CONTROL CONCEPTS INC.

INSTALLATION MANUAL
MODEL 1027

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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 Heath 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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DESCRIPTION

The model 1027 linearly controls, with respect to a command or control signal, the electrical power applied to a single-phase resistive load by distributive zero-cross operation of silicon controlled rectifiers (SCRs). Distributive zero-cross operation implies that the supply voltage is switched on and off only when the instantaneous value of the sinusoidal supply voltage is zero and that the load power is controlled by varying the number of electrical half cycles that power is applied to and removed from the load. (See theory of operation for additional details.)

The controller depending upon the model number is capable of accepting either mA command signals, DC voltage command signals or it may be controlled by a potentiometer. Electrical isolation is provided to isolate the command signals from the line and load voltages.

Additional features of the 1027 controller include:

1. Line voltage compensation, which for a given command signal, maintains the load power constant independent of line voltage variations.
2. Sync-Guard, which provides a means to reproduce the synchronous operation of two or more controllers.
3. Trans-Guard, which prevents saturation of supply transformers which can result from zero-cross operation.

SPECIFICATIONS

CONTROL MODE:	Single-phase, distributive zero-cross control.
CURRENT RATING:	The "[**AAA**]A" term within the model number specifies the maximum continuous RMS current rating at the maximum operating ambient temperature of 55°C.
COMMAND SIGNAL:	Input — Resistance 1/5 mA — 1200 ohms 4/20 mA — 300 ohms 0/10 Vdc — 240K ohms 0/5 Vdc — 120K ohms Potentiometer — 240K ohms (1K recommended; 20K permissible 1/2 watt)
POWER CIRCUIT:	Inverse parallel silicon controlled rectifiers (SCRs)
OPERATING VOLTAGE:	208 or 240 or 480 Vac 50/60 Hertz +10 -15%. Other voltages are available, consult factory.
AMBIENT TEMPERATURE:	Operating 0 to 55°C Storage -40 to 80°C
HUMIDITY:	0 TO 95% Non Condensing
ISOLATION:	Isolation between power circuit, command signal and ground is greater than 2500 Vrms.
LINEARITY:	The load power is linear within 2% of span with respect to the command signal.
VOLTAGE COMPENSATION:	The load power remains constant within 2% of span for line voltage variations of +10% and -15%.
CONTROL RANGE:	0 to 99.5% of supply voltage.
SCR VOLTAGE RATING:	1600 volts peak
SCR I^2t RATING:	15,000 A^2s
DV/DT & TRANSIENT VOLTAGE PROTECTION:	DV/DT rating exceeds 200 volts per microsecond. A snubber circuit and MOV are provided to protect against high frequency transients (dv/dt) and high voltage transients.
ZERO AND SPAN:	Adjustment range is ±20% of span.
COMMAND INDICATOR:	An LED is lit when the SCRs are turned on.
HEAT DISSIPATION:	1.5 watts per amp of SCR current.

SYNC-GUARD™ FEATURE

The sync-guard feature reduces the possibility of synchronous operation of two or more controllers. This 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.

Figures 1 through 3 show the total current as a function of time for three controllers, with, and without SYNC-GUARD™ and various load powers.

Refer to Figure 7 for connections when using SYNC-GUARD™ on multiple model 1027's. Use only one load resistor for each group of controllers connected in this manner.

When using the SYNC-GUARD™ feature, the mA control signals must be isolated from each other.

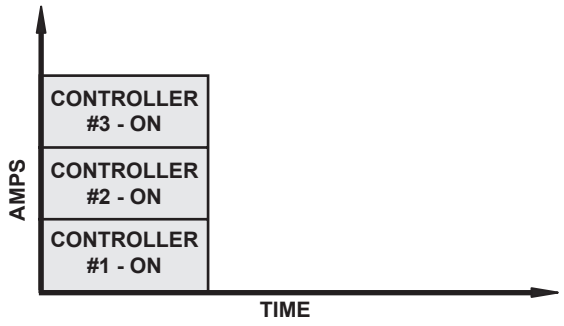

Figure 1. Three controllers providing 33.3% power each, operating synchronously.

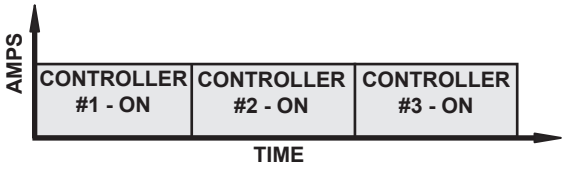

Figure 2. Three controllers providing 33.3% power each, with sync-guard.

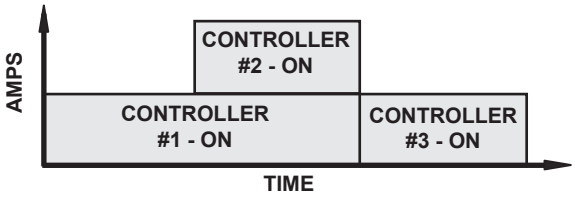

Figure 3. Three controllers with sync-guard, two providing 33.3% power & one providing 66.6% power.

TRANS-GUARD™ FEATURE

The use of zero-cross controllers on the secondary of a transformer can cause saturation of the transformer, resulting in excess transformer temperatures, and early failure.

Transformers can be caused to saturate if a DC voltage is applied to the primary. DC voltage can be induced on the primary by DC components in the secondary. The simple half wave rectifier circuit shown in Figure 4 will induce a DC voltage on the primary due to the fact that the voltage drop across the source resistance during the half-cycle the diode conducts will lower the primary voltage.

The TRANS-GUARD™ feature eliminates the problem by always supplying an odd number of ON half-cycles, and an even number of OFF half-cycles. Refer to table 1.

The saturation problem is not likely to occur when the load is a small percentage of the transformer capacity, or when the source resistance and inductance are small. However, the potential problem is eliminated by the TRANS-GUARD™ feature of the model 1027.

Note: The AC power source inductance can also cause a DC voltage to occur on the transformer primary.

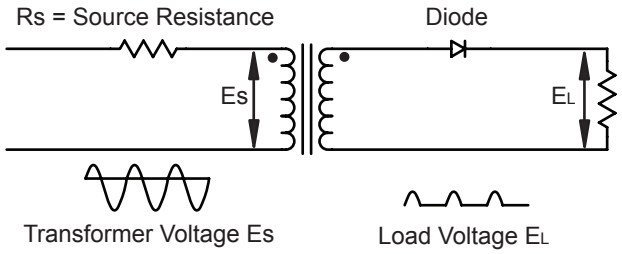

Figure 4. DC components in the secondary induce DC voltage in the primary causing transformer saturation.

INSTALLATION

DETERMINE THAT THE TRANSFORMER TAP IS SET TO A VALUE WHICH CORRESPONDS TO THE SUPPLY VOLTAGE.

MOUNTING AND LOCATION:
The controller should be mounted in an environment that is free from dust and contaminates and which will not exceed 55°C. The 100 amp controller must be mounted on a vertical surface with the fins vertical as shown on the installation drawing. Multiple controllers can be mounted immediately adjacent to each other. The fan cooled 150 amp controller can be mounted in any direction.

FUSES:
It is recommended that a fast acting fuse such as Bussmann types JJS & JJN class T or Carbone–Ferraz Class–FA be used to protect both the SCR controller and the load.

Fuses should typically be rated for approximately 120% of the maximum load current. Control Concepts maintains an inventory of most fuses and fuse holders and technical personnel are available to answer questions regarding fuse applications.

Recommended tightening torque for the line and load connectors: 	
Wire Size (AWG) or Circular Mills	Torque
4 to 6GA	**100 in-lbs**
1 to 2GA	**125 in-lbs**
1/0 to 2/0GA	**150 in-lbs**
3/0 to 4/0GA	**200 in-lbs**
250 to 350MCM	**250 in-lbs**
500MCM	**300 in-lbs**

Recommended tightening torque for edge card connector: 	
Wire Size (AWG)	Torque
14 to 26GA	**4.4 - 5.5 in-lbs**

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 Figure 6.

The connectors are rated for use with wire sizes from 250MCM to a #6. Type THWN or THNN wire is recommended. It is also recommended that an oxide inhibitor such as Brundy Pentrox A, or Ilsco De–OX be used on all power connectors to insure good electrical conductivity.

INSTALLATION DRAWINGS

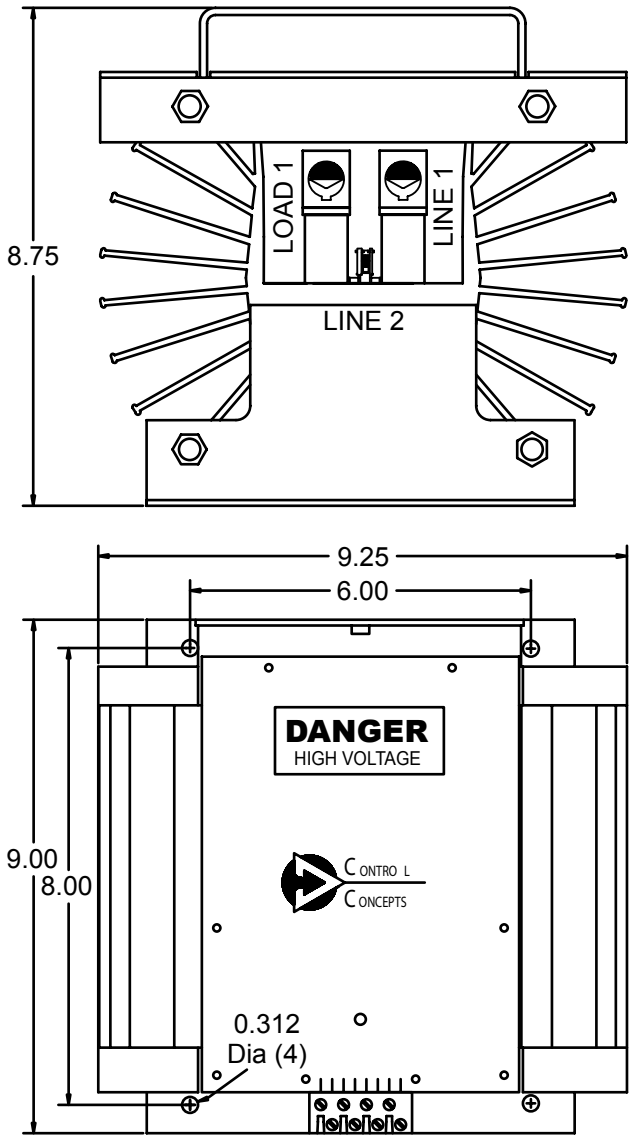

Figure 5. Installation Drawing for 100 to 180 Amp Models.

100 Amp model does not require a fan, and therefore. is important that this model be mounted so that the fins are oriented vertically.

LINE AND LOAD CONNECTIONS

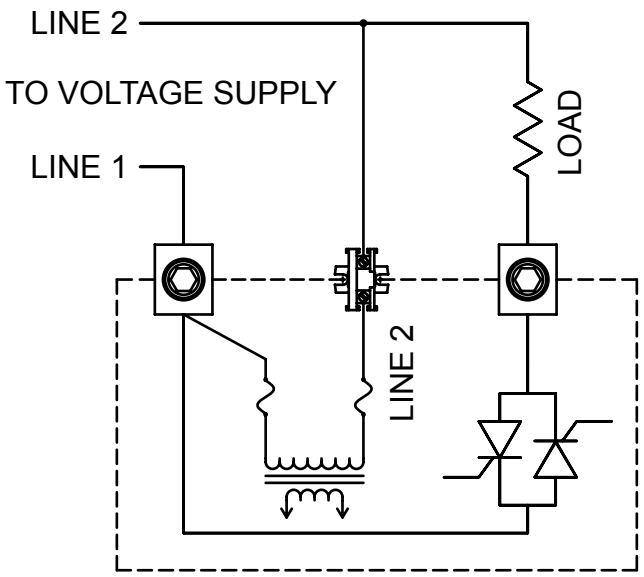

Figure 6. Power Path.

Fusing is recommended to protect the SCR controller and the load.

SYNC-GUARD CONNECTIONS

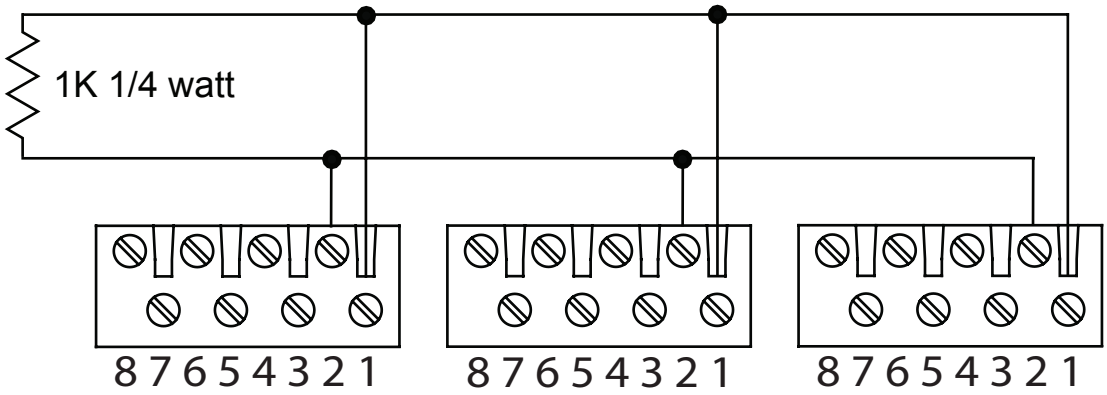

Figure 7. Sync-Guard Connections.

The Sync-Guard feature is implemented by connecting all terminals labeled 1 in parallel and all terminals labeled 2 in parallel and by connecting a 1K resistor as shown in Figure 7 across the connection made to terminals 1 & 2. (This circuit is electrically isolated from the line and load voltages.) A maximum of 8 controllers regardless of the current ratings can be connected in this manner.

LINE AND LOAD CONNECTIONS

4/20mA: Common (-) to terminal P2-4 (CCW), "+" input to terminal P2-3 (4/20mA)

0 to 5 Vdc: Common to terminal 4 (CCW), 5Vdc to terminal P2-3 (0/5V).

0 to 10Vdc: Common to terminal P2-4 (CCW), 10Vdc to terminal 5 (W).

Potentiometer (1K to 20K resistance, 1/2 watt):
Clockwise to terminal P2-6 (CW)
Wiper to terminal P2-5 (W)
Counterclockwise to terminal P2-4 (CCW)

Note: If multiple controllers are controlled by one potentiometer, make the connections as described for one controller and connect terminal P2-4 (CCW) to terminal P2-4 (CCW) on all controllers, and terminal P2-5 (W) to terminal P2-5 (W) on all controllers.

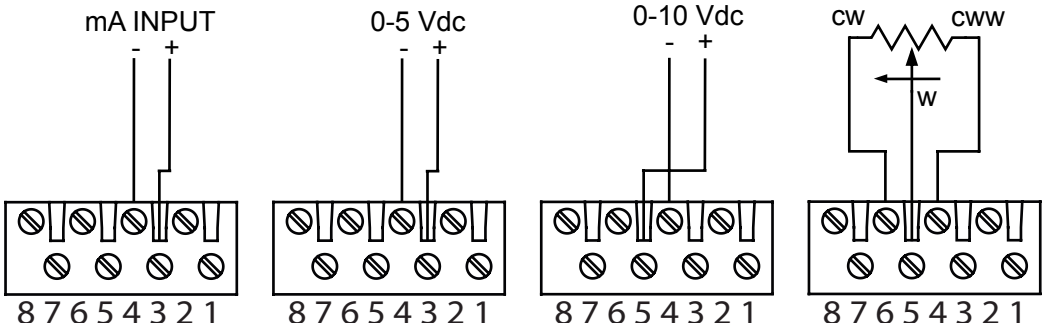

Figure 8. Command Signal Connections.

AUTO/MANUAL & RUN IDLE CONTROL:
Several circuits by which auto/manual control can be implemented are shown in Figure 9. The SCR controller can be switched from a "RUN" command to an "IDLE" command by use of a manual switch or other automatic switching devices.

Shielded wiring is not required. It is recommended that the control wire not be placed adjacent to the power wiring.

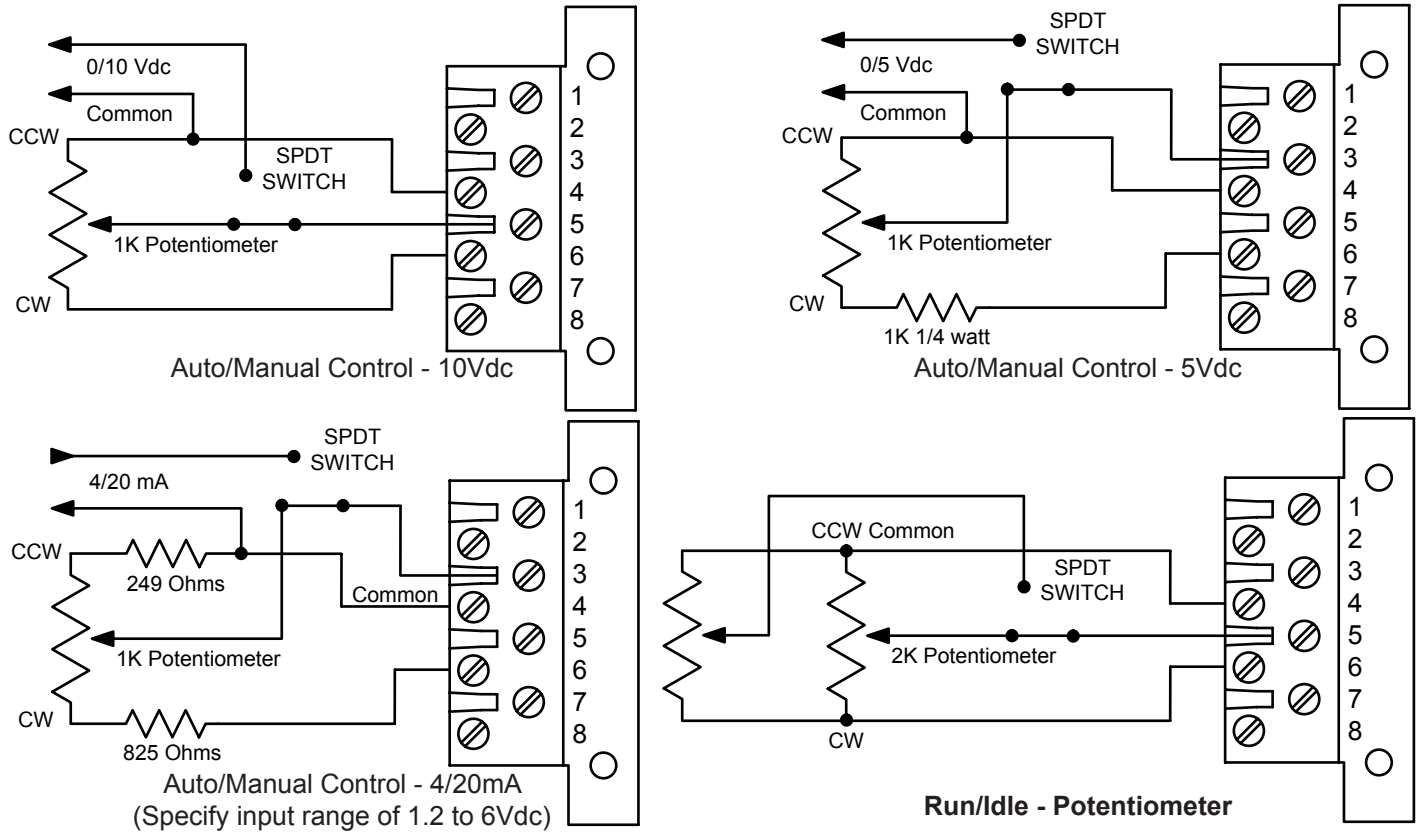

Figure 9. Methods of Controlling the Model 1027 with Multiple Command Signals.

START UP

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

Before applying power, determine that the transformer tap is set at a value corresponding to the supply voltage.

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.

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

ADJUSTMENTS

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.

TROUBLESHOOTING

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

DO NOT APPLY POWER TO THE SCR WITH THE CATHODE OR GATE LEADS REMOVED

It has been mandated by the National Electrical Code and the Occupational Safety and Health Act (OSHA) of 1970 that a physical disconnect be installed ahead of all remotely actuated control equipment and that the disconnect must be opened before maintenance work is performed on the controller or its connected load.

THE FOLLOWING ARE SOME SYMPTOMS WITH SUGGESTIONS TO HELP LOCATE PROBLEMS:

No load power and no command indicator.
1. Check fuses.
2. Determine that power is present between line 1 and line 2 terminals
3. Determine that the command signal is present and that electrical connection is made between the lead wires and the plug–in connector.
3. Determine that 10 Vdc is present between terminal 6 and terminal 4 on the input connector. If the voltage is greater than 11 Vdc the circuit board has probably failed. If the voltage is less than 9 Vdc the circuit board or transformer has probably failed. (Determine that correct transformer tap is selected.)

No load power, command indicator functions correctly.
1. Remove system power and visually inspect circuit board for damage.
2. Check load connections.
3. Measure voltage across load. If voltage exists, check load.

Full load power cannot be obtained and command indicator is on.
1. Visually inspect the circuit board for damage.
2. With the command signal at maximum, the voltage between the corresponding line and load terminals should be less than 2 Vdc. If the voltage is greater than 2 volts, the SCR module has probably failed.
3. Check the Zero and Span potentiometer adjustments. (Page 6.)
4. Determine that load has not aged beyond it's useful life. (Silicon Carbide.)

Full or partial load power, command indicator is off.
1. If the voltage between the line and load terminals is zero, the SCR has likely failed.
2. Remove system power and remove circuit board from the controller. Reapply system power. The SCR has failed if voltage still exists across the load.
3. If load voltage no longer exists when the circuit card is removed, the card has failed.

Full load power, command indicator is on, command signal is at minimum.
1. If the command indicator remains on with zero command signal the circuit board has failed. (A convenient method to apply zero command is to remove the input connector from the controller.)
2. If load power goes to zero when the input connector is removed, determine that the command signal is at minimum and correctly wired.

REPLACEMENT PARTS

Replacement SCR Modules:	
Frame size	Control Concepts Sub Assy
100 & 150 Amp 180 Amp	28325-0395-514 28345-0413-514
Replacement Firing circuit:	
1027-FC-X/XmA **1027-FC** = firing circuit (voltage or potentiometer). **X/XmA** = specifies the milliamp control signal. (for example "4/20mA)"	
It is recommended that the controller and load be protected by Class T fuses:	

MANUFACTURED BY

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MODEL NUMBER IDENTIFICATION

1027-[Volts]V-[Amps]A-[CS]

1027

Specifies a single-phase SCR controller which linearly controls, with respect to a command signal, the power applied to a single-phase restive load by distributive zero-cross operation of a pair of inverse parallel SCRs.

[**Volts**]V

Specifies the operating voltage. It refers to the supply voltage the controller has been calibrated to operate at. Note: the standard transformer installed in the model 1027 has primary voltage taps for operation at 208, 240 or 480 volts, 50/60 hertz. Other voltages are available. Contact factory for information.

[**Amps**]A

Specifies the continuous RMS current rating: 100, 150, or 180 Amps.

[**CS**]

Specifies the range and type of command signals the controller is factory calibrated to respond to. If the [CS] term is blank, the controller will accept a **pot**entiometer input, a **0/5Vdc** command signal or a **0/10Vdc** command signal.

Example:
1027-480V-100A-4/20mA
Specifies 480 volt operation, 100 amps continuous current rating and a 4/20mA command signal.

If a "SC(**VVV**) term is included, it implies special calibration, meaning that the controller has been calibrated for a maximum output of **(VVV)** voltage rather than the rated (line) voltage. Contact factory for information.

THEORY OF OPERATION

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

The SCR has two states, ON and OFF, and allows current to flows in only one direction. SCR's can remain in the OFF state even though the applied potential may be up to 1400 volts; in the ON state, they can pass several thousand amperes. When a small signal is applied between the gate and cathode terminals (Figure 10), 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.

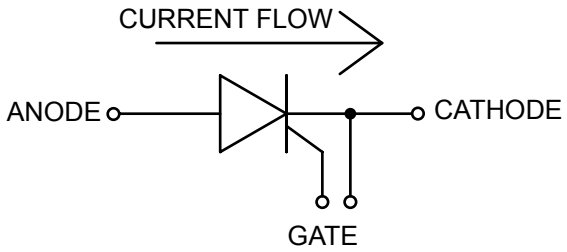

Figure 10. SCR symbol.

Because the SCR allows current to flow in only one direction, two SCR's are connected in an "inverse parallel" configuration to control AC current (Figure 11).

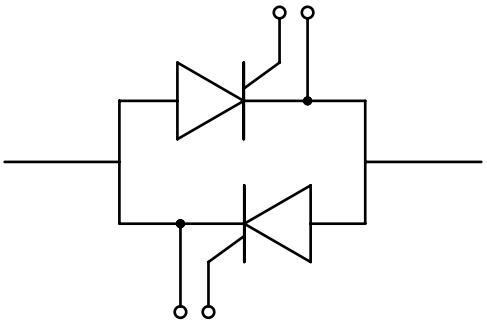

Figure 11. "Inverse Parallel" Configuration.

ZERO-CROSS CONTROL:

In zero-cross control, load power is turned ON and OFF only when 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 1027 always applies an odd number of "ON" cycles and an even number of "OFF" half cycles. The following tabulation shows the sequence of "ON" and "OFF" electrical half-cycles that are applied to the load to achieve 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. Load Power Timing.

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 operating with a 60 Hz supply, the sequence of ON and OFF cycles repeats 0.266 seconds on 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.