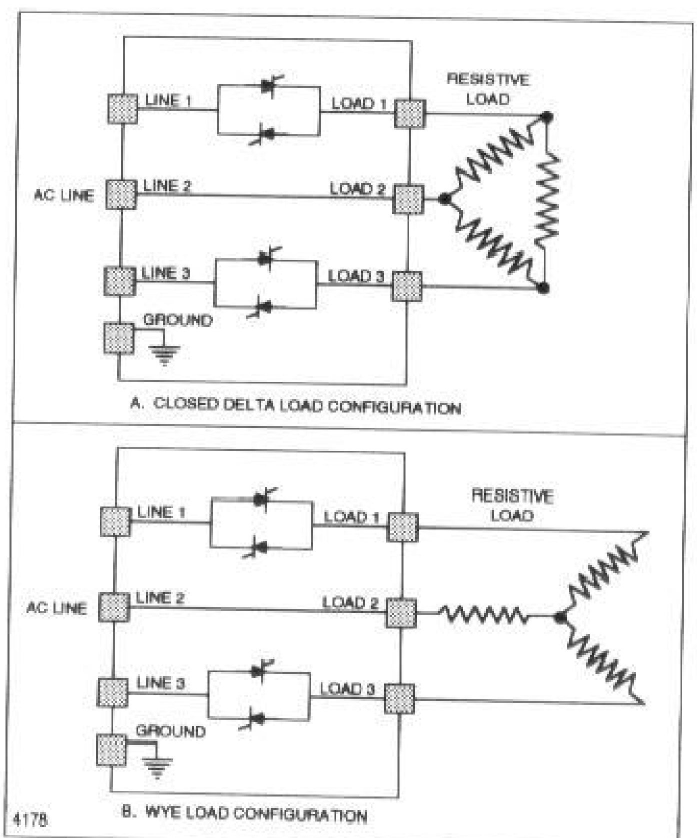

Figure 5–3. Load connections for 664E power controller.

pair of **LOAD** terminals with an AC voltmeter. Also observe the load device to ensure that power is being received properly.

The power to the load should vary smoothly across the full output range being used. If it does not, perform the checks described in the following subsections of section 5.3.6.

5.3.6.2 Step 6A—Check AC Line Source

Measure the voltage across the **LINE** terminals with an AC voltmeter. If the correct voltage is not present, check the AC line source for a tripped circuit breaker or other fault.

5.3.6.3 Step 6B—Check AC Line Connections

If the controller is a model 664E and its output level jumps suddenly as the level of the control signal is increased, the AC line connections may be out of sequence.

1. Remove line voltage from the controller.
2. Reverse any two connections to the **LINE** terminals.
3. Reapply line voltage.
4. If proper power control is achieved, retain the new connections. Otherwise, restore the connections as they were previously and continue with this checkout procedure.

5.3.6.4 Step 6C—Check Subcycle Fuse(s)

Measure the resistance across each subcycle fuse. Replace any fuse that is open (see section 5.6.4 for replacement procedure).

5.3.6.5 Step 6D—Check the ENABLE 1/2/3/4 Circuit

Check whether the **ENABLE** terminals **1**, **2**, **3**, and **4** circuit is open as follows:

1. Remove line voltage from the controller and disconnect one of the control signal leads from the **INPUT** + and – terminals of the firing circuit module (see figure 5–4A or 5–4B).
2. Check the **ENABLE** terminals **1**, **2**, **3**, and **4** circuit as follows:
   A. If only the **ENABLE 2** and **3** terminals are used (see figure 5–4A), check for an open **ENABLE** jumper, ICT circuit, or thermostat circuit by measuring the resistance between **ENABLE** terminals **2** and **3**.
   B. If all four **ENABLE** terminals are used (see figure 5–4B), check for an open circuit between **ENABLE** terminals **1** and **2** (**ENABLE** jumper or thermostat circuit) and between **ENABLE** terminals **3** and **4** (enable/disable switch or ICT option).
   C. Check all wiring terminations for tightness and good electrical contact.
   D. Check all wiring for continuity.

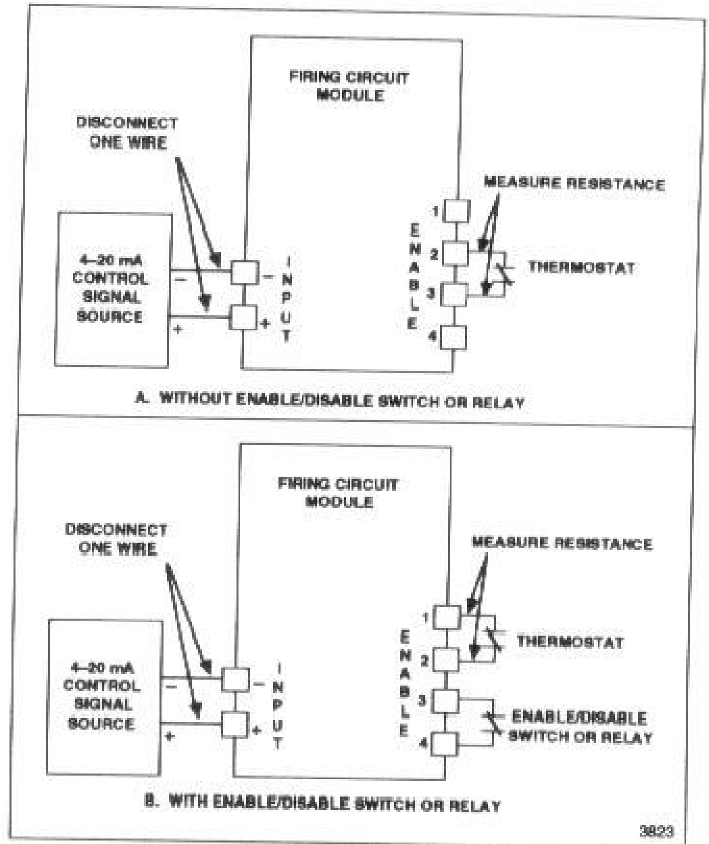

Figure 5–4. Thermostat circuit check.

   E. Check the thermostat for proper operation. If the thermostat circuit is open and the controller was in operation recently, the heatsink may be overheated to the point the thermostat has opened. Allow sufficient time for the heatsink to cool to its normal operating temperature. If the thermostat is operating properly, it will reclose when its temperature reaches approximately 140°F (60°C). If the thermostat does not reclose properly, replace it (see section 5.6.5 for procedure).

If a malfunction is found in the ICT circuit, replace the current module (see section 5.6.6 for procedure).

If the customer-supplied enable/disable switch is open, replace it.

5.3.6.6 Step 6E—Check Load and Load Connections

Check the load and load connections as follows:

1. Remove the line voltage from the controller.
2. Disconnect the load's wiring from the controller's **LOAD** terminals.
3. Using an ohmmeter, check the load and load wiring for damage or failure.

5.3.6.7 Step 6F—Check the Control Signal

1. Verify that a control signal of the correct polarity and level is reaching the firing circuit **INPUT** + and − terminals. To do so:
   A. Disconnect the sensor (thermocouple, etc.) or other normal control-signal source, and in its place connect a source that can provide a test signal of the proper type (voltage or current) and level.
   B. Using a milliammeter (see figure 5–5) verify that a 4–20 mA control signal of the proper level and polarity is reaching the firing circuit's **INPUT** − and + input terminals. Be sure to check for reversed control signal polarity and for open or intermittent connections caused by loose or damaged wiring.
2. Repair or replace the control signal source or wiring as needed.

NOTE

Be sure to reconnect the control-signal source, observing proper polarity, after you finish this step.

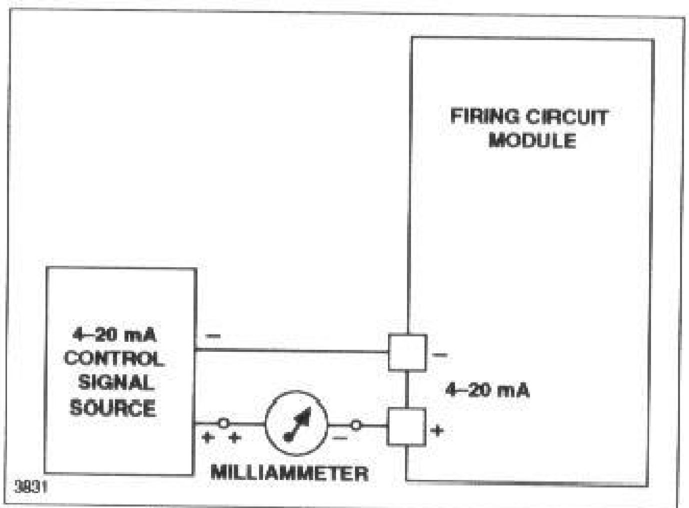

Figure 5–5. Control signal check.

5.3.6.8 Step 6G—Check Input SPAN Potentiometer

Verify that the control signal **SPAN** potentiometer is set correctly, as described in section 2.9.

5.3.6.9 Step 6H—Check SCR Module

Check for a shorted SCR module as follows:

1. Remove line voltage from the controller.
2. Measure the resistance between the **LINE** terminal and **LOAD** terminal of each SCR module in both directions (i.e., measure the resistance once and then reverse the meter leads and measure the resistance again).

Replace any SCR module (see section 5.6.1 for replacement procedure) for which the resistance reads zero ohms in either measurement.

5.3.6.10 Step 6I—Check Firing Circuit Fuses and Gate Connections

Check for an open firing circuit fuse or open gate connection, as follows:

CAUTION

To ensure that ohmmeter current does not blow a fuse, do not set the ohmmeter to its lowest range.

1. Remove the line voltage from the controller.
2. Using an ohmmeter, measure the resistance across each firing circuit fuse. If a firing circuit fuse is open, also check for an open or intermittent gate connection to the SCR module. An open gate connection will cause the firing circuit fuse to blow. If a firing circuit fuse blows repeatedly and its SCR's gate connections have been verified, an SCR in the SCR module associated with that fuse has failed in the open condition. Replace that SCR module (see section 5.6.1 for replacement procedure).

5.3.6.11 Step 6J—If the Problem Still Exists

If the power control problem still exists, replace the firing circuit module (see section 5.6.3 for replacement procedure).

5.4 ICT CIRCUIT CHECKOUT PROCEDURE

The purpose of this checkout procedure is to determine the cause if the ICT circuit in the current module (figure 5–6) trips improperly or cannot be reset.

Before beginning the ICT circuit checkout procedure, confirm that the problem is not elsewhere by performing the general checkout procedure presented in section 5.3. If that does not isolate the problem, perform the ICT circuit checkout procedure.

The ICT circuit's **TRIP 1** signal connects to the firing circuit module's **ENABLE 3** and **4** terminals. When ICT action is activated ("tripped"), the ICT circuit opens the connection between the **TRIP 1** and **COM** terminals. To identify the status of the ICT circuit, measure the DC voltage between the ICT **TRIP1** and **COM** terminals. If the ICT is tripped, the **TRIP 1** terminal measures +6.5 to +7.5 VDC with respect to the **COM** terminal. If the ICT is not tripped, the **TRIP 1** terminal is at the same potential as the **COM** terminal.

NOTE

Because the ICT circuit is powered by the milliampere control signal connected to the 4–20 IN terminals, interrupting the control signal deactivates ICT action.

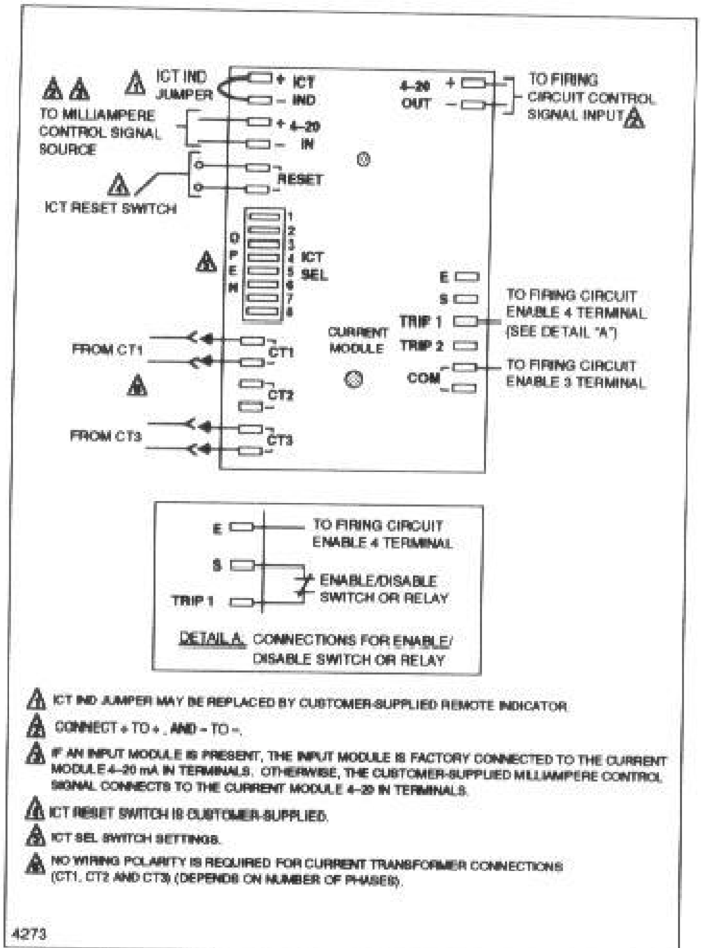

Figure 5–6. Current module connections.

To determine whether the ICT circuit is defective:

1. Ensure that the **ICT SEL** switches are set properly.
2. Check for loose or damaged wiring to or from the current module.
3. Ensure that the AC wiring is routed correctly.
4. Ensure that the ICT reset switch circuit is not closed or shorted.

If the module switch settings and electrical connections have been verified and the ICT circuit trips improperly or cannot be reset, replace the current module (see section 5.6.6 for replacement procedure).

5.5 INPUT MODULE CHECKOUT PROCEDURE

The purpose of this checkout procedure is to determine the cause if the input module (figure 5–7) does not appear to operate properly.

Before beginning the input module checkout procedure, confirm that the problem is not elsewhere, as follows:

1. Perform the general checkout procedure presented in section 5.3.

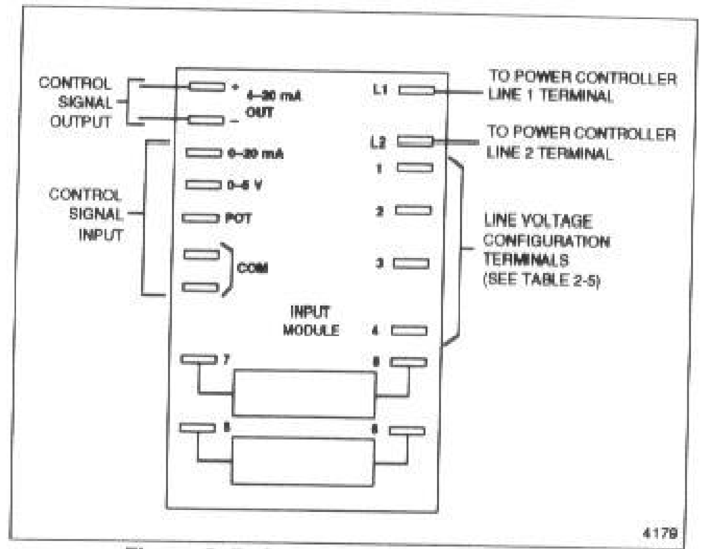

Figure 5–7. Input module connections.

2. Check for reversed signal polarity at each control signal connection.
3. Check for loose or damaged wiring to and from the input module.

If necessary, repair or replace the control signal source and any connections to the input module as needed.

If the preceding steps do not isolate the problem, proceed with the input module checkout procedure as follows:

1. Check for correct input module line voltage configuration (see section 2.7.1).
2. Using an AC voltmeter, verify that line voltage is present at the input module's **L1** and **L2** terminals (see figure 5–8).
3. Using a DC voltmeter or milliammeter (whichever is appropriate for the type of control signal being received), verify that the correct control signal is present at the input module terminals.

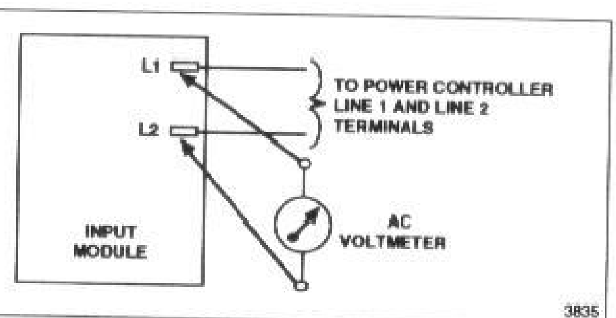

Figure 5–8. Input module line voltage verification.

4. Using a milliammeter (see figure 5–9), verify that the correct 4–20 mA output signal is produced at the input module's **4–20 mA OUT** terminals when signal inputs from each of the signal input configurations shown in figure 5–10 is applied to the input terminals of the input module.

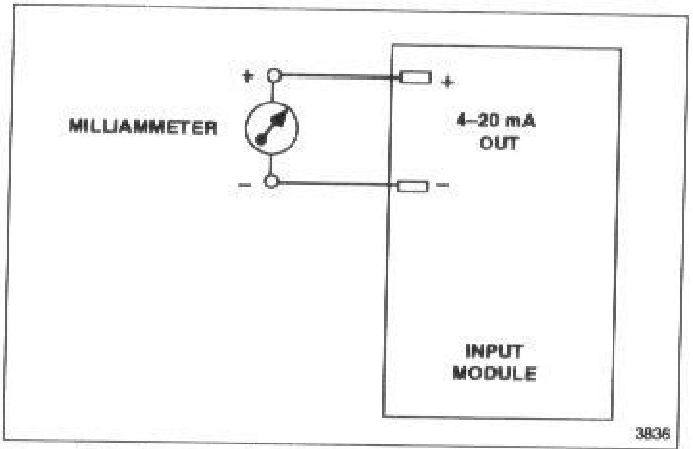

Figure 5–9. Input module 4–20 mA OUT signal verification.

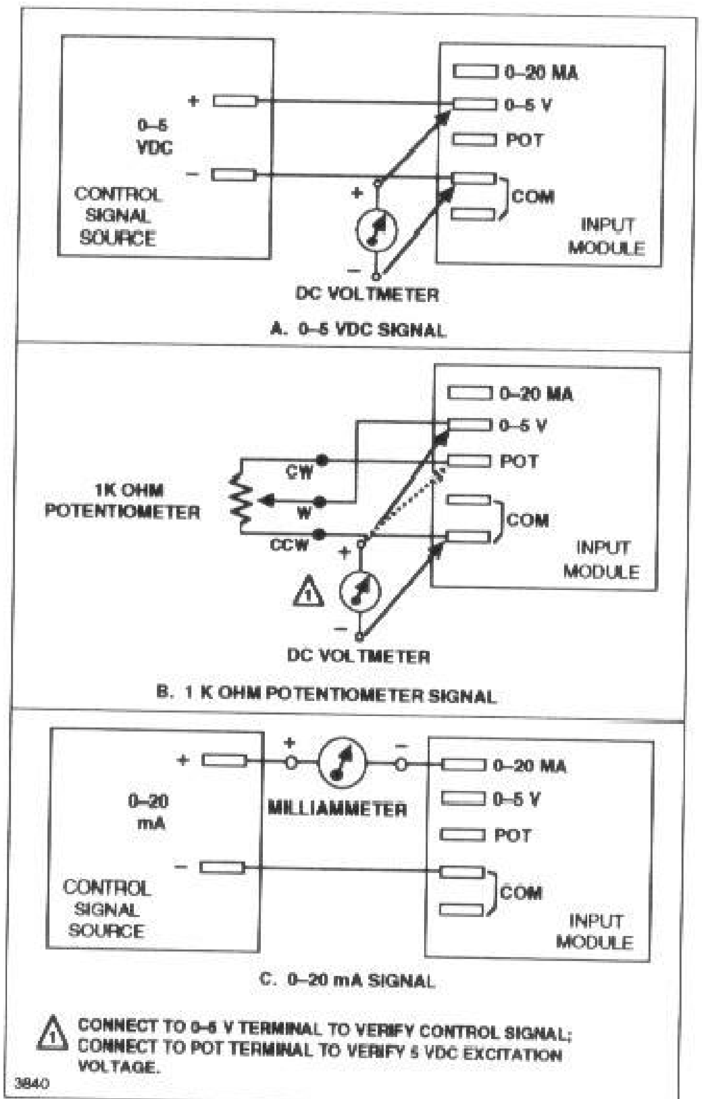

Figure 5–10. Input signal verification.

If the input module does not produce the correct **4–20 mA OUT** signal when its input signal, line-voltage connections, and line voltage configuration have been verified, replace the input module (see section 5.6.7 for replacement procedure).

5.6 REPLACEMENT PROCEDURES

5.6.1 SCR Modules

To replace an SCR module (see table 5–1 for part number):

1. Remove line voltage from the controller.

Table 5–1. Replacement SCR Modules

CONTINUOUS CURRENT RATING	PART NUMBER
35 A	KB062802-003
50 A	KB062802-003
70 A	KB062802-003
90 A	KB062802-001
125 A	KB062802-002
175 A	KB062802-002
250 A	KB062780-002
300 A	KB062780-002

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2. Depending on the SCR module to be replaced, disconnect the firing-circuit leads from the SCR modules (see figures 5–11 and 5–12) as follows:

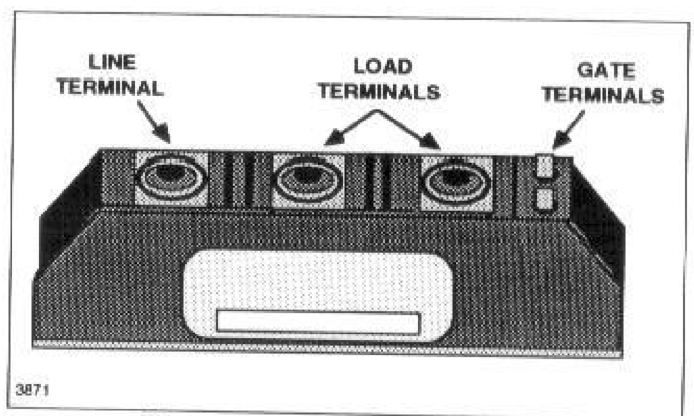

Figure 5–11. 35–175A SCR module.

A. Disconnect the SCR module's **K1** (or **K3**) lead from the **LOAD 1** (or **LOAD 3**) push-on terminal to which it is connected.
B. Disconnect the SCR module's **K2** (or **K4**) lead from the **LINE 1** (or **LINE 3**) push-on terminal to which it is connected.
C. Disconnect the firing circuit **G1** and **G2** (or **G3** and **G4**) gate leads from SCR module terminals **G1** and **G2** (or **G3** and **G4**).

3. Remove the SCR module's **LOAD 1** (or **LOAD 3**) connection.

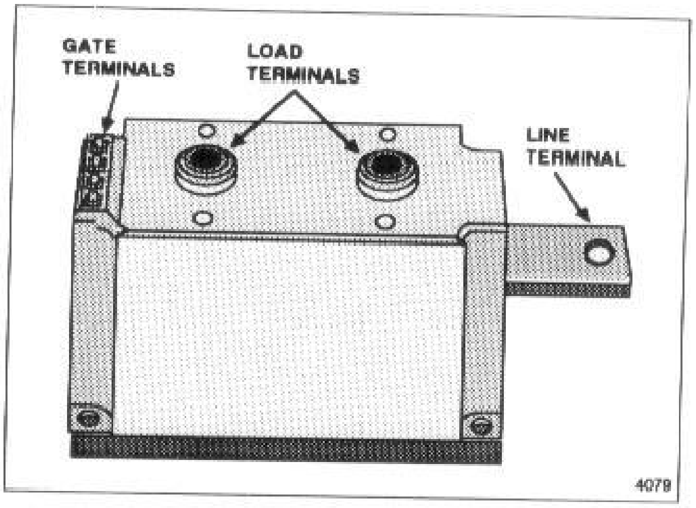

Figure 5–12. 250–300 A SCR module.

4. Remove the SCR module's **LINE 1** (or **LINE 3**) connection.
5. Remove the SCR module's mounting screws and associated spring washers.
6. Lift the SCR module off the heatsink.
7. Clean all traces of the previous heatsink thermal compound from the heatsink.
8. Apply a thin layer of heatsink thermal compound to the bottom of the replacement SCR module.
9. Install the replacement SCR module where the old one was located.
10. Replace the SCR module mounting screws:
    A. Be sure to install the conical spring washers as shown in figure 5–13.

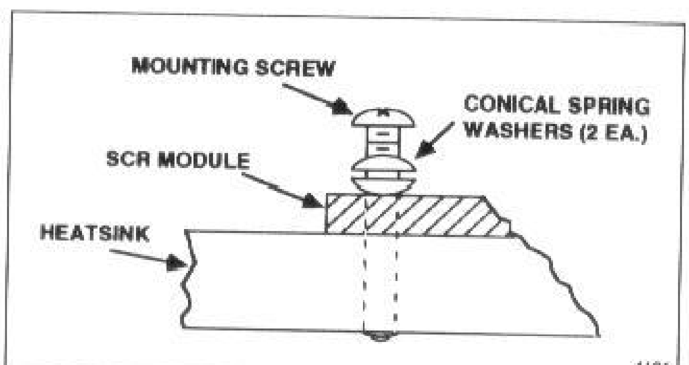

Figure 5–13. SCR module assembly mounting details. Be sure to install the two conical spring washers in series beneath mounting screw head as shown.

    B. Torque the SCR module mounting screws for all SCR modules to 40–50 pound-inches (4.5–5.5 Newton-meters).

11. If the controller has an input module, reconnect the input module's **LINE 1** push-on terminal connection.
12. Depending on the SCR module replaced, reconnect the disconnected firing circuit gate leads to the SCR module as follows:
    A. Connect the **G1** lead to SCR module 1 terminal **G1**.
    B. Connect the **G2** lead to SCR module 1 terminal **G2**.
    C. Connect the **G3** lead to SCR module 2 terminal **G3**.
    D. Connect the **G4** lead to SCR module 2 terminal **G4**.
13. Depending on the SCR module replaced, reconnect the other disconnected firing-circuit leads to the SCR module as follows:
    A. Connect the **K1** lead to a **LOAD 1** push-on terminal.
    B. Connect the **K2** lead to a **LINE 1** push-on terminal.
    C. Connect the **K3** lead to a **LOAD 3** push-on terminal.
    D. Connect the **K4** lead to a **LINE 3** push-on terminal.
14. Re-install the controller.

5.6.2 Firing Circuit Fuses

To replace a firing circuit fuse:

1. Remove line voltage from the controller.
2. Inspect the controller for damaged or loose SCR gate wiring before replacing the firing circuit fuse.
3. Remove the firing circuit fuse from its holder (see figure 5–14 for 664D or figure 5–15 for 664E) and install a replacement.

CAUTION

Replace the firing circuit fuse only with an AGC 1/4 A fast-acting fuse.

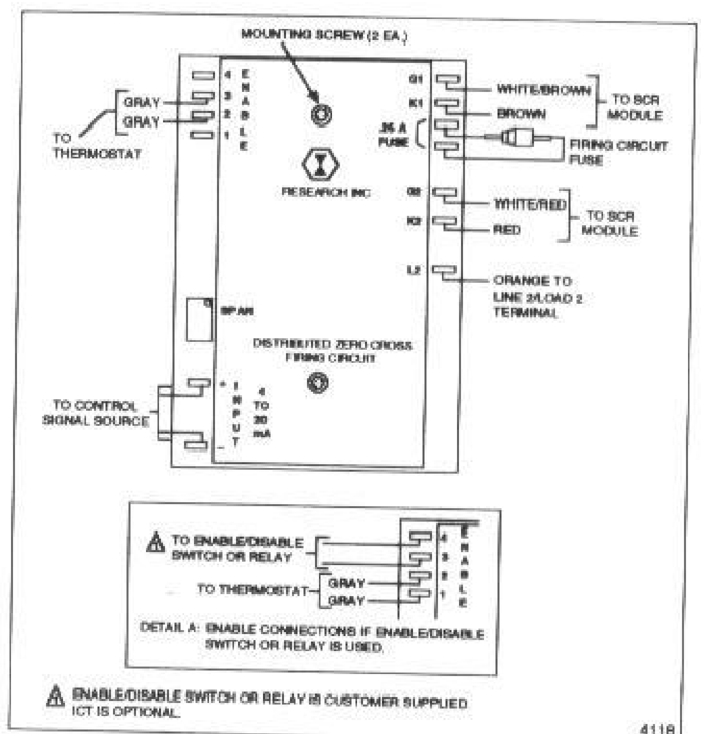

Figure 5–14. Firing circuit module connections, model 664D.

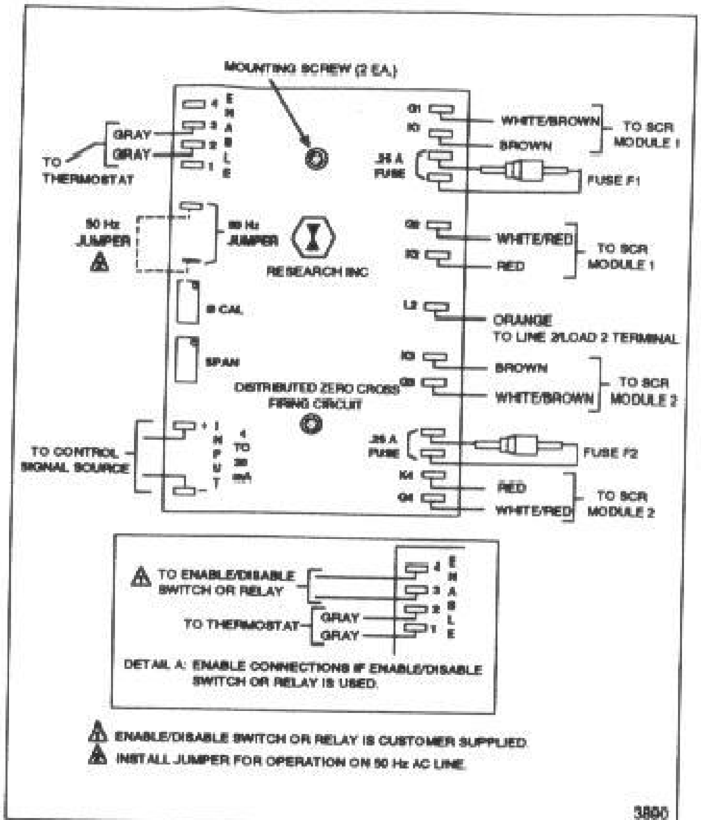

Figure 5–15. Firing circuit module connections, model 664E.

5.6.3 Firing Circuit Module

To replace the firing circuit module (see table 5–2 for part number):

1. Remove line voltage from the controller.
2. Loosen the screws that secure the controller's cover plate.
3. Remove the cover plate and place it on its edge (see figure 5–16).
4. Note the locations of all push-on lugs on the firing circuit module (see figure 5–14 for 664D or figure 5–15 for 664E). Then disconnect them from the firing circuit module.
5. Remove the two firing circuit mounting screws and remove the firing circuit module.
6. Install the replacement firing circuit module and secure it in place with the mounting screws removed in step 5.
7. Replace all wiring push-on lugs removed in step 4.
8. Reconnect line voltage to the controller.
9. Check that the firing circuit module is correctly configured for the line frequency in use as described in section 2.8.
10. Set the control signal input **SPAN** potentiometer as described in section 2.9.
11. Replace the cover plate and secure it in place with the screws loosened in step 2.

Table 5–2. Replacement Parts List

DESCRIPTION	PART NUMBER
Caution High Voltage Label	KA048319-000
Cover and Module Panel Mounting Screw (6-32 x 3/8 pan head screw with self-forming threads)	KB065023-001
Firing Circuit Fuse (AGC 1/4A)	KB062972-001
Model 664D Firing Circuit Module	OC070401-001
Model 664E Firing Circuit Module	OC070402-001
<u>Firing Circuit and Option Module Mounting Hardware</u>	
4-40 x 3/4 truss-head screw	KB065023-002
#4 flat washer	KA055029-002
Push-On Lug (for Firing Circuit and Line/Load Bracket Connections)	KB067427-001
SCR Module	See Table 5–1
<u>SCR Module Mounting Hardware</u>	
#10 conical spring washer	KB055442-004
#10 flat washer	KB055310-027
Thermal compound	KA057842-000
Subcycle Fuse	See Table 5–3
Thermostat	KB070025-001
<u>Mounting Bracket</u>	
Bracket "A"	KB062775-001
Bracket "B"	KB062775-002
Fan	KC047118-001
<u>Fan Capacitor</u>	
208 VAC	KB062877-002
240 VAC (Requires both capacitors)	KB062865-001 KB062877-001
277 VAC	KB062877-001
380 VAC	KB062878-002
415 or 480 VAC	KB062878-001
600 VAC	KB062878-003
1 Turn 1K Potentiometer	KB067513-001
Knob	KA055844-002
10 Turn 1K Potentiometer	KB055769-004
Digital Dial	KA055819-000
Manual	664D/E
Schematic, 664D	OD070038-001
Schematic, 664E	OD070039-001
Input Module	OC070397-001
Current Module	OC070396-001

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5.6.4 Subcycle Fuse(s)

To replace a subcycle fuse (see table 5–3 for part number):

1. Remove line voltage from the controller.
2. Inspect all wiring and components for damage and replace if necessary.
3. Remove the subcycle fuse mounting screws and lift the fuse off its standoffs (see figures 2–5 and 2–6).
4. Install a replacement subcycle fuse.
5. Replace and tighten the fuse mounting screws.

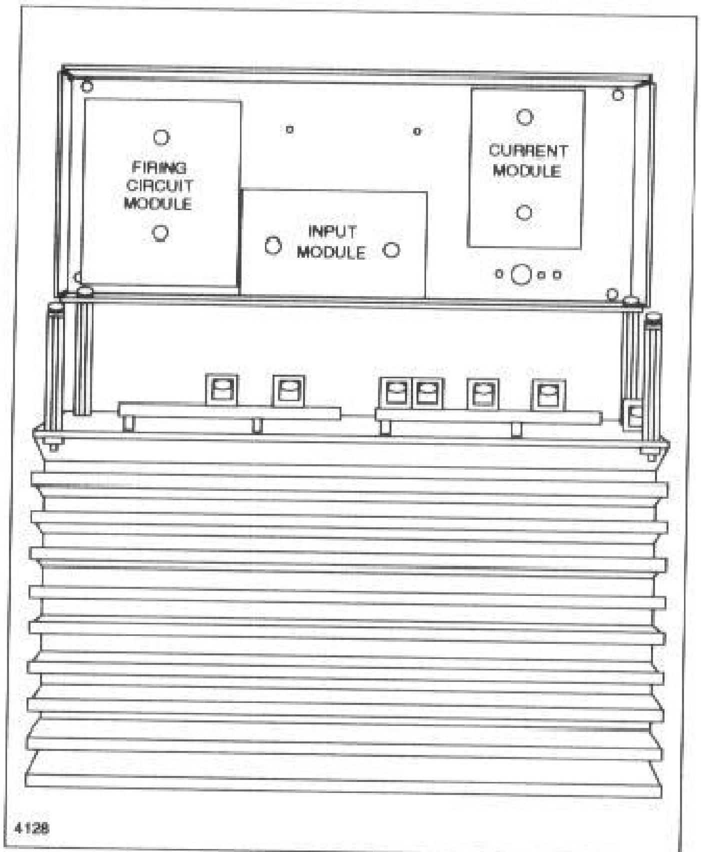

Figure 5–16. Model 664 controller with cover plate on edge for access to modules.

Table 5–3. Replacement Subcycle Fuses

CONTINUOUS CURRENT RATING	PART NUMBER	
	500 V FUSES	600 V FUSES
70 A	KB057525-008	KB057519-008
90 A	KB057525-009	KB057519-009
125 A	KB057525-001	KB057519-010
175 A	KB057525-010	KB057519-011
250 A	KB057525-011	KB057519-012
300 A	KB057525-003	KB057519-007

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5.6.5 Thermostat

To replace a thermostat (see table 5–2 for part number):

1. Remove line voltage from the controller.
2. Remove the perforated shield from the end of the heatsink near the thermostat.
3. Remove the screws that secure the thermostat to the heatsink.
4. Lift the thermostat off the heatsink.
5. Pull the push-on terminals of the thermostat wires off the thermostat's terminal lugs.
6. Push the push-on terminals of the thermostat wires onto the replacement thermostat's terminal lugs.
7. Remove all traces of the previous thermal compound from the heatsink. Make certain the surface on which the thermostat will be mounted is clean and smooth.
8. Apply a thin layer of thermal compound to the bottom of the replacement thermostat.
9. Place the thermostat on the heatsink and tighten the mounting screws firmly.
10. Reinstall the perforated shield on the end of the heatsink.
11. Reapply line voltage to the controller.

5.6.6 Current Module

To replace the current module (see table 5–2) for part number):

1. Remove line voltage from the controller.
2. Loosen the screws that secure the controller's cover plate.
3. Remove the cover plate and place it on edge (see figure 5–16).
4. Note the settings of the **ICT SEL** switches and the locations of all push-on lugs on the current module (see figure 5–6). Then disconnect all wiring from the current module.
5. Remove the two module mounting screws and their washers.
6. Remove the current module from its mounting location.
7. Place the replacement module in the location from which the old current module was removed.
8. Reinstall the two module mounting screws and washers.
9. Reconnect all wiring disconnected in step 4.
10. Replace the cover plate and secure it in place with the screws loosened in step 2.
11. Reconnect line voltage to the controller.

5.6.7 Input Module

To replace the input module (see table 5–2 for part number):

1. Remove line voltage from the controller.
2. Loosen the screws that secure the controller's cover plate.
3. Remove the cover plate and place it on edge (see figure 5–16).
4. Note the locations of all push-on lugs on the input module. Then disconnect all wiring from the input module.
5. Remove the two module mounting screws and their washers.
6. Remove the input module from its mounting location.
7. Place the replacement module in the location from which the old current module was removed.
8. Reinstall the two module mounting screws and washers.
9. Reconnect all wiring disconnected in step 4 (see figure 5–7).

NOTE

Be sure to reinstall the input module line-voltage configuration jumper where it was connected previously.

10. Replace the cover plate and secure it in place with the screws loosened in step 2.
11. Reconnect line voltage to the controller.