CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODEL 3227

DESCRIPTION:

The model 3227 SCR power controller, linearly controls, with respect to a command signal, the electrical power applied to three-phase resistive load. It does this by zero-cross operation of silicon controlled rectifiers (SCRs) which are connected in two of the three load leads.

The command signal may be a mA current signal, a 0 to 5 Vdc signal, a 0 to 10 Vdc signal or a potentiometer. The 3227 provides electrical isolation of the command signals allowing either grounded or ungrounded commands.

Three fast acting fuses within the controller protect the SCRs from fault currents. These fuses can, in many situations, also be relied upon to protect the load from fault currents.

Features of the model 3227:

Sync-Guard eliminates the chance of two or more controllers operating sychronously, thereby reducing the possibility of all controllers being on and off simultaneously. The "Sync-Guard" feature provides a more uniform or continuous power demand and therefore reduces the variations in the supply voltage that can occur when multiple controllers operate synchronously.

Trans-Guard eliminates the DC load voltage and current that can exist with zero-cross operation. The "Trans-Guard" feature therefore prevents saturation and over heating of supply transformers due to DC voltage which can occur on the transformer primary because of secondary DC currents.

Isolated Set Points feature eliminates problems which can occur when circuits are grounded together (such as when using Sync guard) and command signals are daisy chained (mA current, for example).

Soft Start Ramp circuit causes the controller to start at 0 output and ramp up to the set point output at a fixed rate. The fixed rate is the **T[xx]S** time specified in the model number.

This feature is useful when slow turn on is necessary for loads whose resistance is very low when cold.

Soft Start Reset causes the controller to restart the ramp from zero. A momentary, normally open switch may be used for this purpose. This feature may also be used for an on-standby operation. As long as the contacts are held closed, the controller will remain at zero output. When the switch is released, the controller will begin it's ramp toward the set-point.If the Ramp time is zero, the output will go instantly to the set point.

THEORY OF OPERATION:

THE SCR

The heart of the SCR power controller is the SCR (silicon controlled rectifier, also sometimes referred to as a thyristor).

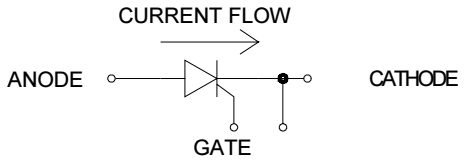


Figure 1. SCR symbol

The SCR has two states, ON and OFF, and allows current to flow in only one direction. SCR's can remain in the off state even though the applied potential may be several thousand volts; in the on state, they can pass several thousand amperes. When a small signal is applied between the gate and cathode terminals (Figure 1), the SCR will turn on within 10-100 microseconds. Once turned on, it will remain on until the current through it is reduced below a very low value called the holding current.

Because the SCR allows current to flow in only one direction, two SCR's are connected in a "back to back" configuration to control AC current (Figure 2).

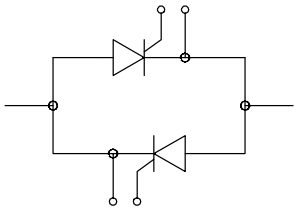
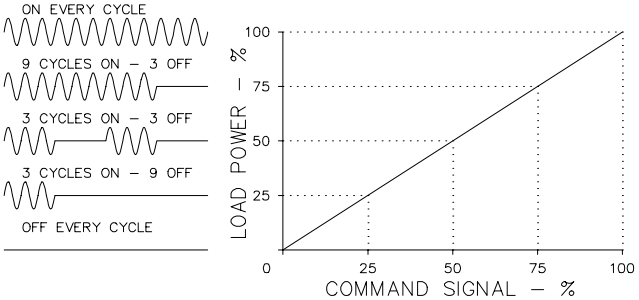


Figure 2.

ZERO-CROSS OPERATION

In zero-cross control load power is turned on or off only when the instantaneous value of the sinusoidal waveform is zero. Load power is controlled by switching the SCRs "on" for a number of complete electrical half-cycles and then "off" for a number of complete electrical half-cycles.



THEORY OF OPERATION:

In zero-cross control, load power is turned on or off only when the instantaneous value of the sinusoidal waveform is zero. Load power is controlled by switching the SCRs "on" for a number of complete electrical half-cycles and then "off" for a number of complete electrical half-cycles.

Because of the Trans-Guard feature, the 3227 always applies an odd number of "on" half cycles and an even number of "off" half cycles. The following tabulation shows the number of "on" and "off" electrical half-cycles of power that are applied to the load to acheive the percentage of load power indicated. The percentage of load power is equal to the ratio of the number of electrical half-cycles that power is applied to the total number of electrical half-cycles.

LOAD POWER				
10%	**25%**	**50%**	**75%**	**85%**
5 on	5 on	9 on	17 on	23 on
46 off	14 off	8 off	6 off	4 off
5 on	5 on	7 on	19 on	23 on
44 off	16 off	8 off	6 off	4 off
				23 on
				4 off
				23 on
				4 off
				23 on
				4 off
				21 on
				4 off

Table 1. Percentage of ON-OFF time.

From the above tabulation, it can be seen that power is applied for 16 out of 32 electrical half-cycles to acheive 50% load power and that power is applied for 136 out of 160 electrical half-cycles to obtain 85% power.

When operated with a 60 hertz supply, the sequence of on and off cycles repeats every 0.266 seconds at 50% and every 1.33 seconds at 85% power. Note that even though it takes 1.33 seconds to obtain precisely 85% power, the load power during the 23 on and 4 off cycles is 23/27 or 85.185% power and that this cycle is repeated every 0.225 seconds.

Sync-Guard

Two or more zero-cross controllers connected to the same power source, each running at less than 100% command, could all turn on simultaneously causing a power surge.

The sync-guard feature reduces the variations in power demand, resulting in a more stable supply voltage and improved power factor. The Sync-Guard feature does not alter the power applied to the load, but adjusts the time when power is applied in such a manner as to reduce the possibility of two or more controllers being ON and OFF at the same time. Up to ten controllers may be connected together in this manner. See fig. 10 on page 6.

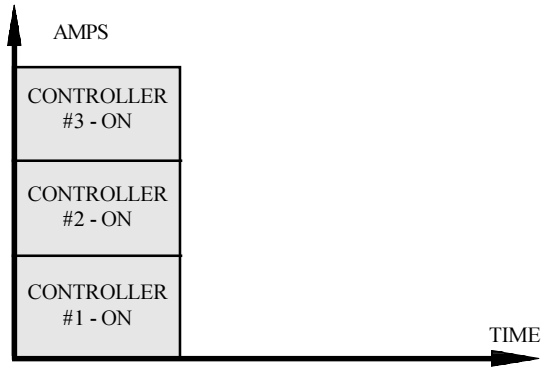


Figure 3. Three controllers, each providing 33.3% power, operating synchronously.

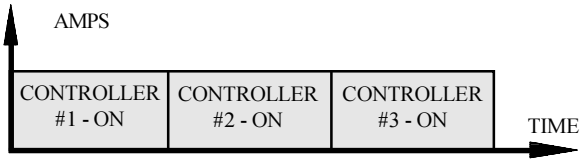


Figure 4. Three controllers, each providing 33.3% power, with sync-guard.

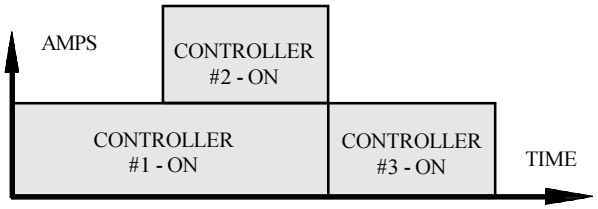


Figure 5. Three controllers, two providing 33.3% power each & one providing 66.6% power, with synch-guard.

As shipped from the factory, each model 3227 controller will have a jumper placed on connector P3 in the Sync-Guard position. (P3-3 to P3-2, 'in'.) If you connect two or more controllers togther for sync-guard, as shown in fig. 9 on page 6, <u>the sync-guard jumper must be in the 'out' position (P3-1 to P3-2) or removed, on all but one of the controllers.</u>

SPECIFICATIONS:

CONTROL MODE:	Zero-cross, two leg distributive power control to three-phase resistive loads.
CURRENT RATING:	The "A" term within the model number specifies the maximum continuous RMS current rating at the maximum operating ambient temperature of 55ºC.
COMMAND SIGNAL:	INPUT — INPUT RESISTANCE 0-5Vdc — 125 K ohms 0-10Vdc — 250 Kohms 4/20mA — 60 ohms Potentiometer — 125 Kohms (1KΩ to 20 KΩ, 1/2 watt pot permissible. 1KΩ pot. recommended for maximum linearity)
OPERATING VOLTAGE:	240 or 480 Vac, 50/60 Hertz +10 -15% Other voltages available, consult factory.
AMBIENT TEMPERATURE:	Operating 0 to 55ºC Storage - 40 to 80ºC Humidity 0 to 95% non - condensing
ISOLATION:	Isolation between power circuit, command signal and ground is greater than 2500 Volts peak. All command signals are optically isolated to prevent current loop problems when units are grounded together.
LINEARITY:	The load power is linear within 2% of span with respect to the command signal.
POWER CIRCUIT:	Inverse parallel silicon controlled rectifiers (SCRs). Two leg control.
CONTROL RANGE:	0 to 99% of supply voltage.
DV/DT AND TRANSIENT VOLTAGE PROTECTION:	DV/DT rating exceeds 200 volts per microsecond. DV/DT snubber circuit and MOV's are provided to protect against high frequency transients (dv/dt) and high voltage transients.
MAX OFF STATE VOLTAGE:	240 Volt Unit: 600 volts peak 480 Volt Unit: 1200 Volts peak
ZERO AND SPAN ADJ:	±20% of span.
COMMAND INDICATOR:	An LED is turned on when SCR's receive a control signal.
HEAT DISSIPATION:	1.5 watts per amp of SCR current.
SCR SURGE CURRENT: peak one cycle	25 Amp max. unit: 450 Amps. 50 Amp max. unit: 1000 Amps
SCR I^2T RATING: 60 Hz, half cycle	25 Amp max unit: 840 A^2 Sec 50 Amp max unit: 3375 A^2 Sec
SOFT START RAMP	Fixed, between 0 and 60 seconds. Ramp time is specified in model number.
RAMP RESET	Resets the ramp to zero. When released, the ramp begins to climb toward the set point at the fixed ramp rate. Holding these contacts closed keeps the output at zero.

INSTALLATION:

MOUNTING:

The controller must be mounted on a veritcal surface with the fins oriented vertically so that air may flow freely across them.

POWER CONNECTIONS: Wire the controller in accordance with the electrical codes for the area in which it will be used.

Connect the supply power and load as shown in the power connenctions drawing on page 6.

NOTE: The controller is not phase rotation dependent.

An oxide inhibitor such as Burndy Pentrox A, Ilsco De-OX, etc. should be used between electrical connections to insure good electrical contact.

The connectors are rated for use with wire sizes from 14ga to 2ga. Type THWN or THNN wire is suggested.

TORQUE TABLE FOR USD CONNECTORS

Wire Size	Recommended Torque
10 -14 ga	35 in-lbs
8 ga	40 in-lbs
4 - 6 ga	45 in-lbs
2-3 ga	50 in-lbs

120 Volts Ac must be supplied to the board thru connector P4, terminals P4-1 and P4-3. This voltage can be supplied from any 120 Volt, 50/60 Hz source.

ADJUSTMENTS:

The 3227 controller will be calibrated before leaving the factory, therefore field adjustment is usually not required.

If adjustment becomes necessary, this procedure should be followed.

ZERO: Reduce the command signal to minimum and adjust the ZERO pot so that the output of the controller just stays off.

SPAN: Increase the command signal to maximum and adjust the SPAN pot so that the output of the controller is just on continuously.

(The span and zero adjustments may interact, therefore it may be necessary to repeat these two steps.

MODEL NUMBER:

3227 - [vv] - [aa] - F[ff] - T[xx]S - [cs] - [fc]

3227 specifies a three-phase SCR controller which provides zero-cross distributive control by controlling the current in two of the three load leads.

The **"[vv]"** term specifies the operating voltage.

24 = 240 Volts A.C.

48 = 480 Volts A.C.

The **"[aa]**" term specifies the continuous RMS current rating.

25 = 25 Amps, 10 to 30 amp fuse range.

50 = 50 Amps, 35 to 60 amp fuse range.

The "**[ff]**" term specifies the size of the fuse installed at the factory. The fuse rating is usually 125% of the [aa] current rating.

10 = 10 Amp Fuse
15 = 15 Amp Fuse
20 = 20 Amp Fuse
25 = 25 Amp Fuse
30 = 30 Amp Fuse
35 = 35 Amp Fuse
40 = 40 Amp Fuse
45 = 45 Amp Fuse
50 = 50 Amp Fuse
60 = 60 Amp Fuse

The **"[xx]"** term specifies the ramp time in seconds.

xx = 0 to 60 seconds

The **"[cs]"** term specifies the command signal that the controller is calibrated for.

0/5V = 0 - 5 Volts DC
0/10V = 0 - 10 Volts DC
4/20mA = 4/20mA DC
Pot = Potentiometer

The "**[fc]**" term specifies a replacement firing circuit.

FC = Firing circuit only.

Example No. 1, **3227-48-50-F50 -T25S-4/20mA** specifies a zero cross controller with the 3227 features, 480 volt operation, 50 amps continuous current rating, 50 amp fuses, a 25 second ramp time and a 4/20mA command signal.

Example No. 2, **3227 - T00S - 0/10V - FC** specifies a 3227 replacement firing circuit without ramp delay time that accepts a 0 to 10 Vdc command signal.

INSTALLATION DRAWINGS:

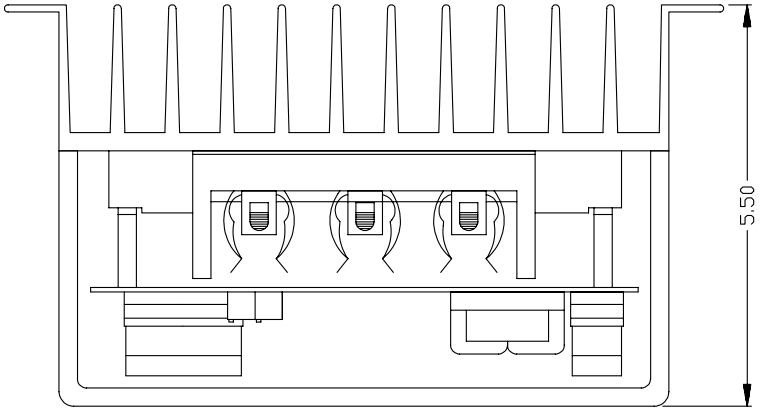


Figure 6. End view of 3227.

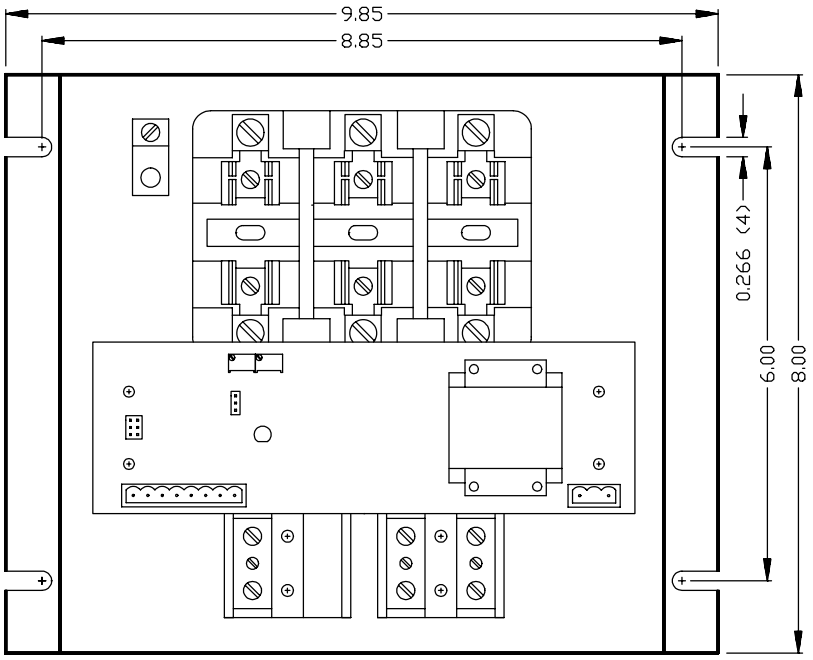


Figure 7. Top view of model 3227

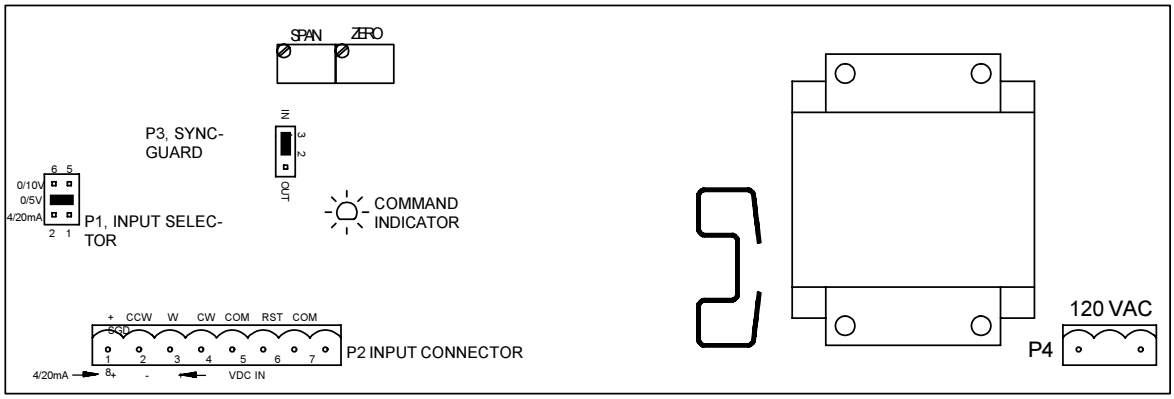


Figure 8. Board layout showing adjustments and connectors.

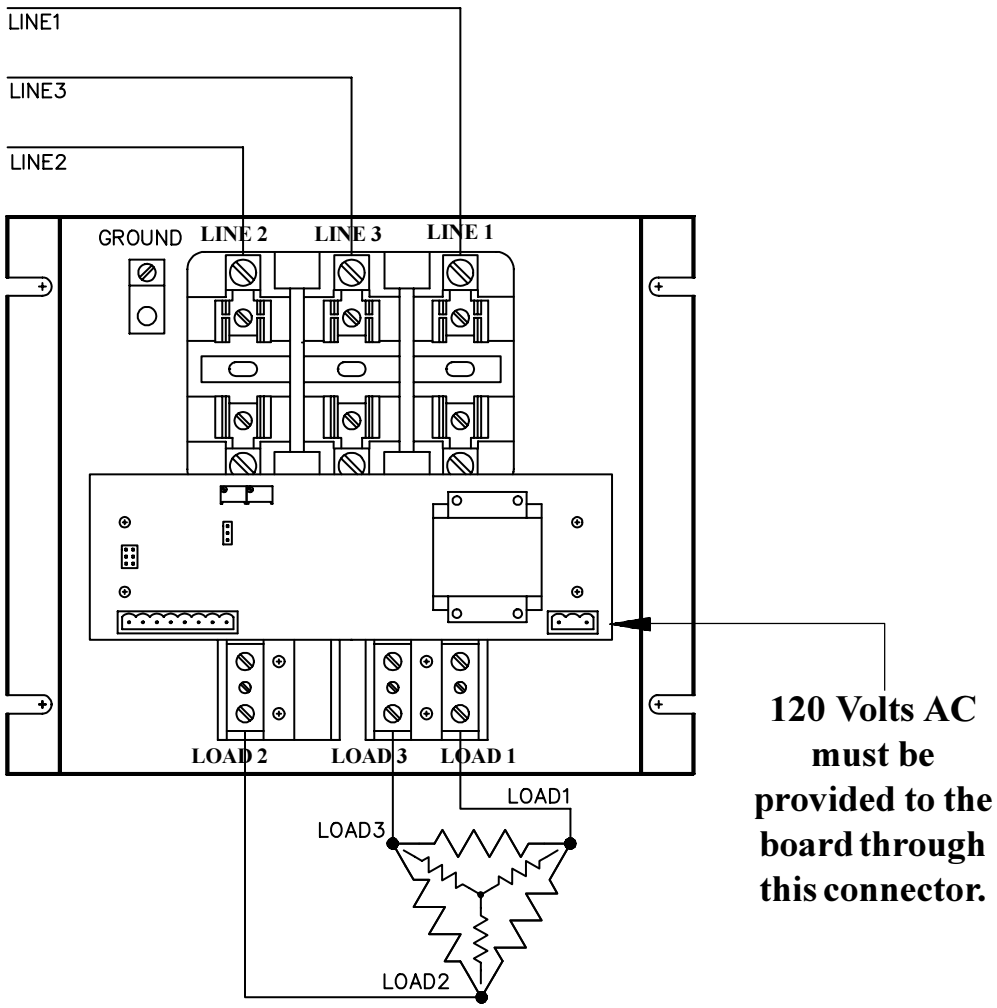


Figure 9. Power connections.

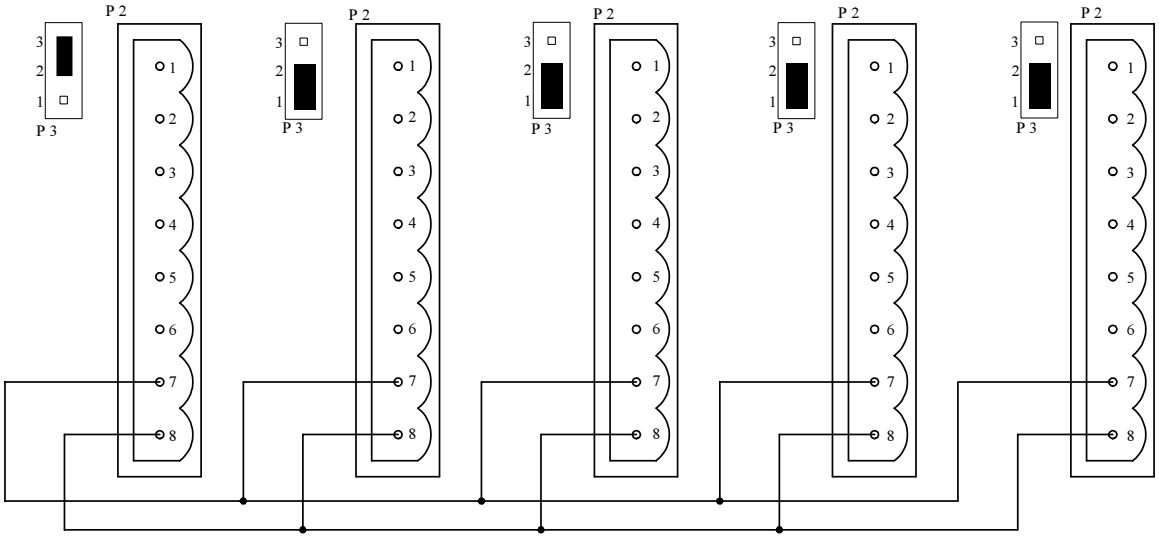


Figure 10. Sync-Guard connections (showing P3 jumpers).
See Sync-guard column on page 7.

CONTROL CONNECTIONS:

Connect the control wiring as shown in the command connector connections drawing, Fig 11.

Note: Shielded control wiring is not required, however, it is recommended that the control wire not be placed adjacent to the power wiring.

POTENTIOMETER INPUT:

1K recommended, 20K max. resistance 1/2 watt
CW to terminal 4 P1 jumper on pins 3 to 4
CCW to terminal 2
W to terminal 3

VOLTAGE INPUT:

0 to 5 Vdc to terminal 3 - P1 jumper on pins 3 to 4
0 to 10 Vdc to terminal 3 - P1 jumper on pins 5 to 6
Common to terminal 2,

mA INPUT:

+ input to terminal 1 - P1 jumper on pins 1 to 2
- input to terminal 2

SYNC-GUARD:

The Sync-Guard feature may be implemented by linking terminal (P2-8) on all of the sync-guarded controllers together, and terminal (P2-7) on all of the sync-guarded controllers together. See figure 10 on page 6.

Any one of the controllers linked together in this way must have the jumper on the sync-guard selector (P3) in position from pin 2 to pin 3.
On all other controllers linked together, the jumper must be removed. The unused jumper may be stored on pin 1 to pin 2 on the same connector.

The sync-guard circuit is electrically isolated from the line and load voltages.

Up to ten controllers of the same type may be connected together in this manner.

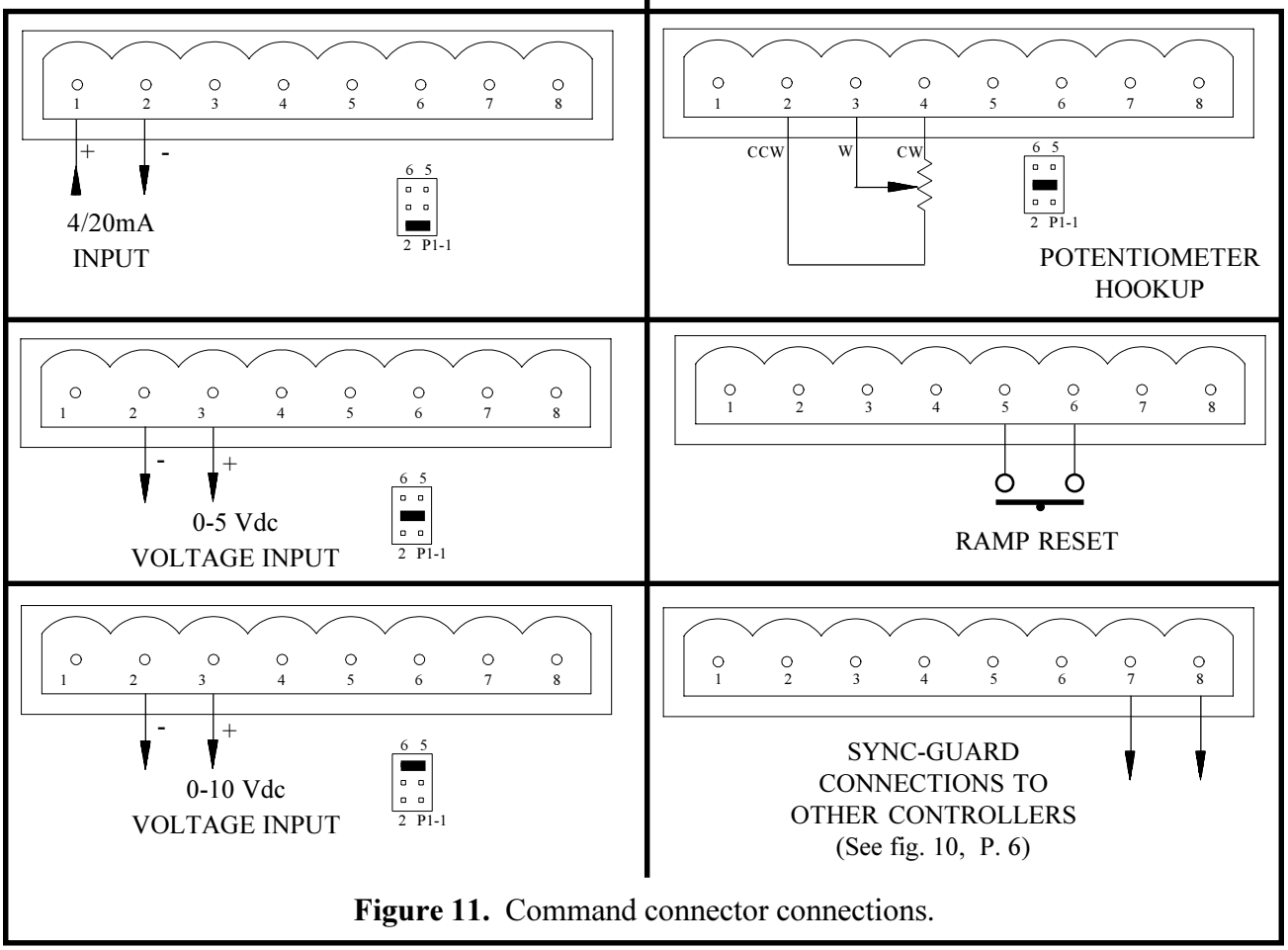


Figure 11. Command connector connections.

CHECKOUT:

CAUTION: Portions of the electronic circuit and other parts of the controller are at line voltage.

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

Set the command signal to minimum and apply system power. The command indicator light should be off and no power should be applied to the load. Slowly increase the command signal. The command indicator should blink on and off proportional to the magnitude of the command signal and load power should increase.

If the command indicator blinks on and off with no command signal, adjust the "zero" potentiometer until the indicator no longer turns on. If the command indicator blinks when the maximum command signal is applied, adjust the "span" potentiometer until the indicator just remains on continuously. Keep in mind that the ramp circuit will prevent the output from reaching setpoint until it has timed out.

TROUBLE SHOOTING:

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

The following are possible symptoms and procedures to follow.

No load power and command indicator does not function.

1. Check main fuses.
2. Determine that 120 Vac is present on circuit board.
3. Determine that the command signal is present.
4. Determine that 5 Vdc is present between terminal 3 and terminal 4 on the input connector.

No load power and command indicator functions correctly.

1. It is unlikely that both SCR modules have failed.
2. Check load connections and load fuses.

Full or partial load power with command indicator off.

1. One or both SCR modules may have failed. Remove system power and remove circuit board from the controller. Reapply system power. An SCR or both SCR's have failed if load voltage exists. If the voltage between the line 1 and load 1 terminals is zero, or the voltage between the line 2 and load 2 terminals is zero, the SCR connected between those terminals has failed.

   If no load voltage exists with the circuit board removed, the board has failed.

Full load power and command indicator is on.

1. Check that the command signal is zero and correctly connected. (A convenient method to apply zero command is to remove the input connector from the controller.) If the command indicator remains on with zero command signal, the circuit board has failed. If the command indicator goes off, the problem is likely in the command signal or wiring.

Full load power cannot be obtained and command indicator is on.

1. Check the fuse between line 3 and load 3.
2. Visually inspect the circuit board for damage.
3. With the command signal at maximum the voltage between the corresponding line and load terminals should be less than 2 vdc. SCR modules which have a voltage greater than 2 volts have probably failed.

REFERENCE DRAWINGS:

Circuit Schematic	D1000711

MANUFACTURED BY:

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