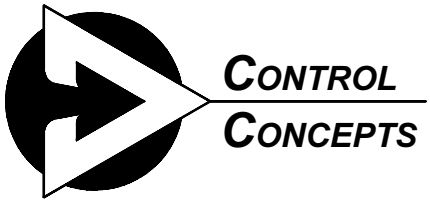
CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODEL 1039



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DESCRIPTION:

The model 1039 is a Phase-angle SCR power controller which allows either the RMS value of the load current, the RMS value of the voltage, or the average value of the load voltage to be linearly controlled with respect to the command signal.

The controller uses an electrically isolated SCR module containing two silicon controlled rectifiers arranged in an "inverse parallel" configuration to provide solid state switching of AC electrical power.

The SCRs are controlled by an electronic circuit which determines when the SCRs are turned "ON" within each electrical half cycle to obtain the desired load voltage or current. The circuit uses a digital phase locked timing technique to accurately determine the turn on time of the SCRs.

The entire assembly is mounted on an aluminum extrusion which dissipates the heat generated by the operation of the SCRs.

Additional Features include:

1. Current meter output: An electrically isolated 0-5Vdc output signal, proportional to the percentage of load current, is provided to operate a remote monitoring device. **Maximum load is 100mA.**

2. Voltage meter output: An electrically isolated signal, representing 1Vdc output per 100 volts across the load (RMS or average voltage, depending upon the model), is provided to operate a remote monitoring device. **Maximum load is 100mA.**

3. Missing cycle detection and soft start: This insures that the load voltage will always start at zero and increase at a predetermined rate to the desired output on start up or after a momentary power interruption.

4. Remote on/off switch: The circuit has a provision by which the SCRs can be turned off by opening the contacts of a remote switch.

5. LED indicators: Four LED indicators are provided. The intensity of two indicators are proportional to the command signal and hence proportional to the "ON" time of each of the SCRs. The intensity of another LED is proportional to the load current. The fourth indicator when "ON" indicates that the circuit has power and that the circuit is functional.

6. Load options: The controller is intended for the operation of inductive, capacitive, resistive or transformer coupled loads. The soft start feature and missing cycle detection feature make it ideally suited for transformer coupled loads and/or resistive loads such as tungsten lamps in which the resistance of the load is low when cold.

7. Voltage or Current feedback. A jumper on the circuit board selects whether the circuit will operate in the voltage or current feedback mode. Current feedback is useful when variable resistance loads are used.

8. DC Voltage or potentiometer control: The controller will accept 0 to 5Vdc, or a potentiometer command signal input. A 1K potentiometer is recommended for optimum linearity, up to 20K is permissible. Other voltage command signals may be specified at time of ordering. Figure 4, on page 4 shows how a controller may be operated from a potentiometer or a 0 to 5Vdc signal using a form C switch as an auto-manual operation.

9. Optional current command signal: If specified at time of ordering, a current signal of 4 to 20 mA may be used as a command signal.

10. Optional current control circuit: The 1039 control circuit has a connector into which may be plugged, piggy-back style, a current option circuit which will add Over current trip, Shorted SCR detection, current limiting and run/idle control features to the 1039 controller.

11. Small size: The model 1039 was designed to give the most power controlling capability available in the smallest practical package.

12. Built in fuses: The model 1039 has built in fast acting fuses to protect the controller. These fuses can be used to protect the load as well. This feature cuts installation costs and space requirements by eliminating the need for extra fuse blocks in your equipment cabinets.

THEORY OF OPERATION:

An SCR is a solid state device capable of blocking line voltage in both polarities. The SCR can be caused to conduct current from anode to cathode by applying a signal between it's gate and cathode terminals. Alternating current is controlled by using two SCRs arranged such that current can be controlled in either direction.

Phase angle control controllers using SCRs vary the voltage or current applied to the load by varying the time within each electrical half cycle that power is applied to the load. The waveform shown as E_L in figure 1 represents the voltage waveform applied to the load. As the load voltage is increased the SCRs are turned on earlier in the cycle. As the load voltage is decreased the SCRs are turned on later in the cycle. The load voltage can be varied with infinite resolution from 0 to 100% of the line voltage. When the controller is used to control the load current the load voltage is varied to achieve the desired load current.

The circuit uses the point at which the sinusoidal waveform of the supply voltage is zero as a reference to determine the timing for when the SCRs are turned on. The circuit determines this point by a phase locked loop technique which computes the average value of the voltage for 45 electrical degrees before and 45 electrical degrees after what is assumed to be the instantaneous zero and then assumes the zero point to be that time within the electrical cycle that results when the two average values are equal. This greatly reduces the timing errors that would normally result, due to voltage transients that exist in industrial supply voltages.

This technique provides an extremely accurate SCR timing means and insures that virtually no DC components are applied to the load.

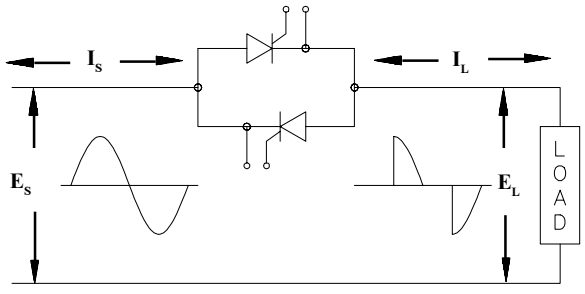


Figure 1.

INSTALLATION:

MECHANICAL:

The controller should be mounted in an enclosure that is free from dirt and dust and in which the temperature will not exceed 135ºF. The smaller frame controllers must be mounted on a vertical surface with the heat radiating fins vertical. The 90-180 amp frame, being forced air cooled, may be mounted in any direction.

WIRING:

The line and load terminals will accept wire sizes from #2 to #14 AWG. The terminals for control signals will accept wire up to #18 AWG. Figures 2 and 3 show the control and power connections to be made to the controller.

FUSES:

The fuses provided on the controller are intended for protection of the SCRs and the load. These are JJS class "T" fuses rated at 600 volts and manufactured by the Bussman Corporation. Control Concepts stocks a complete line of these fuses for your convenience. When ordering, give complete model number along with frame voltage and current ratings. See page 10 for a list of recommended spare parts.

START-UP:

CAUTION: Line voltage potential exists on the assembly and the circuit. Use extreme caution to avoid electrical shock. Before applying power to the controller confirm that the transformer tap is selected to be equal to the supply voltage. Avoid looking at or being near the equipment when power is first applied. Wiring errors could cause electrical arcs which can be dangerous.

Dielectric or hi-pot tests should be conducted with the fuses removed to avoid possible damage to the SCRs.

The following steps are recommended for initial start up.

1. Check that all electrical connections are correct and secure.
2. Set the command or control signal to zero.
3. Apply power.
4. The load voltage and/or load current should be zero.
5. Slowly increase the command signal and observe that the load voltage and/or current increases linearly as the command signal is increased.
6. Increase the command signal to maximum and observe that full power is applied to the load. Note that the controller may not turn completely on due to the characteristics of feedback control. For example, if voltage control is used, the load voltage may be less than the supply voltage if the supply voltage is greater than nominal. If load current control is used the load voltage may or may not be equal to the line voltage when the desired current is obtained.

SPECIFICATIONS:

Control Mode:	Single-phase, phase-angle control of either the RMS or the average value of the load voltage or of the RMS load current, depending upon the model.
Command Signal:	Standard control signals are either 0/5Vdc or potentiometer. Other control signals such as 4/20mA, 0/20mA, 1/5mA, etc. are available and identified in the model number.
Input Impedance:	0 to 5Vdc and potentiometer = 200K, 4/20mA = 300 ohms. Other current inputs will use input resistors to generate a 5Vdc control span.
Control Range:	0 to 98% of line voltage
Linearity:	Output will be linear within 0.5% of span over entire range of control.
Output Current Signal:	A 0 to 5Vdc signal representing the RMS value of the load current. Maximum loading of output signal is 100mA. Signal is derived from a current transformer on the controller.
Output Voltage Signal:	A DC signal scaled to provide 1Vdc per 100 volts of load voltage representing the RMS or average (depending upon control mode) voltage applied to the load. Signal is obtained by an optically isolated amplifier measuring the applied load voltage.
Zero and Span Adjustments:	Multi-turn potentiometers are provided to adjust the zero and span of the controller as well as the zero and span of outputs representing load voltage and current.
Cooling:	Convection up to 75 Amps. Forced air cooling on 90 to 180 Amp frame.
Dissipation:	Approximately 1.5 watts per amp of current will be dissipated by the controller.
Supply Voltage:	240, 480, 575Vac +10%,-20% 50/60 Hertz. Other operating voltages are available and specified within the model number identification.
Environment:	Operating temperature 0 to 55°C (32 to 132F)
Storage temperature:	-40 to 80°C (-40 to 176°F)
Humidity:	0 to 95% Non-condensing
Isolation:	Heat sink to supply and load voltage 2500 volts peak. Control or command signal to supply and load voltage 1500 volts peak. Capacitance between the command signal and the supply and load voltage 30 picofards.
Current Indicator:	The intensity of an LED varies as a function of the magnitude of the load current.
Line OK indicator:	An LED indicates that the circuit has power and that the phase locked loop detection circuit is operating. This indicator proves that nearly all of the circuit is operational.
Gate Drive Indicators:	The intensity of an LED on each gate drive varies with the ON time of each SCR and the magnitude of the command signal applied to the circuit.
SCR Gate Drive:	Optically coupled, current source, Duration - 90 electrical degrees
SCR Surge Current:	Peak 1 cycle surge current rating 1750 amps.
SCR I^2T Rating:	15,000 A^2S
SCR Voltage Rating:	Peak forward and reverse voltage rating 1400V.
DV/DT & Transient Rating:	200 volts/usec minimum. A dv/dt snubber and a metal oxide varistor (MOV) are provided to protect the SCRs against high frequency transients (dv/dt) and voltage spikes.
Physical:	Weight: 10 pounds
Dimensions:	Refer to installation drawing.

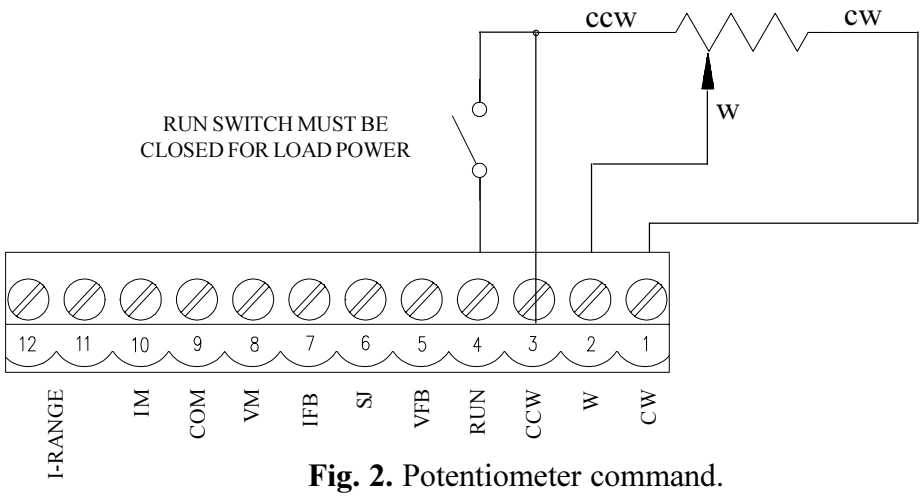


Fig. 2. Potentiometer command.

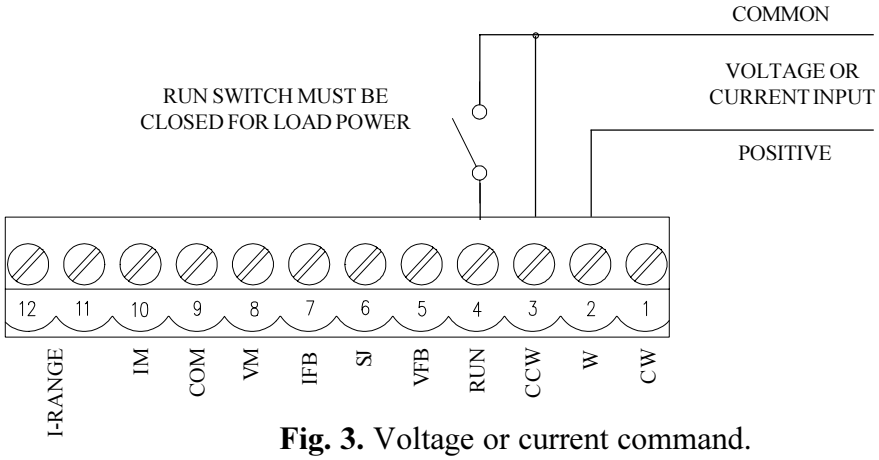


Fig. 3. Voltage or current command.

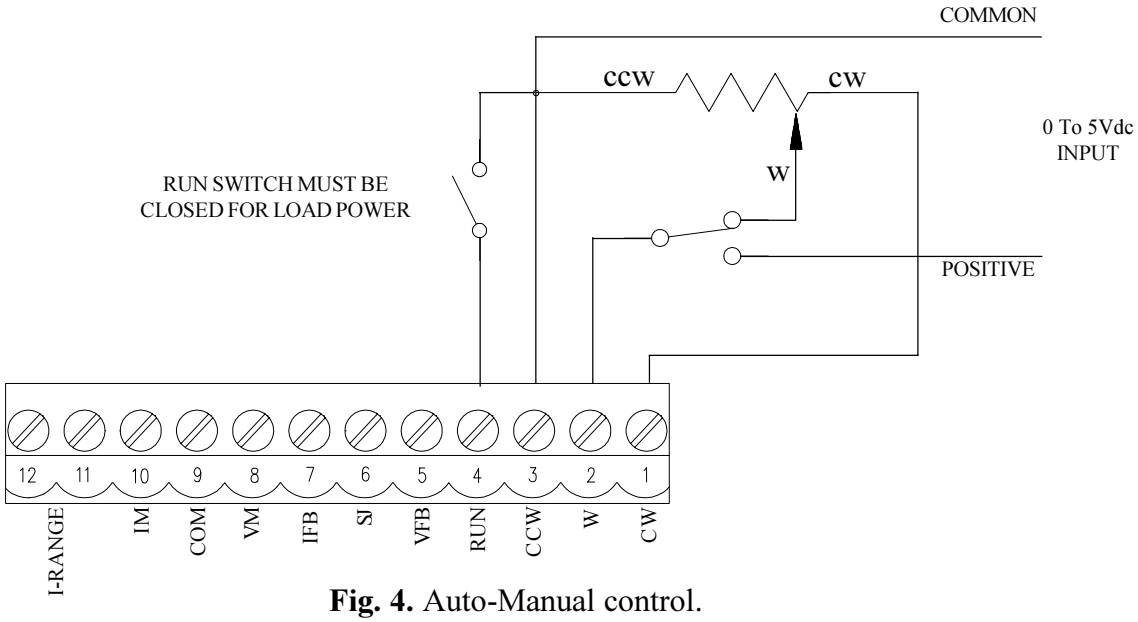


Fig. 4. Auto-Manual control.
(Auto-Manual control is also provided on the Current Option Circuit.)

VOLTAGE SELECTION:

It is possible to use the controller on 240, 480 or 575 volt lines. (Other voltages are available by special order.) To change to a different voltage requires the transformer tap be reselected to correspond to the new voltage. If the controller is set up for voltage feedback, the voltage feedback resistor must be changed as well. (Figure 6.)

Disconnect all power and load wires from the controller. Remove the connector from the transformer tap. Reapply the connector to the tap which corresponds to the new voltage.

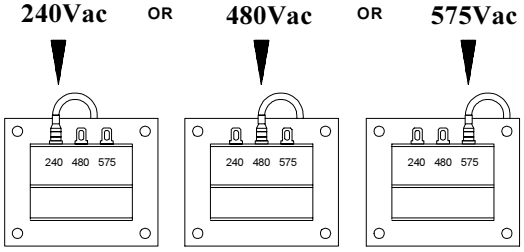
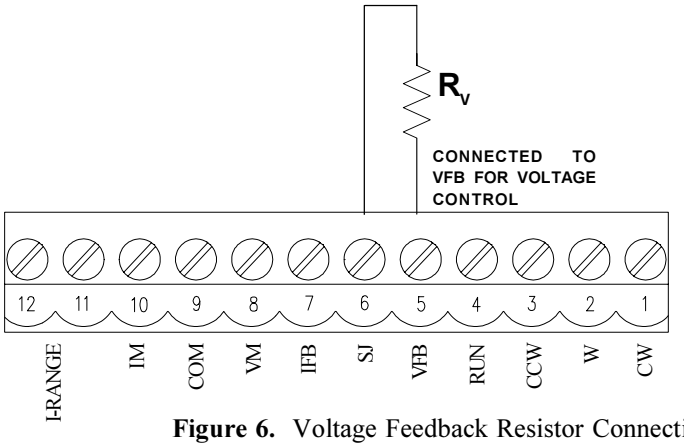


Figure 5. Transformer Tap Selection.



THE APPROPRIATE 1% VOLTAGE FEEDBACK RESISTOR R_V MAY BE SELECTED FROM THIS LIST;

120V - 1.24K
208V - 2.15K
240V - 2.49K
277V - 2.87K
380V - 3.92K
415V - 4.32K
480V - 4.99K
575V - 6.04K

Figure 6. Voltage Feedback Resistor Connections.

TO CHANGE CURRENT RANGES, THE SCALING RESISTOR R_I IS SELECTED BY ONE OF THE FOLLOWING FORMULAS;

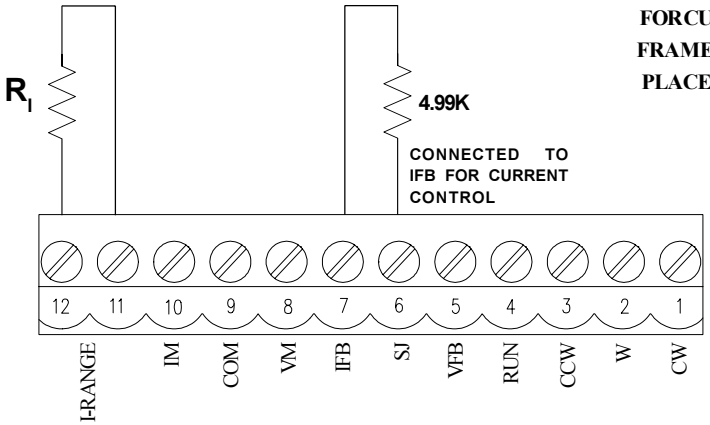
FRAMES UNDER 90 AMPS

$$R_I = \frac{1000}{\text{LOAD CURRENT}}$$

FRAMES 90 AMPS & LARGER

$$R_I = \frac{3000}{\text{LOAD CURRENT}}$$

1% RESISTORS ARE USED IN ALL CASES.



FOR CURRENT FEEDBACK ON ALL FRAMES, A 4.99K 1% RESISTOR IS PLACED ACROSS TERMINALS P2-6(SJ) TO P2-7(IFB)

Figure 7. Current Feedback Resistor Connections.

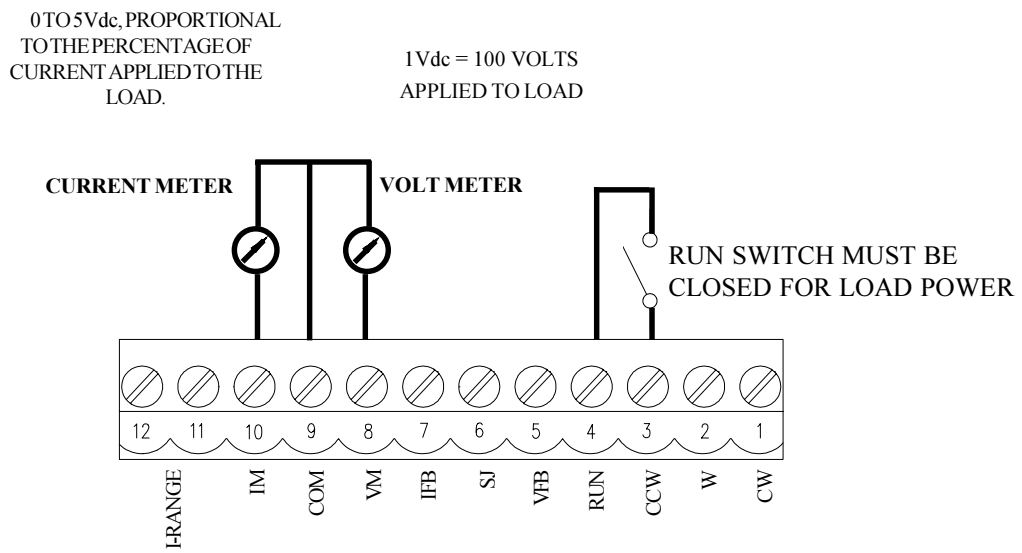


Fig. 8. Voltage and Current metering output.

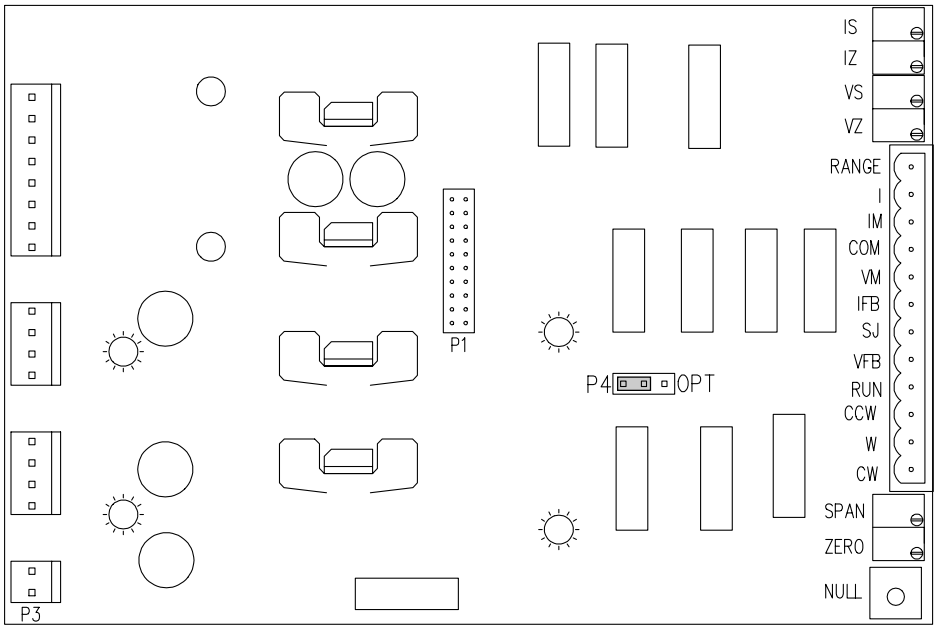


Fig. 9. 1039 board layout.

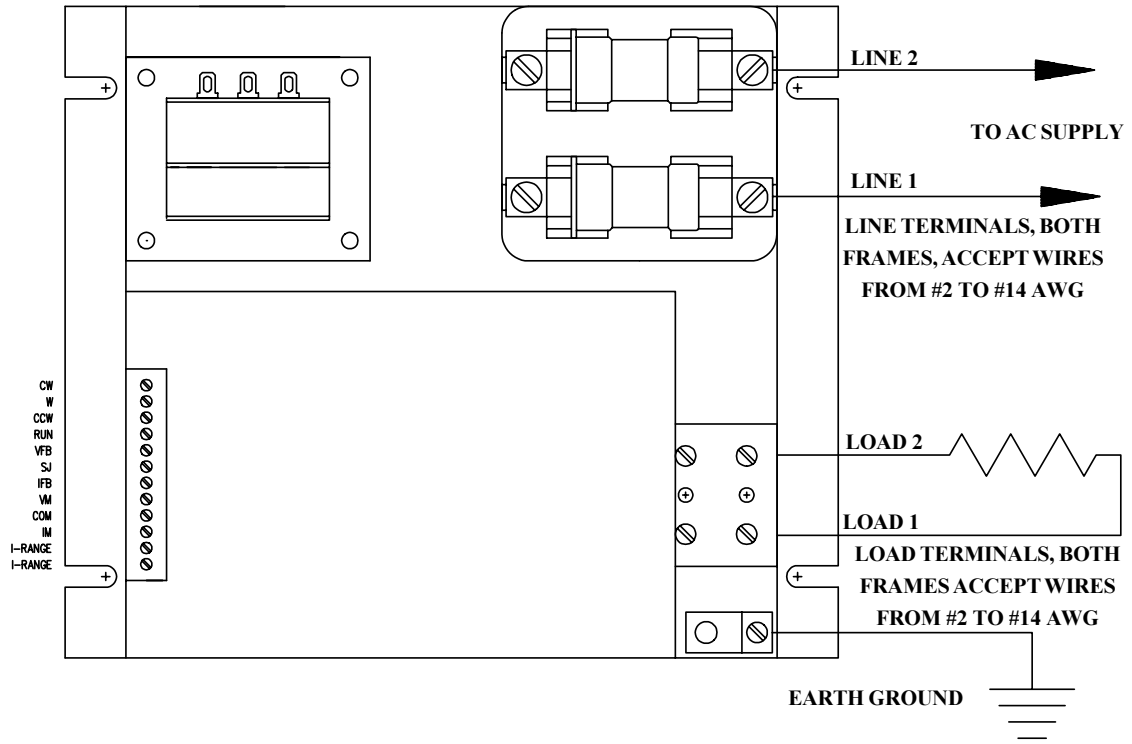


Figure 10. Power Connections, 10, 15, 20, 25, 30, 35, 40, 45 and 50 amp frames.

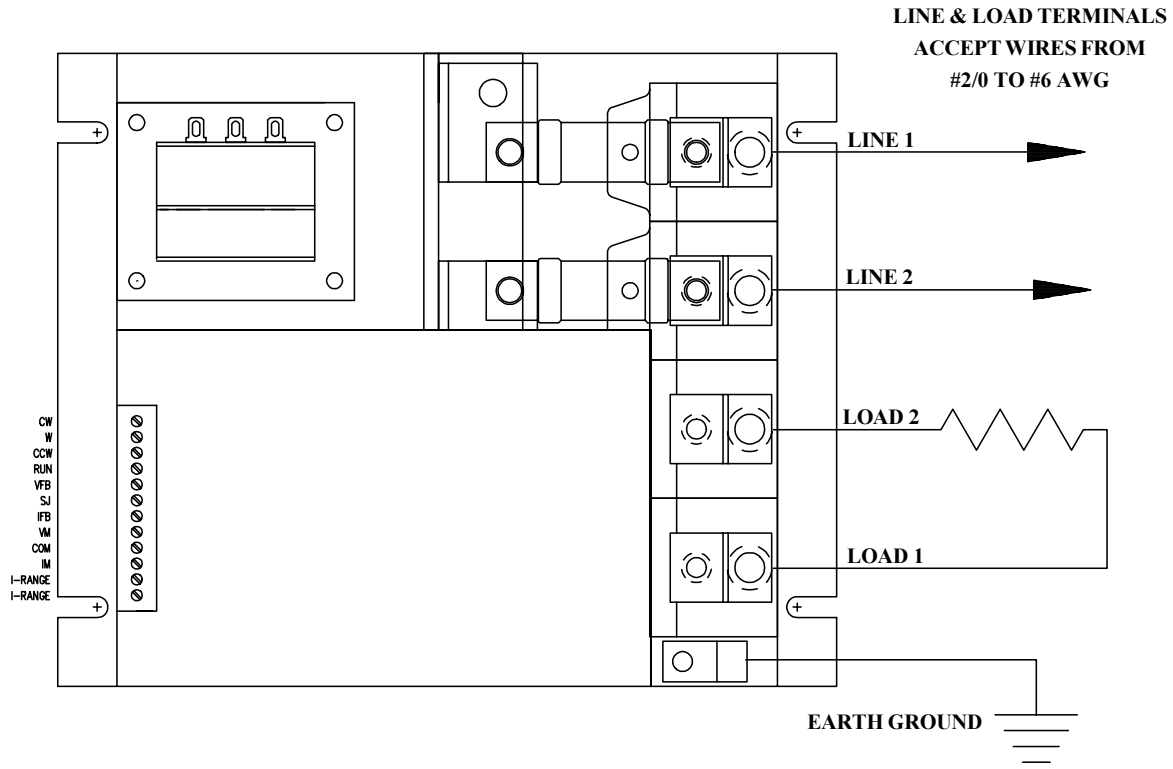


Figure 11. Power Connections, 55, 60, 65, 70 and 75 amp frames.

INSTALLATION DRAWINGS:

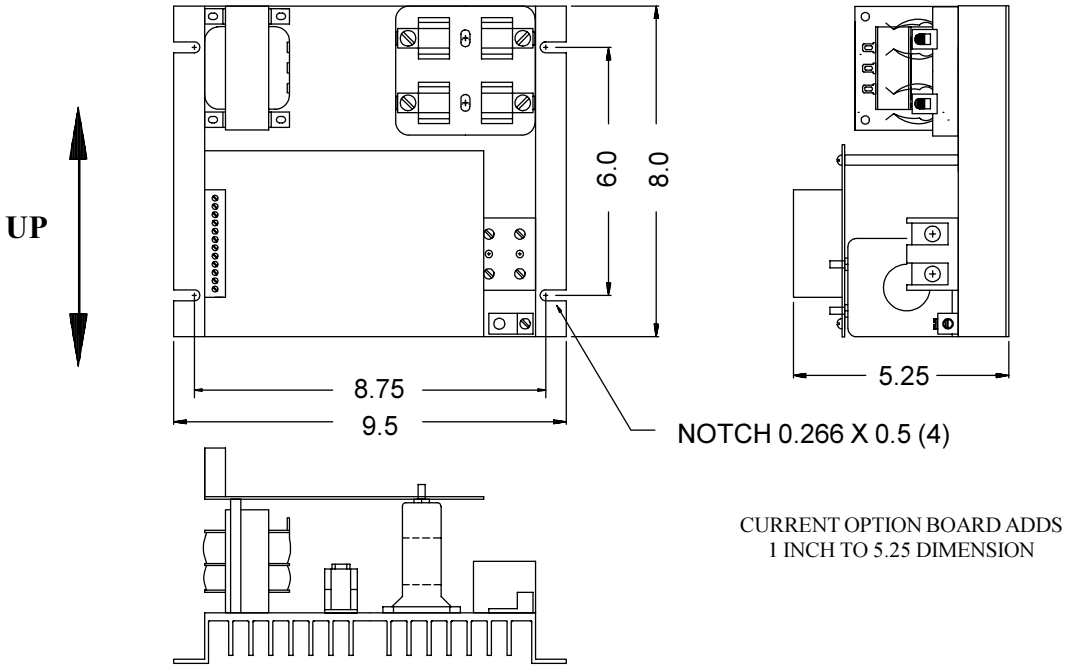


Fig. 12. Mounting dimensions of 10, 15, 20, 25, 30, 35, 40, 45 and 50 amp frames.

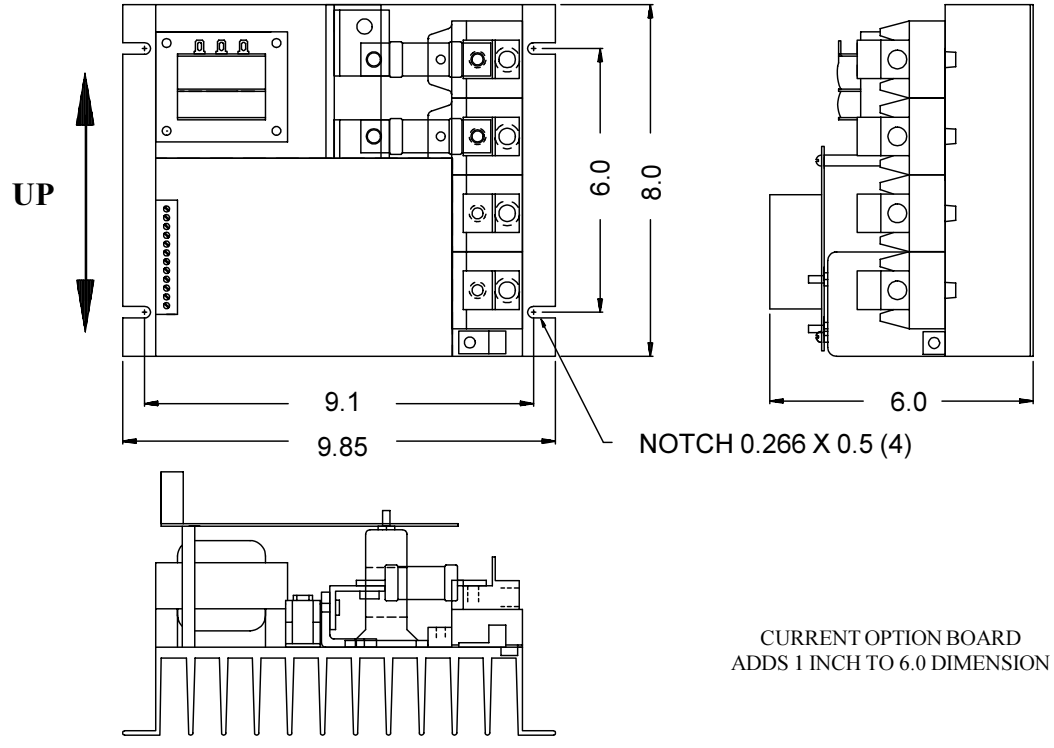


Fig. 13. Mounting dimensions of 55, 60, 65, 70 and 75 amp frames.

INSTALLATION DRAWINGS (cont):

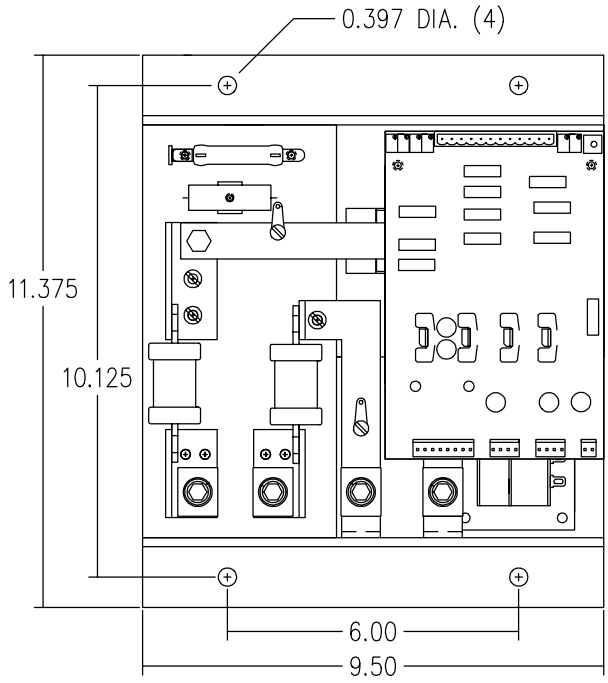


Fig. 14. Installation drawing of 90, 140 and 180 amp frame (top view).

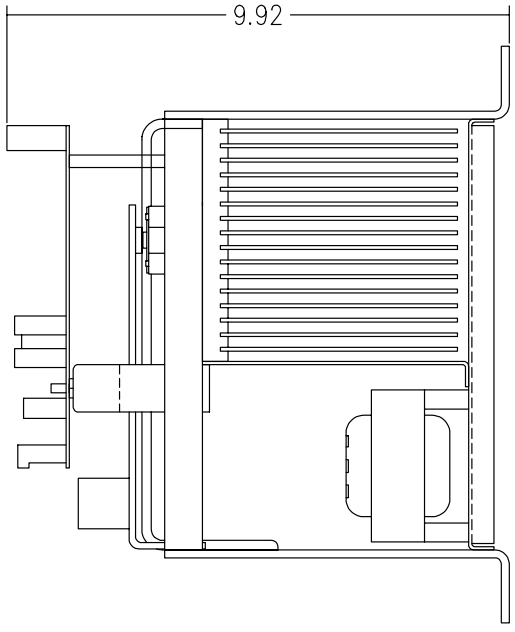


Fig. 15. Installation drawing of 90, 140 and 180 amp frame (side view).

ADJUSTMENTS:

The zero adjustment which determines the output at zero command and the span adjustment which determines the output at full command signal have been factory adjusted and should require no further adjustments. If adjustments are desired the following procedures should be followed.

1. With zero command signal determine that the voltage between the terminals labeled VFB and COM is zero (Terminal VFB is positive with respect to terminal COM). If this voltage is not zero adjust the potentiometer labeled R45. This is a null balance type of adjustment therefore adjusting potentiometer R45 will cause the voltage to decrease to zero and then increase. (The voltage will not become negative)

2. With the command signal set to zero adjust the zero potentiometer (R44) until the load voltage is zero (or is at the desired value).

3. With the command signal set to maximum adjust the span potentiometer (R43) until the desired load voltage is obtained.

4. It may be necessary to repeat steps 2 and 3.

5. Voltage output: Adjust the zero and span potentiometers VZ and VS (R41 and R42) with zero load voltage and maximum load voltage in the same manner as previously described to obtain the desired output signal. Note the voltage output is factory calibrated to provide 1Vdc per 100 volts of load potential.

6. Current output: Adjust the zero and span potentiometers IZ and IS (R40 and R39) with zero load current and maximum load current in the same manner as previously described to obtain the desired output signal. Note the current output signal has been factory calibrated to provide 5Vdc when the load current is equal to the rated current of the controller.

Note that RMS voltages or currents must be measured with meters that determine the true RMS values.

RECOMMENDED SPARE PARTS:

SCR Module:	Frame size	CCI #
	50 amps	28325-0395-514
	75 amps	28325-0410-514
	80-140 amps	28325-0410-514
	145-180 amps	28345-0413-514

FUSES:	CCI #	Bussman #
10 amp	42110-0460-310	JJS-10
15 amp	42110-0460-315	JJS-15
20 amp	42110-0460-320	JJS-20
25 amp	42110-0460-325	JJS-25
30 amp	42110-0460-330	JJS-30
35 amp	42110-0460-335	JJS-35
40 amp	42110-0460-340	JJS-40
45 amp	42110-0460-345	JJS-45
50 amp	42110-0460-350	JJS-50
55 amp	42110-0460-355	JJS-55
60 amp	42110-0460-360	JJS-60
65 amp	42110-0460-365	JJS-65
70 amp	42110-0460-370	JJS-70
75 amp	42110-0460-375	JJS-75
90 amp	42110-0460-390	JJS-90
100 amp	42110-0460-410	JJS-100
125 amp	42110-0460-412	JJS-125
150 amp	42110-0460-415	JJS-150
175 amp	42110-0460-417	JJS-175
200 amp	42110-0460-420	JJS-200

MODEL NUMBER

IDENTIFICATION:

MODEL 1039-FB-(vvv)V-(aa)A-F(ff)-(CS)

FB indicates the type of control

- **V** = RMS voltage control
- **I** = RMS current control
- **A** = Average voltage control

(vv)V = Rated voltage

(aa)A = Current at which meter output equals 5Vdc Also maximum output current when load current is controlled.

F(ff) = Fuse rating

(CS) = Type of Command signal: 0/5Vdc, 4/20mA or potentiometer. Or; specify special command signal: 1.2/6Vdc Etc.

For example, a **1039-V-480V-50A-F60-4/20mA** specifies that the RMS value of the load voltage is controlled, that the operating voltage is 480 Vac, that a current metering signal will be 5Vdc when the RMS value of the load current is 50 amps, fuses rated for 60 amps will be supplied with the controller and the controller will be calibrated for a command signal of 4/20mA.

Other designators may imply special calibrations and/or modifications which will be identified in an addendum to this instruction manual.

TROUBLE SHOOTING:

Control Concepts has field service engineers who can aid in determining the cause of controller problems. Please call with any problems or questions you may have.

CAUTION:

High voltage exists on controller, circuit board and may exist on other equipment located near the controller. Use extreme caution to avoid electrical shock.

Note: The controller must have a load capable of drawing at least 1 amp to operate properly.

Circuit card replacement: Remove the plug-in connectors from the circuit and plug-in to replacement. **Do not remove resistors from the connector or the wires to the plug-in connectors**.

THE FOLLOWING ARE SYMPTOMS AND POSSIBLE CAUSES:

NO LOAD POWER AND LINE OK LED IS NOT ON:

Determine that the fuses are okay and that power is applied to the correct terminals on the controller by measuring 5Vdc between terminals CW and CCW. If there is no 5Vdc present, check that the wiring to the control potentiometers is correct. A common problem is that of the wiper being connected to the CW terminal on the circuit. This can cause the 5Vdc supply to be shorted out. If another 1039 circuit board is available, swapping the boards would help in determining if the problem exists on the circuit board.

NO LOAD POWER: GATE DRIVE INDICATORS ARE OFF & LINE OK IS ON:

Determine that a command signal is being applied. On new installations check all command wiring and confirm that polarities are correct. Determine that the potential between the terminal labeled RUN and the CCW terminal is zero. If a remote run switch is used (terminals 3 & 4), check that the switch is closed. If a remote run switch is not used, check that the RUN terminal is connected to the CCW or COM terminal.

LOAD POWER AT MAXIMUM & GATE DRIVE INDICATORS ARE OFF:

On new installation check that the wiring is correct. On existing installations the problem is most likely due to a failure of the SCR module.

LOAD POWER AT MAXIMUM & GATE DRIVE INDICATORS ARE ON:

The problem is most likely associated with the command signal. Remove the plug-in connector. If gate drive indicators are now off, the problem is associated with the command signal. If the gate drive indicators remain on, the problem is associated with the circuit.

LOAD VOLTAGE WILL NOT EXCEED 70% OF THE SUPPLY:

This problem is a circuit board or an SCR failure. If only one gate drive indicator is on, the circuit has probably failed. Examine the circuit for failure of the 12 ohm resistors R5 or R8. Failure of these resistors will be due to other failures in the circuit and the circuit should be returned to the factory for repair. If one LED is bright and the other is dim the problem is probably due to an SCR failure or the electrical connections to it. The SCRs can be checked by measuring the resistance of the gate to cathode circuit. This measurement can be made by removing the plug-in connector connecting the assembly to the circuit and measuring that the resistance between terminal 7 and terminal 8 does not exceed 100 ohms and that the resistance between terminal 13 and terminal 14 does not exceed 100 ohms. Note; if the SCR module is replaced, apply a smooth thin coating of thermal compound (supplied with replacement modules purchased from Control Concepts, Inc.) to both mating surfaces.

REFERENCE DRAWINGS:

Schematic D1000568_2

MANUFACTURED BY:

CONTROL CONCEPTS