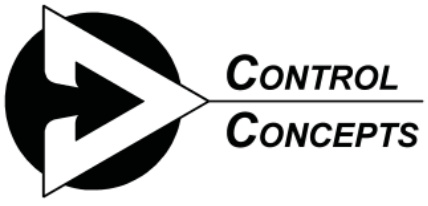
CONTROL CONCEPTS INC.

INSTALLATION MANUAL
MODEL 3659



7870 PARK DRIVE
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CONTROL CONCEPTS, INC. 2 YEAR LIMITED WARRANTY

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CONTROL CONCEPTS, INC. warrants to the original user that CONTROL CONCEPTS, INC. products will be free from defects in materials and workmanship for a period of two (2) years after the date CONTROL CONCEPTS, INC. ships such products.

If any CONTROL CONCEPTS, INC. product is found to be defective in material or workmanship during the applicable warranty period, CONTROL CONCEPTS, INC.'s entire liability, and the purchasers sole and exclusive remedy, shall be the repair or replacement of the defective product at CONTROL CONCEPTS, INC.'s election. CONTROL CONCEPTS, INC. shall not be liable for any costs or expenses, whether direct or indirect, associated with the installation, removal or re-installation of any defective product. All shipping and freight costs are the responsibility of the customer. CONTROL CONCEPTS, INC.'s limited warranty shall not be effective or actionable unless there is compliance with all installation and operating instructions furnished by CONTROL CONCEPTS, INC., or if the products have been modified or altered without the written consent of CONTROL CONCEPTS, INC., or if such products have been subject to accident, misuse, mishandling, tampering, negligence or improper maintenance. Any warranty claim must be submitted to CONTROL CONCEPTS, INC. in writing within the stated warranty period.

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WARNING: The Control Concepts, Inc. power controllers use power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off. It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

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Model 3659 Table of Contents

DESCRIPTION:

This is to be a 3-phase 6-SCR power controller consisting of a high voltage controller (>120Vac) and a low voltage remote firing circuit (<=120Vac). The controller may be configured as either as a 3-phase, 6-SCR IN LINE controller, or as an INSIDE DELTA controller to control 3 single phase loads isolated or non isolated.

The controller will have 3 basic firing modes:
1. Phase-Angle control
2. Zero-cross control
3. Burst-fire control

The circuit will have current limiting in the phase control mode and over current trip when operating in the phase control, zero-cross or burst fire mode. Zero cross and burst fire modes will have the Sync-Guard™ and Trans-Guard™ features.

SPECIFICATIONS:

Environmental	
Temperature	Storage: -40 to 85C Operating: 0 to 40C
Humidity	0 to 90 percent (non-condensing)
Altitude	9,000 feet above sea level
Controller Ratings	
Voltage Rating	120 to 600 VAC +10%, -15%
Frequency	45 to 65 Hz
Load Current	1000 Amps RMS
Cooling	Forced Air: 3-230 CFM fans in controller
Cabinet cooling airflow	500 CFM cabinet cooling required to maintain surrounding air temp of <= 50° C
Circuit Board Inputs	
Supply Voltage	Remote Firing Circuit / Controller Input Voltage Range: 90-264 Vac / 90-264 Vac Frequency Range: 47-63 Hz / 47-63 Hz Inrush Current: 30A @ 100 Vac input* / 60A @ 100 Vac input* 50A @ 200 Vac input* / 100A @ 200 Vac input* *Typical at nominal input, full load and 25° C
Thermostat	The circuit will monitor a normally closed thermostat on each of three heatsink assemblies. A separate T-STAT LED for each zone will light, the SHUT DOWN LED will light, a mechanical relay with form C contacts will be energized, and the controller will shut down when a thermostat opens due to excessive heatsink temperature.
Feedback	No internal feedback will be provided. The control will be proportional to the command and the power control feedback will be provided by the customer supplied ION meter external to the controller. An optional isolated external 120V RMS feedback is available.
Command Selection	Closure between two terminals, on P12 connector, on the input terminal strip of the remote firing circuit disables the CMD1 command signal and enables the CMD2 command signal.
Control Mode Selection	On the P12 connector of the remote firing circuit a closure between a terminal on the input terminal strip and common enables the phase-angle control mode. Closure between a terminal on the input terminal strip and common enables the controller in the zero-cross control mode. Closure of both terminals to the common terminal enables the controller in the burst-fire mode.

SPECIFICATIONS: (Continued)

Zone Disable	A DIP Switch will be provided to disable the gate drive to any or all zones.
Current Transformers	3 current transformers will be provided to monitor the line currents for current limiting, over-current trip, 2 leg mode and shorted SCR detection.
Control	
SCR Operation:	The controller may be hooked up in-line or as 3 separate single phase controllers with a common set point. 3-Phase Phase-Angle 3-Phase Zero-cross 3-Phase Burst-fire with first pulse occurring at 90 degrees. The control mode is to be selected by jumpers on the input terminal strip. The controller will automatically switch to a 2-leg (single phase) mode of the above three modes when one leg of a WYE (3 or 4 wire) connected 3-phase load opens.
Feedback Mode	Phase-Angle Control: Conduction angle proportional to command Zero-cross & Burst fire: Duty cycle (% ON time) proportional to command signal
Linearity	The output is to be linear within 1% of span over range of 5 to 95% of output
Temperature Drift	0.05% of span or less, per degree C over operating temperature range
Slew Rate	400mS to 600mS time constant nominal
Command Signal(s)	All outputs are controlled from the same command. Either of two command signals referred to as “CMD1” & “CMD2” are to be selected by a jumper on the input terminal strip. CMD1 Command: 4/20mA 249 ohms input resistance CMD2 Command: 0/5Vdc 200K input resistance Or 1K to 20 K ohm Potentiometer
Gate Drive	Gate drives to provide 300 mA minimum with a compliance of 10 volts or greater. Gate drives to be optically coupled. Minimum gate drive duration 120 electrical degrees.
Load Characteristics	Minimum load power factor is 0.6.
Current Limit	This function is only available in the phase control mode. A remote multi-turn potentiometer will be provided to adjust the maximum RMS value of the load current from 20 to 105%. A form C relay energizes when in current limit.
Over Current Trip	In the event that the peak load current exceeds a value adjustable by a multi-turn potentiometer from 50 to 500% of the controller rating, the gate drive will be disabled and a form C relay will be energized. The SHUT DOWN LED will be illuminated and the corresponding phase’s load current led will illuminate to indicate which phase caused the OCT. With an in-line control mode more than one LOAD CURRENT LED may light. The circuit will be enabled by removing and then reapplying power or by the momentary closure of a remote contact. See Reset on page 13.
Shorted SCR	A form-C relay energizes and the gate drive will be disabled when an SCR fails shorted. The SHUT DOWN LED and SSCR LED will be illuminated and the corresponding phase’s load current LED will illuminate to indicate which phase caused the SSCR. This function is disabled for the last 30 degrees of conduction in phase control to eliminate false tripping with inductive loads. The circuit will be enabled by removing and then reapplying power or by the momentary closure of a remote contact on the reset input. See Reset on page 13.
2 Element Mode	In the event of a load loss, the controller will enter 2 element mode. When in 2 element mode a form C relay, “ALARM relay”, energizes and the corresponding phase’s load current LED will go out showing which load has been lost. The 2 element mode is disabled in the first 60° of the condition.

SPECIFICATIONS: (Continued)

Indicators	
LED Indicators (local) (On Circuit Card)	Shorted SCR: A red LED lights if a shorted SCR condition occurs. ZC mode: A green LED lights when in Zero-Cross mode. PA mode: A green LED lights when in Phase-Angle mode. Burst mode: The green PA mode LED and the green ZC mode LED will be lit to indicate Burst mode. 2 Element Mode: A red LED lights when in 2 element mode. Current Limit: A yellow LED lights if the controller is in current limit. Line OK: A green LED lights if the supply voltages are present. Alarm: A red LED lights if a fault condition exists (current limit or 2 element mode). Shut Down: A red LED lights if a shut down condition exists (SSCR, OCT, or Over Temp). Thermostat: A red LED for each phase lights in the event that one of the remote normally closed thermostat opens. 3-Load Current LEDs: The intensity of a green LED varies as a function of the load current. Command: The intensity of a green LED varies as a function of the command signal.
LED Indicators	Provisions are to be provided by which the functions indicated by the LEDs mounted on the circuit card can also be indicated by remote LEDs. These are connectors P13 & P14.
Form C Relays	Alarm: Indicates if unit is in current limit or 2 element mode. Shut Down: Indicates if unit has a SSCR, OCT, or an over temp condition.
Miscellaneous	
Approvals	The circuit is to be designed to meet UL-508 requirements.
Fusing	The remote firing circuit will be fused with (2) Littelfuse 0218002.MXP 5x20mm slo-blo on the supply voltage. The controller circuit will be fused with (2) Littelfuse 0218002.MXP 5x20mm slo-blo on the supply voltage and with a Bussmann KTU 1200A fuses on each Line terminal. Additional protection will be provided by an upstream circuit breaker and the over current trip feature of the power controller.

INSTALLATION:

Mounting:
The Model 3659 contains two units, the controller and remote firing circuit. These are mounted in separate locations and need to be wired together.

The 3659 controller was designed for vertical panel mounting. In this position the bus bars will be located on the top of the controller. This can be seen in Figure 3.

When mounting the Model 3659 controller allow adequate clearance for air to flow to prevent overheating. It is recommended that the controller be free from all interference for at least 6 inches from top and bottom.

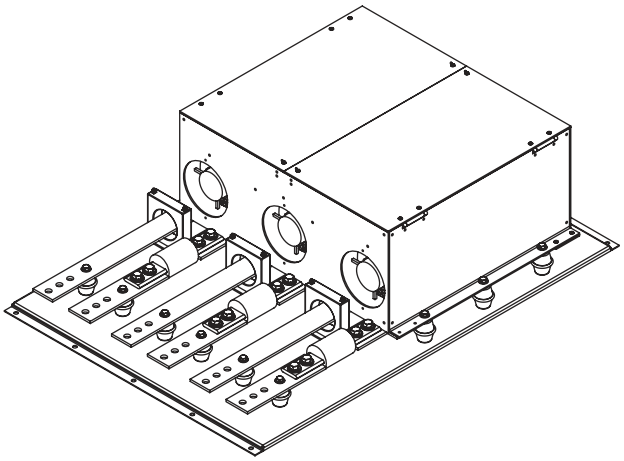


Figure 1. Model 3659 Controller.

The firing circuit box is mounted in a remote location from the controller. When mounted in a vertical position the dials should be located on the bottom.

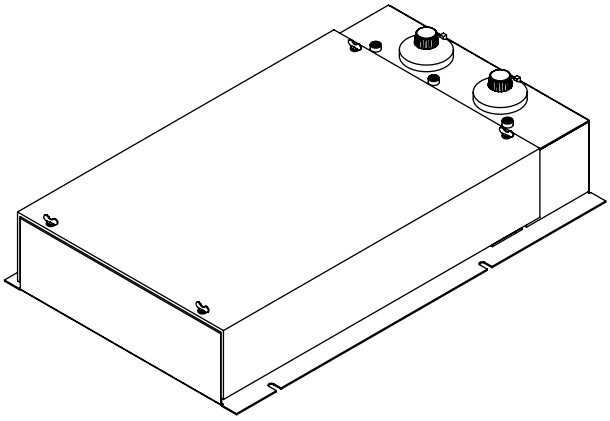


Figure 2. Model 3659 Remote Firing Circuit.

Mounting holes and dimensions for the 3659 controller and remote firing circuit can be viewed in Figures 3 - 6.

Note: All dimensions are in inches.

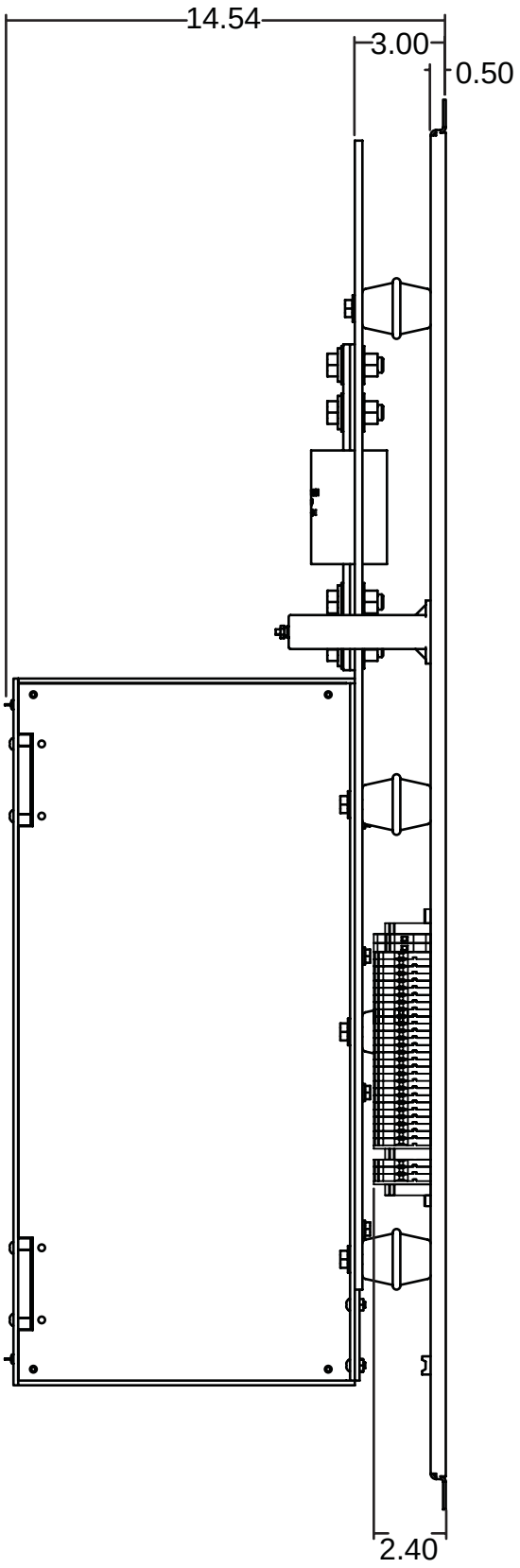


Figure 3. 3659 Controller (Side view).

INSTALLATION: (Continued)

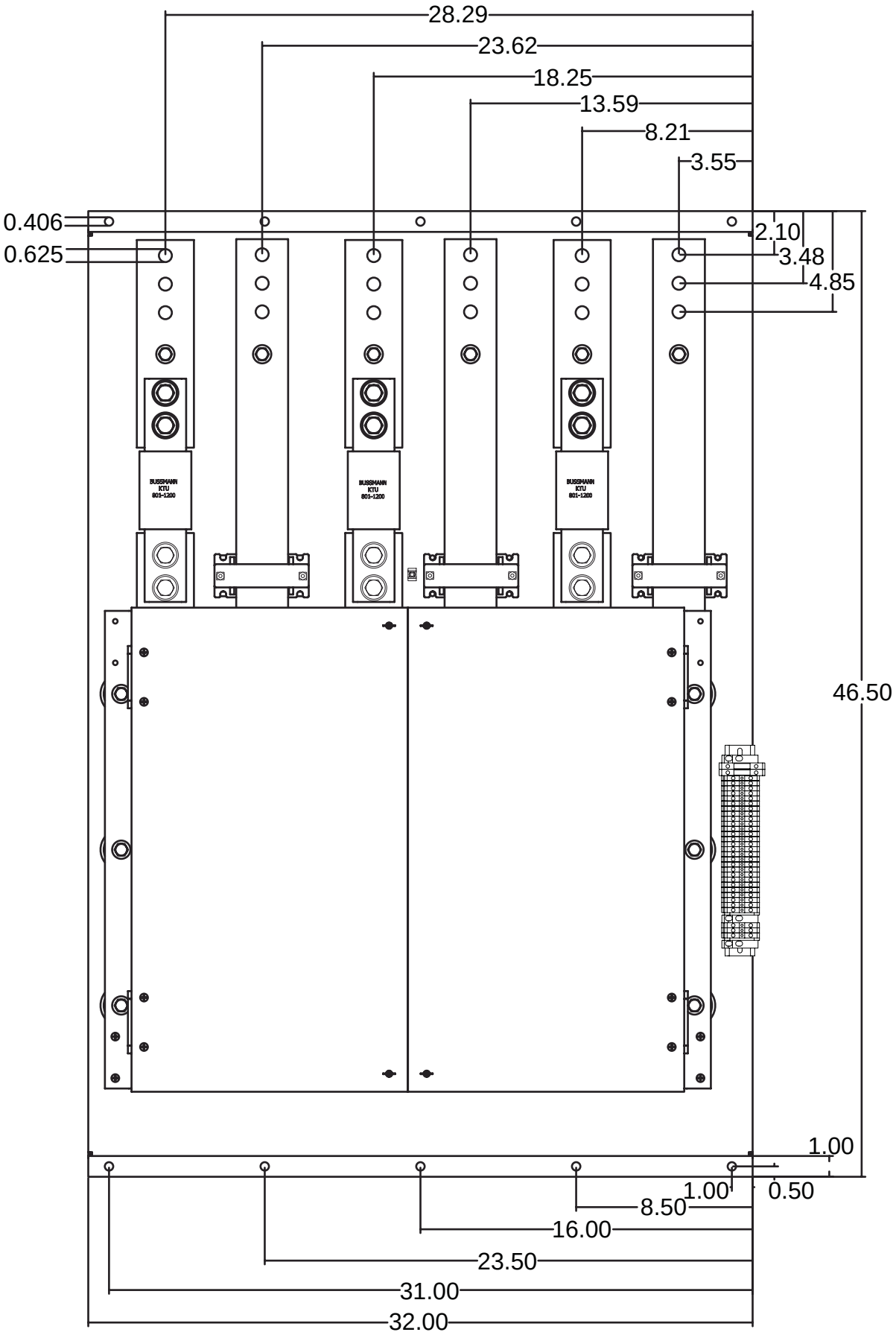


Figure 4. 3659 Contoller (Top view).

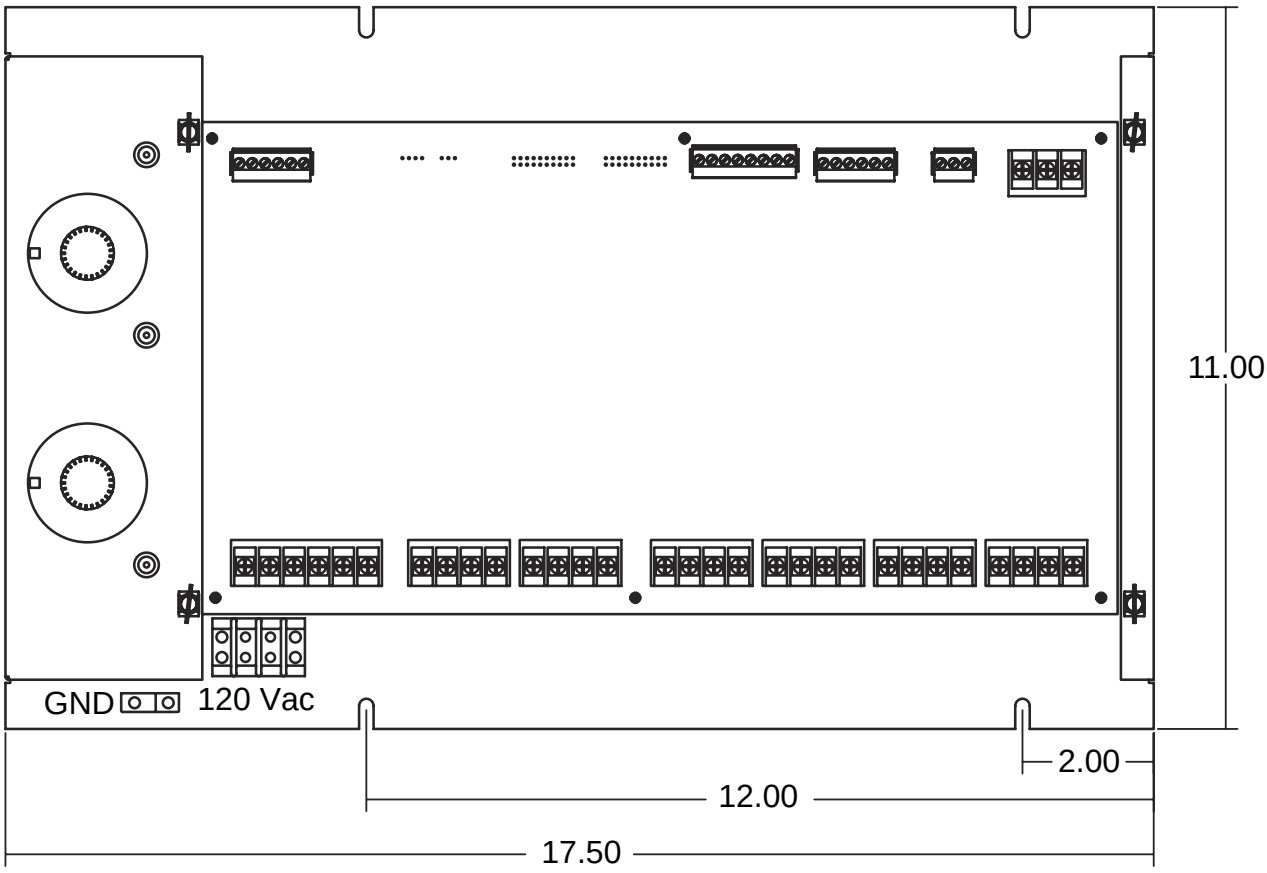


Figure 5. 3659 Remote Firing Circuit (Top view).

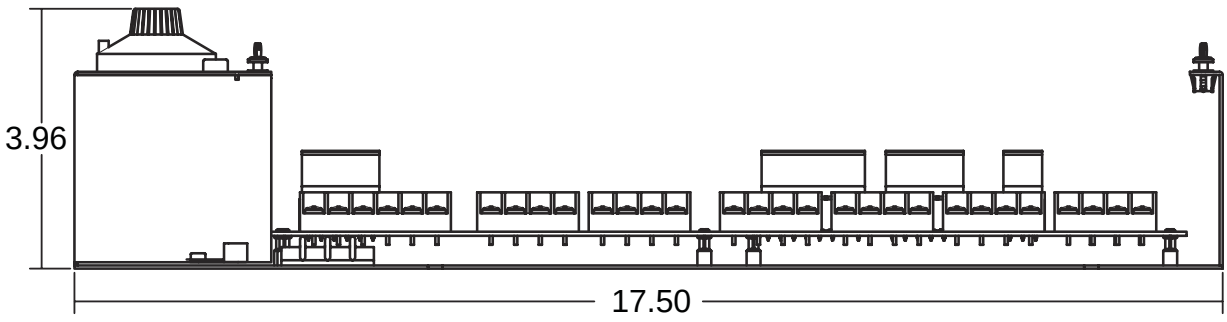


Figure 6. 3659 Remote Firing Circuit (Side view).

ADJUSTMENTS:

The Model 3659 is shipped from the factory fully calibrated. In most applications very little or no calibration is required. If field calibration is required, refer to the following:

REMOTE FIRING CIRCUIT
There are two multi-turn potentiometers (PA I Limit and OCT) and three metering connections on the remote firing circuit (com, PA I Limit and OCT).

PA I LIMIT (Phase-Angle Current Limit)
Rotating the PA I LIMIT potentiometer clockwise will increase the point at which the RMS load current will no longer increase when using phase-angle control. Current limit is not active in zero-cross or burst mode.

The PA I LIMIT is factory calibrated at 105%. If adjustments are desired, measure the voltage from the PA IL to the COM connections. Use the table below for appropriate settings.

Load Current %	Voltage (V)
20	-2.01
40	-4.02
60	-6.03
80	-8.04
100	-10.05
105	-10.55

Table 1. PA I LIMIT Calibration Voltage.

OCT (Over-Current Trip)
Rotating the OCT potentiometer clockwise will increase the point at which the RMS load current will cause the controller to trip or shutdown.

The OCT is factory calibrated at 175%. If adjustments are desired, measure the voltage from the OCT to the COM connections. Use the table below for appropriate settings.

Load Current %	Voltage (V)
50	.125
100	.250
150	.375
200	.500
250	.625
300	.750
350	.875
400	1.000
450	1.125
500	1.250

Table 2. OCT Calibration Voltage.

Refer to Figure 12 for the location of the Model 3659 controller calibration/adjustment potentiometers.

CMD1
ZERO (Command 1 Zero)
Rotating the CMD1 ZERO potentiometer clockwise will increase the output when the 4/20 mA command input is at its minimum. Rotating counter clockwise will decrease the output at a minimum.

SPAN (Command 1 SPAN)
Rotating the CMD1 SPAN potentiometer clockwise will increase the output when the 4/20 mA command input is at its maximum. Rotating counter clockwise will decrease the output at a maximum.

CMD2
ZERO (Command 2 Zero)
Rotating the CMD2 ZERO potentiometer clockwise will increase the output when the voltage or potentiometer command input is at its minimum. Rotating counter clockwise will decrease the output at a minimum.

SPAN (Command 2 Span)
Rotating the CMD2 SPAN potentiometer clockwise will increase the output when the voltage or potentiometer command input is at its maximum. Rotating counter clockwise will decrease the output at a maximum.

CALIBRATION
The zero and span adjustments for a given input or output will interact. If adjustments become necessary, the following procedure should be followed.

1. Set the command signal to minimum and adjust the zero potentiometer until the output is zero. If this pot is set incorrectly, the output of the controller may not be linear with respect to the command signal, or, the controller may be unable to shut off completely.

2. Set the command signal to maximum and adjust the span potentiometer until the output is at the desired maximum value. If this pot is set incorrectly, the output of the controller may not be linear with respect to the command signal, or, the controller may be unable to reach full output.

3. Repeat steps 1 and 2 until no further adjustment is necessary.

INDICATORS:

The LED indicators are to assist in determining the status of the Model 3659, and also assist with troubleshooting. All indicators are located on the remote firing circuit board and can be seen in Figures 7 & 9.

SSCR (Red)
A red LED lights if a shorted SCR condition occurs.

ZC MODE (Green)
The ZC MODE indicator will turn on while the controller is in zero-cross mode. This is determined by the connections made on P12 (Refer to Figure 18).

PA MODE (Green)
PA MODE indicator will turn on while the controller is in phase-angle mode. This is determined by the connections made on P12 (Refer to Figure 17).

BURST MODE
The green PA mode LED and the green ZC mode LED will be lit to indicate Burst mode.

2 ELEMENT MODE (Yellow)
2 ELEMENT MODE indicator will turn on when the controller loses one of the loads. It will operate on 2 elements. The ALARM LED will also turn on.

IL (Yellow)
IL indicator will turn on while the controller is in current limit. The current limit can be adjusted by a multi-turn potentiometer on the bottom of the remote firing circuit. The ALARM LED will also turn on.

LINE OK (Green)
LINE OK indicator will turn if supply voltages are present.

ALARM (Red)
ALARM indicator will turn on if a 2 element mode or current limit condition exists.

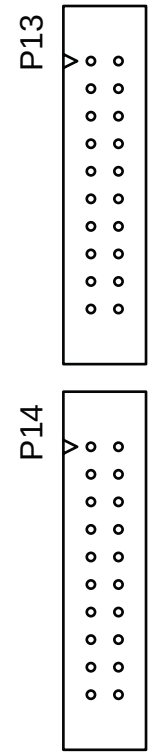
SHUT DOWN (Red)
SHUT DOWN indicator will turn on if the controller has a SSCR, OCT, or over temp.

T-STAT (Red)
There are 3 T-STAT indicators, one for each of the different phases (A, B, C). Each T-STAT is connected to a separate heatsink. The SHUT DOWN LED will also turn on.

I LOAD (Green)
There are 3 I LOAD indicators for each of the different phases (A, B, C). The intensity of the indicator varies as a function of load current.

CMD (Green)
CMD indicator varies as a function of command signal.

20 PIN CONNCECTORS FOR REMOTE HOOK-UP



P13	
ZC MODE (Green)	3, 4
PA MODE (Green)	5, 6
2 ELEMENT MODE (Yellow)	7, 8
IL (Yellow)	9, 10
LINE OK (Green)	11, 12
ALARM (Red)	13, 14
SHUT DOWN (Red)	15, 16
SSCR (Red)	17, 18

P14	
T-STAT A (Red)	4, 5
T-STAT B (Red)	6, 7
T-STAT C (Red)	8, 9
I LOAD A (Green)	10, 11
I LOAD B (Green)	12, 13
I LOAD C (Green)	14, 15
CMD (Green)	16, 17

The even pins on P13 and P14 are the Cathode.

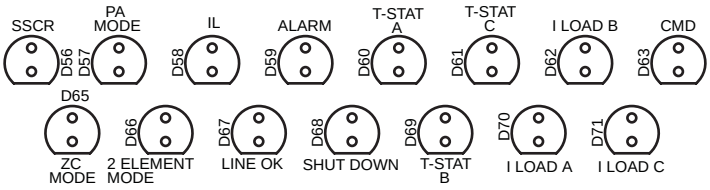


Figure 7. Indicator LED Arrangement.

REMOTE FIRING CIRCUIT BOARD:

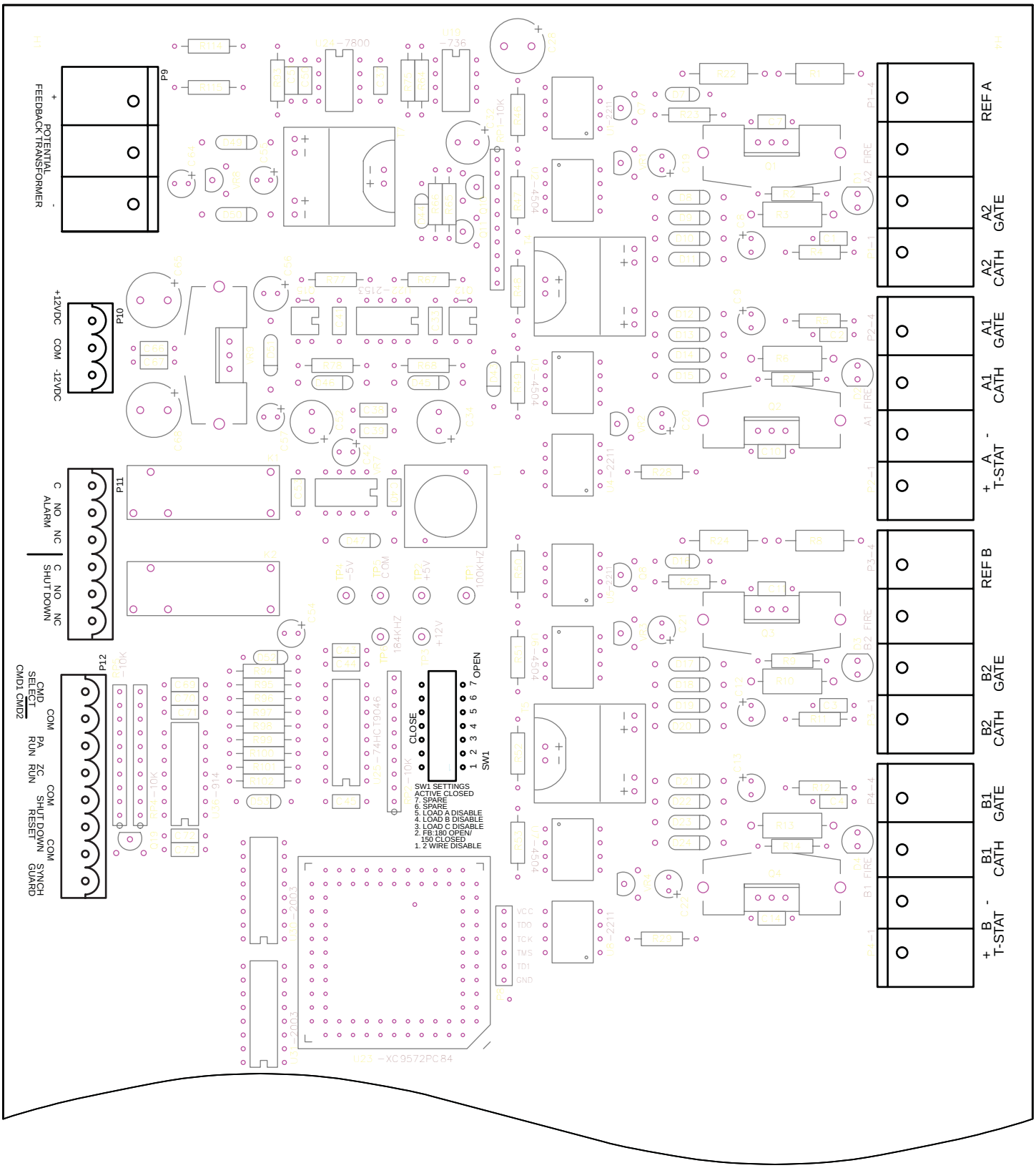


Figure 8. Remote Firing Circuit Board.

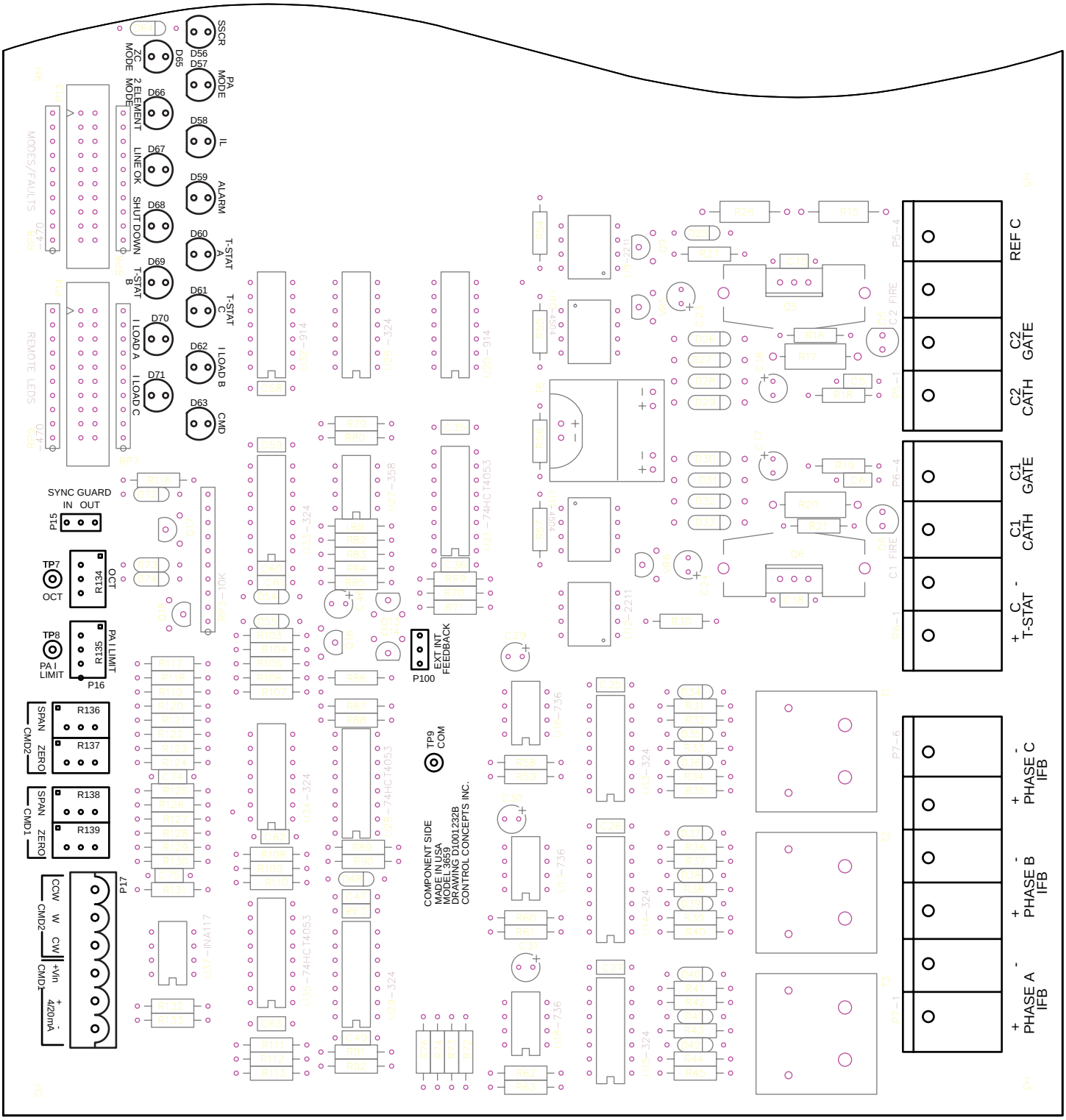


Figure 9. Remote Firing Circuit Board (Continued).

CONNECTIONS:

Additional wiring is required after installation of the 3659 controller and the remote firing circuit box. Consult factory for field wiring diagrams.

On the remote firing circuit there are black terminal blocks that span vertically on the right side of the circuit board. Each connector is labeled with the appropriate connection to be made. This can be seen in Figure 8 & 9.

On the controller there is a gray command connector (TB1) located on the side of the base plate. This can be seen in Figure 8. The connector is enlarged and labeled with the appropriate connections in Figure 11. The controller is also labeled with the connections.

The controller (numbers 1 & 2) and the remote firing circuit have two 120 Vac terminals. These need to be wired to a 120 Vac source with 5 x 20 mm 2A 250V SLO-BLO fuses in place.

Note: See Figure 9 for location of the 120 Vac terminals of the remote firing circuit.

The EARTH GND (number 3) of the 3659 controller needs to be connected to an earth ground.

The TB1 command connector needs to be wired directly to the black terminal blocks of the remote firing circuit. There will be 27 connections, these are numbered 4 - 30.

The current transformers (numbers 4 - 9) need to be wired in the appropriate phase. Figure 10 shows how the transformers are wired with respect to the frame.

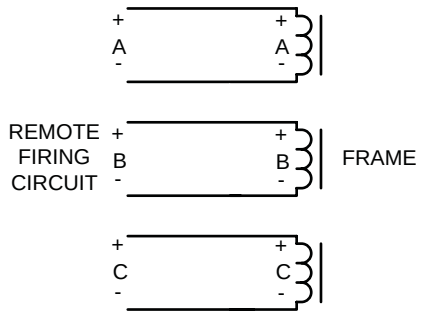


Figure 10. Current Transformer Wire Diagram.

Each zone has 2 sets of cathode and gate connections. These require a twisted pair, to each set, to limit noise. The connections that are affected are numbers 12-15, 19-22, 26-29. There should be six sets of total.

The phase reference wiring (numbers 31 - 33) is determined from the load connections. See Figures 24 - 26.

Note: Phase reference terminals in Figure 13 DO NOT get connected to the remote firing circuit.

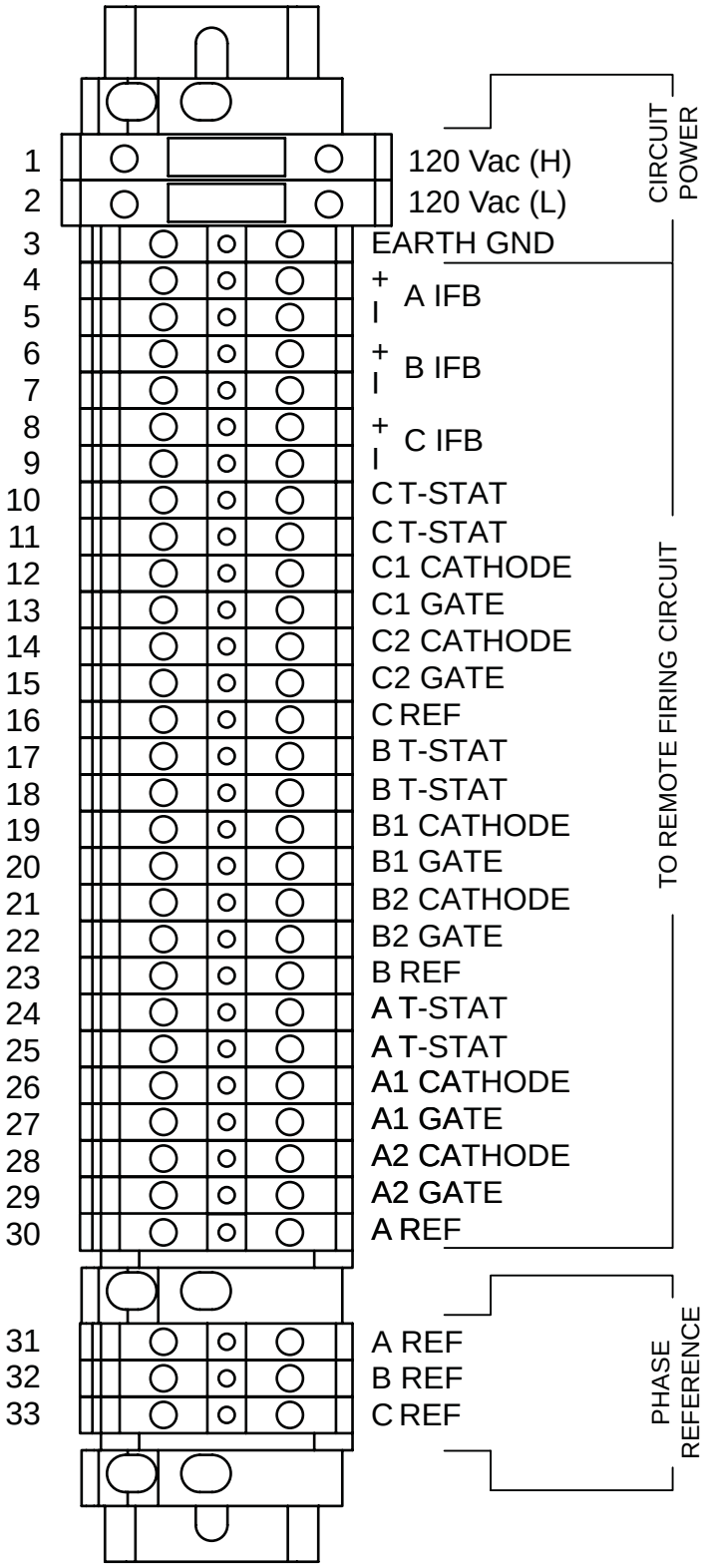


Figure 11. TB1 Command Connector.

SEE PAGE 14 FOR TORQUE SPECIFICATIONS
SEE SKETCH NUMBER S2115A ON PAGE 22

CONNECTIONS: (Continued)

4/20 mA Command Signal
On connector P17, connect the positive current connection to the +CMD1 and the negative current connection to the -CMD1 terminal.

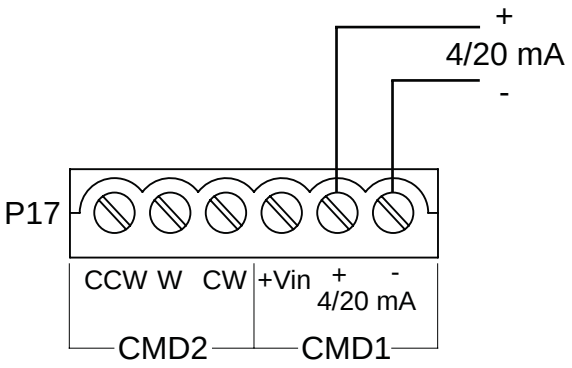


Figure 12. 4/20 mA Connection.

Voltage Command Signal
On connector P17 connect the positive voltage connection to the W CMD2 and the negative voltage connection to the CCW CMD2 terminal.

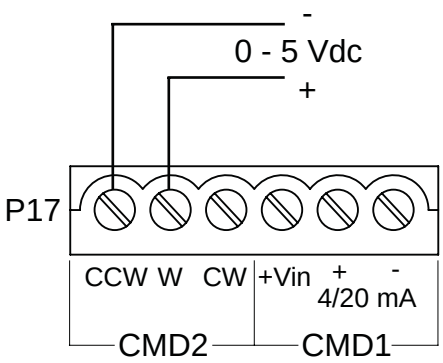


Figure 13. Voltage Connection.

Potentiometer Command Signal
On connector P17 connect the clockwise potentiometer connection to the CW CMD2 terminal. Connect the wiper potentiometer connection to the W CMD2 terminal and the counterclockwise potentiometer connection to the CCW CMD2 terminal.

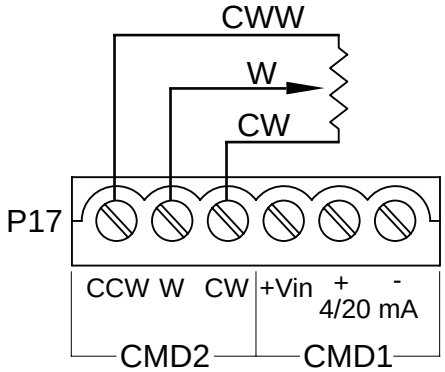


Figure 14. Potentiometer Connection.

Command Select
To select the 4/20 mA command (CMD1), leave the CMD SELECT to COM terminals open on P12. To select the Voltage or Potentiometer command (CMD2), short the CMD SELECT to COM terminals on connector P12.

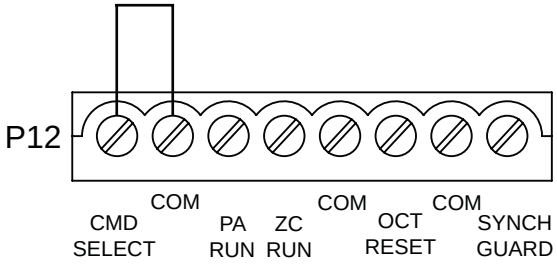


Figure 15. Command Select.

Phase-Angle Mode Select
To select the Phase-Angle control mode, short PA RUN to the COM terminal on connector P12.

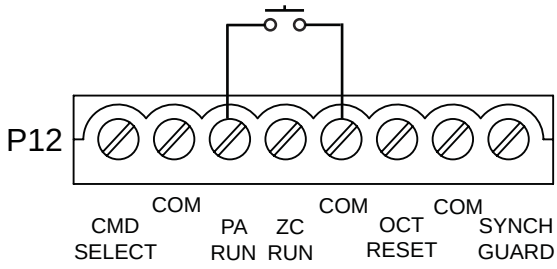


Figure 16. Phase Angle Select.

Zero-Cross Mode Select
To select the Zero-Cross control mode, short the ZC RUN to the COM terminal on connector P12.

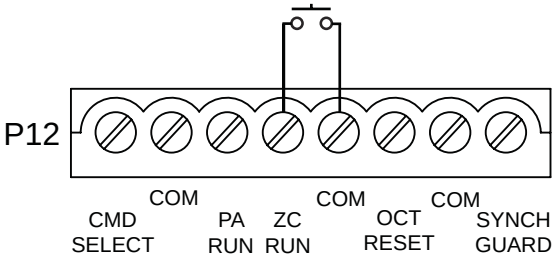


Figure 17. Zero Cross Select.
Note: When command is removed controller will shut down, **not** phase down.

Note: Connector P12 can be located on Figure 8.
Connector P17 can be located on Figure 9.

CONNECTIONS: (Continued)

Burst Mode Select
To select the Burst control mode, short the ZC RUN and PA RUN to the COM terminal on connector P12.

Note: When both the PA RUN and ZC RUN circuits are open, the control output will immediately go to zero.

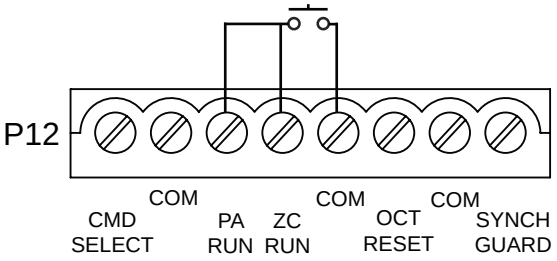


Figure 18. Burst Mode Select.
Note: When command is removed controller will shut down, **not** phase down.

Reset
To reset the circuit and latching relay output, short the RESET to the COM terminal on connector P12.
NOTE: The controller will shut down if Reset is closed while the controller is operating.

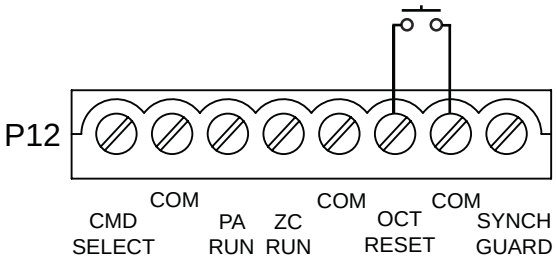


Figure 19. Reset.

Alarm
A Form C relay contact output is available to indicate the presence of current limit or 2 element mode. When an alarm condition exists, the NO ALARM to C contact will be closed and the NC to C contact will be open on the relay output on connector P11.

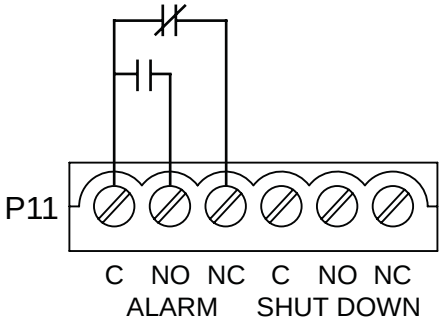


Figure 20. SSCR.

Shut Down
A Form C relay contact output is available to indicate the presence a shut down condition (SSCR, OCT or Over Temp). When a SHUT DOWN condition exists, the NO SHUT DOWN to C contact will be closed and the NC to C contact will be open on the relay output on connector P11.

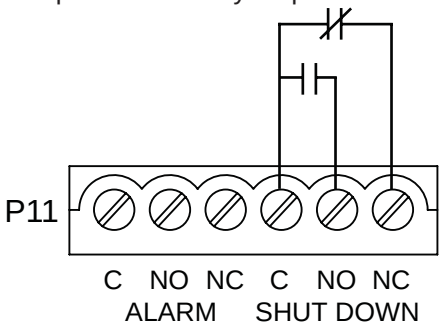


Figure 21. OCT.

Sync-Guard
The sync-guard feature is implemented by connecting the SYNCH GUARD terminal from all the controllers together, and the COM terminal from all the controllers together.

NOTE: A max of 8 controllers can be connected in the manner. One and only one of the controllers must have the P15 jumper in the "IN" position when using the Sync-Guard feature. The jumper location can be seen in Figure 9.

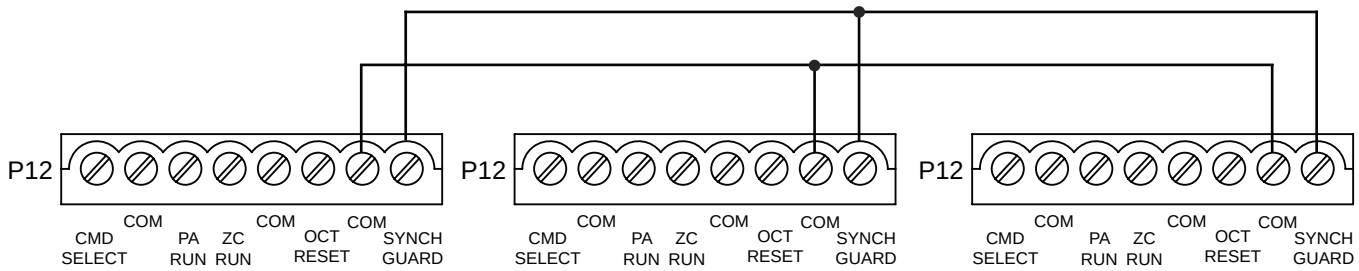


Figure 22. Sync-Guard Connection.

Note: Connector P11 and P12 can be located on Figure 12.

CONNECTIONS: (Continued)

Recommended tightening torque for screw down terminals:	
Wire Size (AWG)	Torque
12 to 22GA	**7.0 in-lbs**

Recommended tightening torque for green connector:	
Wire Size (AWG)	Torque
12 to 26GA	**5.0 in-lbs**

LINE AND LOAD CONNECTIONS:

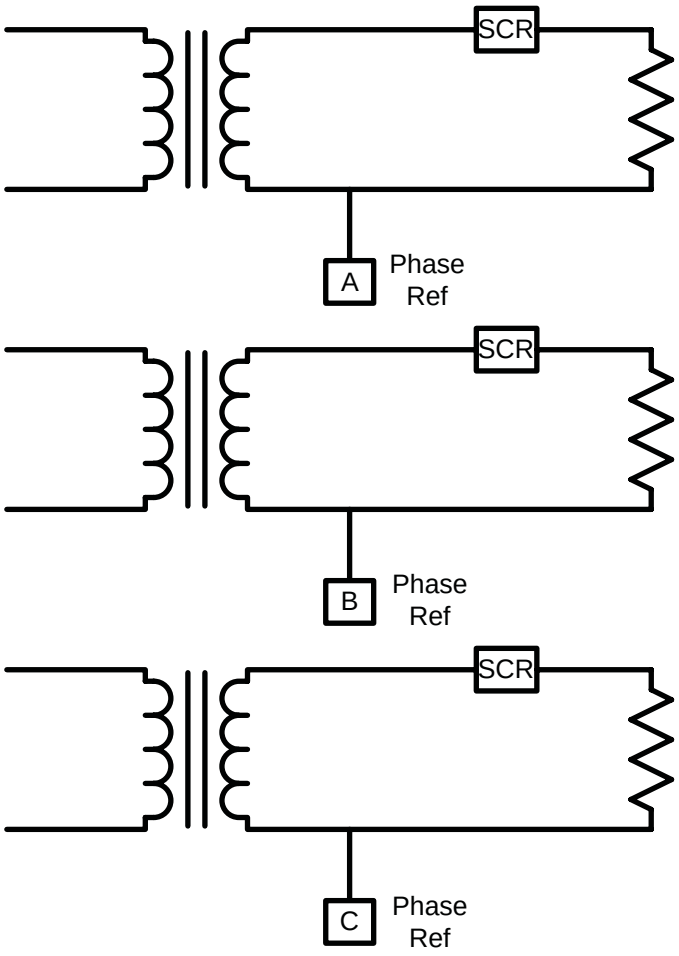


Figure 23. 3 Single Phase Supplies.

SEE SKETCH NUMBER S2116 ON PAGE 23 FOR ADDITION CONNECTIONS

SW1 SWITCH:

Make sure the power is OFF while changes are being made.

SW1 has seven switches that allow different operations. This is located on the remote firing circuit and can be seen in Figure 8 and enlarged in Figure 24. The switch setting are as follows:

SW1 Settings Active Closed:

1. 2 WIRE DISABLE
2. FB: 180° OPEN / 150° CLOSED
3. LOAD C DISABLE
4. LOAD B DISABLE
5. LOAD A DISABLE
6. SPARE
7. SPARE

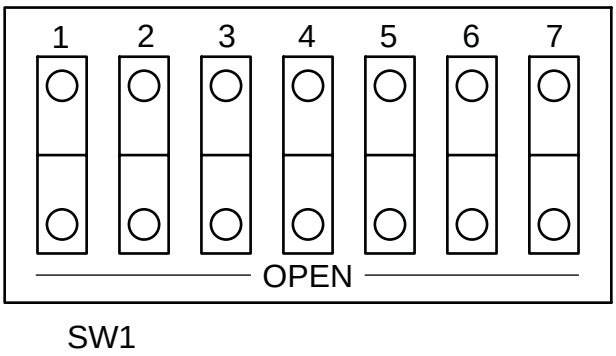


Figure 24. SW1 switch.

1. The controller will automatically switch to 2 element mode when a load does not draw enough current. When the switch is closed this feature is disabled.

2. If inline switch is open the controller is full on at 180° phase shift (4 wire wye or 2 legged mode).
   If inline switch is closed the controller is full on at 150° phase shift (not in 4 wire wye).

3. When this switch is closed it will disable Load C,

4. When this switch is closed it will disable Load B,

5. When this switch is closed it will disable Load A,

6. This switch is unused.

7. This switch is unused.

EXTERNAL FEEDBACK MODE:

Make sure the power is OFF while changes are being made.

To set the controller into external feedback mode an external feedback source is required. A 120 Volt potential transformer may be connected to P9. This is located on the remote firing circuit and can be seen in Figure 8 and enlarged in Figure 25.

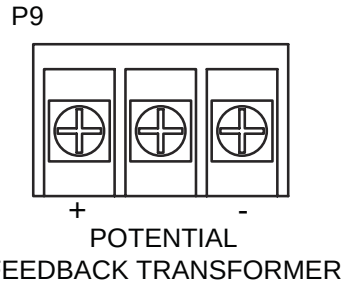


Figure 25. External Feedback Terminals.

P100 is a 3 pin header with a jumper. To find location see Figure 9 on page 10. In normal operation the jumper is connected to pin 1 and 2. See Figure 26. When external feedback is desired this needs to be connected to pins 2 and 3. See Figure 27.

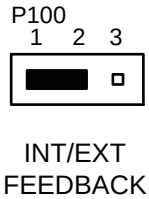


Figure 26. Internal Feedback mode.

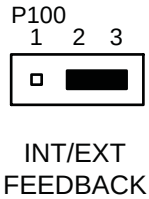


Figure 27. External Feedback mode.

To get back to internal feedback mode:
Remove the 120 Volt potential transformer.
Place the jumper of P100 on pins 1 & 2 (Figure 26).

OPERATION:

PHASE-ANGLE CONTROL
In Phase-Angle control, each SCR of the back-to-back pair is turned on for a variable portion of the half cycle that it conducts. Power is regulated by advancing or delaying the point at which the SCR is turned on within each half cycle.

Phase-Angle control provides a fine resolution of power and is used to control fast responding loads such as tungsten-filament laps or loads in which the resistance changes as a function of temperature.

Phase-Angle control is generally required if the load is transformer coupled, capacitive, inductive, or a variable resistance requiring current limit.

ZERO-CROSS CONTROL
In Zero-Cross control, load power is turned on or off only when the instantaneous valued of the sinusoidal waveform is zero. Load power is controlled by switching the SCRs "ON" for a number of complete half cycles and then "OFF" for a number of complete half cycles.

The following tabulation shows the number of "ON" and "OFF" half cycles that are applied to the load to achieve the percentage of load power indicated. The percentage of power is equal to the ratio of the number of half cycles that are "ON" to the total number of 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 off
				4 off
				23 on
				4 off
				23 on
				4 off
				21 on
				4 off

Table 3. 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 achieve 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.

BURST CONTROL
Burst control operates the same as zero cross control with some exceptions. In a 3 wire wye connections the first half cycle is fired at 60 degrees then at 90 degrees instead of at 0 degrees. This can be seen on page 18. In a 4 wire wye connection the first half cycle of every "ON" period is fired at 90 degrees then again at 120 degrees instead of at 0 degrees. This can be seen on page 19.

This hybrid type of control can consequently be used to control the primary of a transformer with transformer coupled loads by avoiding the excessive inrush currents that can occur with magnetizing inductance of the transformer (prevent transformer saturation).

Figures 28 - 45 on pages 17 - 19 are photos taken from an oscilloscope showing burst control operation in a delta, 3 and 4 wire wye load connections.

OPERATION: (Burst Control - Delta Load)

VOLTAGE

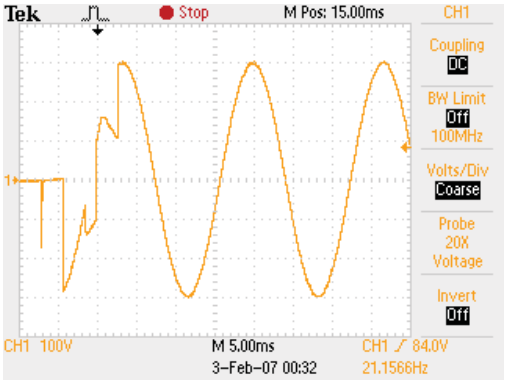


Figure 28. LOAD A - B (1-2).

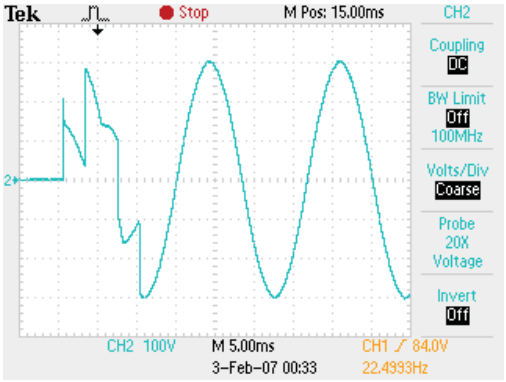


Figure 29. LOAD B - C (2-3).

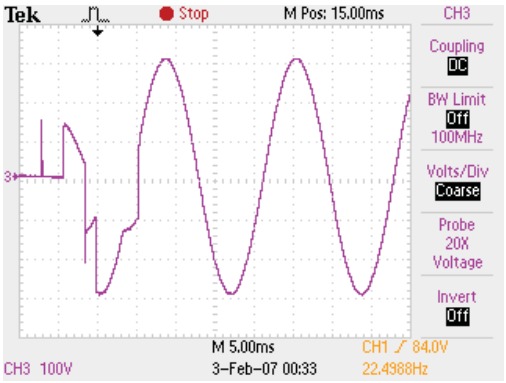


Figure 30. LOAD A - C (1-3).

CURRENT

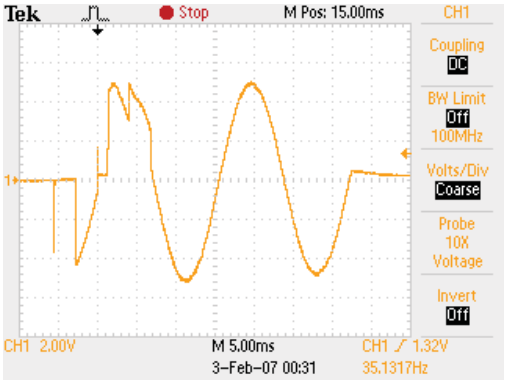


Figure 31. LOAD A (1).

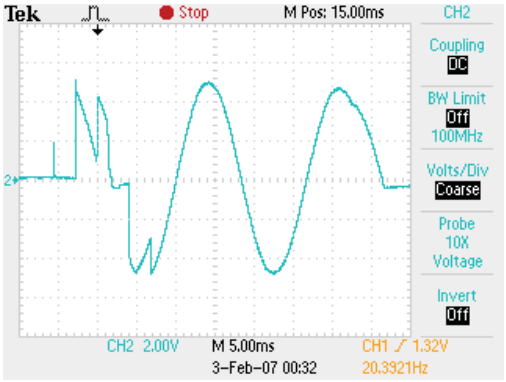


Figure 32. LOAD B (2).

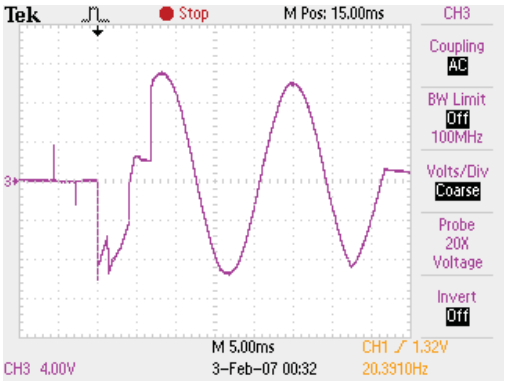


Figure 33. LOAD C (3).

OPERATION: (Burst Control - 3 Wire Wye Load)

VOLTAGE

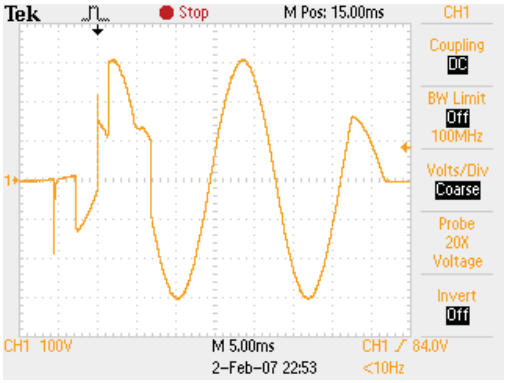


Figure 34. LOAD A - B (1-2).

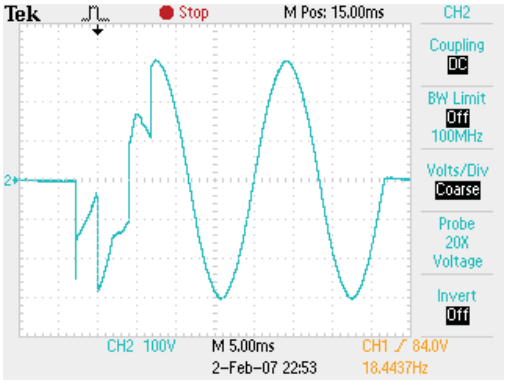


Figure 35. LOAD B - C (2-3).

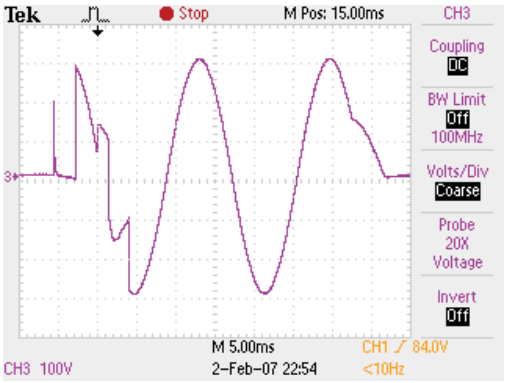


Figure 36. LOAD A - C (1-3).

CURRENT

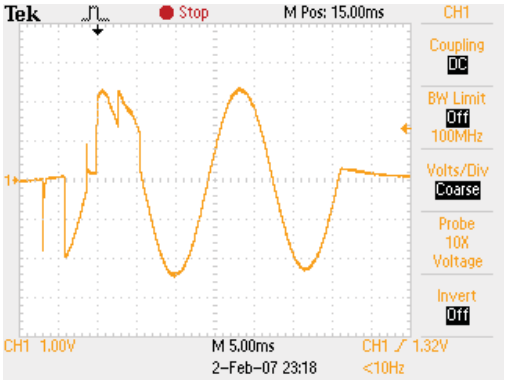


Figure 37. LOAD A (1).

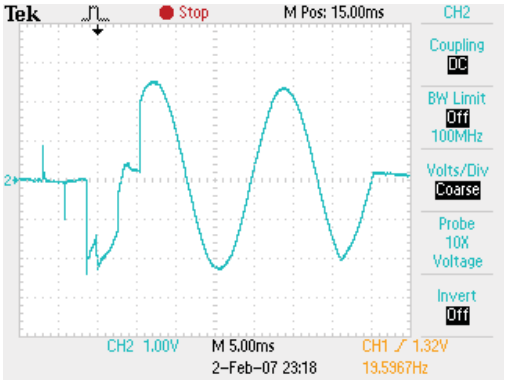


Figure 38. LOAD B (2).

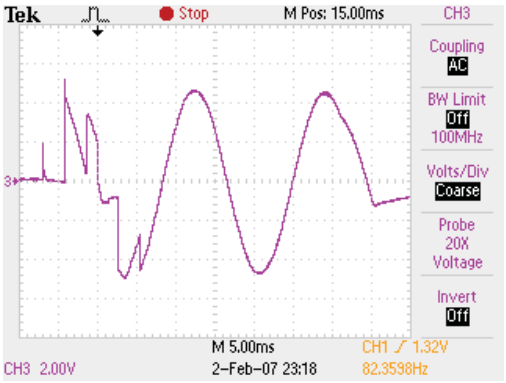


Figure 39. LOAD C (3).

OPERATION: (Burst Control - 4 Wire Wye Load)

VOLTAGE

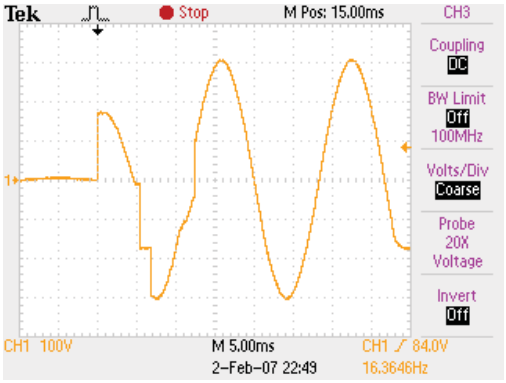


Figure 40. LOAD A - B (1-2).

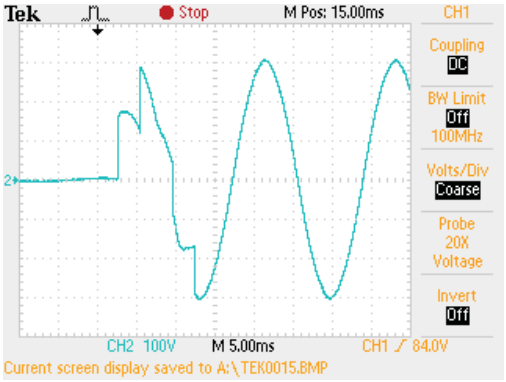


Figure 41. LOAD B - C (2-3).

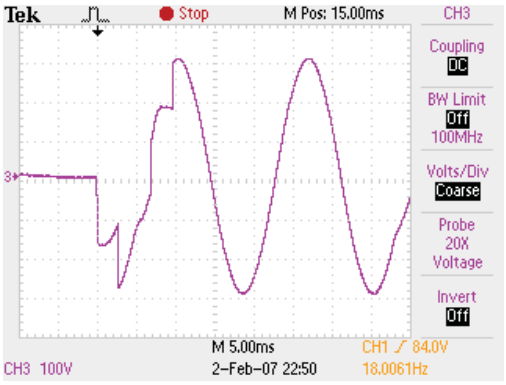


Figure 42. LOAD A - C (1-3).

CURRENT

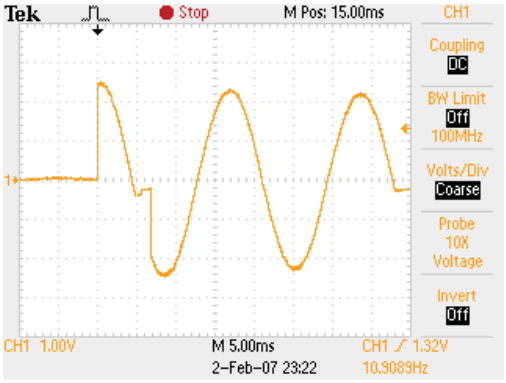


Figure 43. LOAD A (1).

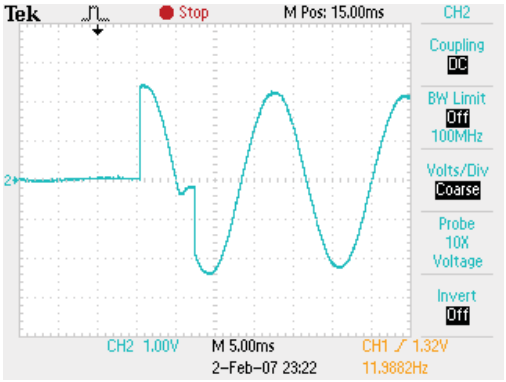


Figure 44. LOAD B (2).

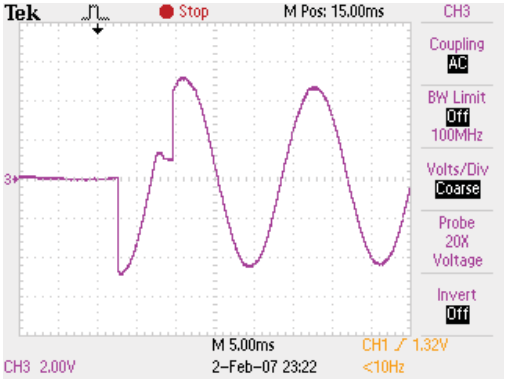


Figure 45. LOAD C (3).

TROUBLESHOOTING:

CAUTION:

High Voltage exists on controller, circuit board, and other equipment located near the controller. Use extreme caution to avoid electrical shock. Except for voltage and current measurements, remove power before attempting to service this equipment. Electrical measurements should be made by qualified personnel only.

NOTES	
Control Concepts has field service engineers who can help to determine the cause of controller problems. Please call (952) 474-6200 with any questions you may have.	When using average feedback you will get more accurate results if you make your measurements with an average responding meter. For accurate readings when using RMS feedback, use only a true RMS meter. The controller must have a load capable of drawing at least 1 A to operate properly. A circuit board with the exact same specifications may be substituted for a questionable circuit to help identify the location of the problem.

SYMPTOMS	POSSIBLE CAUSES
ZERO LOAD POWER. **'LINE OK' LED IS NOT ON:**	**PHASE MISSING AT LINE INPUT.** Check for line voltage at the line terminals. **CIRCUIT FUSE CLEARED.** Any transformer fuses, when cleared, will cause a loss of power to the firing circuit and will disable the controller. **POOR CONNECTIONS.** Determine that the frame wiring connectors are plugged fully into the circuit board connectors.
ZERO LOAD POWER. **'LINE OK' LED IS ON:**	Determine that a command (set point) signal is present between the CCW and W terminals on the command signal connector. See page 9. **INCORRECT COMMAND WIRING.** On new installations, check all command wiring and confirm correct polarities. **SHUT DOWN TRIP HAS OCCURRED.** If the SHUT DOWN LED has illuminated, an over current trip, shorted SCR or over temp has occurred. Close the reset switch or remove power temporarily to reset. **CLOSED RESET SWITCH.** If a remote reset switch is used, check that the switch is open. If a remote switch is not used, check that the voltage on terminal 9 is at least 10 Volts with respect to terminal 10.
LOAD POWER AT MAXIMUM. **'COMMAND' LED IS ON**	**PROBLEM WITH THE COMMAND SIGNAL.** Remove the command connector. If load power and line current indicators go off, the problem is associated with the command signal. **PROBLEM ON CIRCUIT BOARD.** If, after removing the command connector, the command indicator remains on, the problem is probably associated with the circuit board.
LOAD POWER AT MAXIMUM. **'COMMAND' LED IS OFF**	If this contition exists there could be a shorted SCR condition present. If this is not the case, then the circuit board is possibly bad.

TROUBLESHOOTING: (Continued)

SYMPTOMS	POSSIBLE CAUSES
LOAD VOLTAGE WILL NOT REACH MAXIMUM.	**INSUFFICIENT COMMAND SIGNAL.** Determine that the command signal is at maximum. **INSUFFICIENT LINE VOLTAGE.** Measure the voltage from phase to phase on the line and load terminals. If the voltage is correct at the load terminals but not at the load, check load wiring or external load fuses. **CURRENT LIMITING IS ACTIVE.** Current limit LED is on. The current limit prevents excessive current when controlling variable resistance loads. It is recommended that the current limit not be changed until the load requirements and the controller ratings are thoroughly understood. **INCORRECT SPAN ADJUSTMENT.** If the span adjustment pot is adjusted incorrectly, the controller may be unable to reach maximum output. See page 7. **INCORRECT LOAD WIRING.** On new installations, check the load connections carefully. **FAULTY SCR OR CONTROL CIRCUIT.** With a digital voltmeter set on the 2000 VDC range, check for a DC voltage present on the load output terminals of the controller. More than 1Vdc between any of the three load outputs could be due to a faulty SCR or control circuit. If the line current indicators are on, the circuit may have failed. If one LED is bright and the others are dim, an SCR or its connections may have failed.

REPLACEMENT PARTS:

The remote firing circuit is fused with (2) Littelfuse 0218002.MXP 5x20mm Slo-Blo 2A 250V.

The controller is fused with (2) Littelfuse 0218002.MXP 5x20mm Slo-Blo 2A 250V and (3) Bussmann KTU 1200A fuses.

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ATTACH SKETCH # S2115A

ATTACH SKETCH # S2116