CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODEL 1027A

CONTROL CONCEPTS

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+1-770-840-9811

DESCRIPTION:

This manual describes the model 1027A controller rated 50 to 160 Amps.

The model 1027A is a single-phase, distributive-zero-cross SCR controller which linearly controls, with respect to a command signal, the electrical power applied to a single-phase resistive load.

Zero-cross control implies that the load voltage is switched on and off only when the instantaneous value of the sinusoidal supply voltage is zero.

Distributive zero-cross control implies 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 zero-cross operation for additional details.)

The controller responds to: Dc mA command signal, DC voltage command signal or a potentiometer. 10Vdc is provided by the controller to excite the potentiometer.

Electrical isolation is provided to isolate the command signals from the line and load voltages.

The <u>peak</u> load current must be no more than 200 Amps.

FEATURES:

1. Line voltage compensation, which for a given command signal, maintains the load power constant within 2% of span for line voltage variations of +10% and -15%.
2. Sync-Guard, which provides a means to reduce the syncronous operation of two or more controllers.
3. Trans-Guard, which prevents supply transformer saturation which can result from zero-cross operation.

MODEL No. IDENTIFICATION:

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

"1027A" specifies a single-phase SCR controller which linearly controls, with respect to a command signal, the power applied to a single-phase resitive 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 1027A 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: 50, 80, 120 or 160 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 potentiometer input, a 0 to 5Vdc command signal or a 0 to 10Vdc command signal.

For example, the model number
1027A-480V-80A-4/20mA
specifies 480 volt operation, 80 amps continuous current rating and a command signal of 4/20mA.

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.

MANUFACTURED BY:

CONTROL CONCEPTS

THEORY OF OPERATION:

THE SCR

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 flow 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 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.

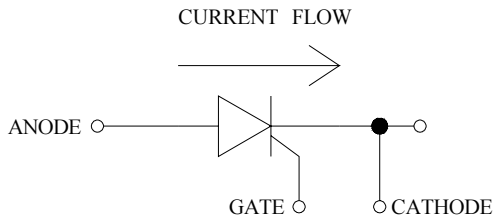


Figure 1. SCR symbol

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 2).

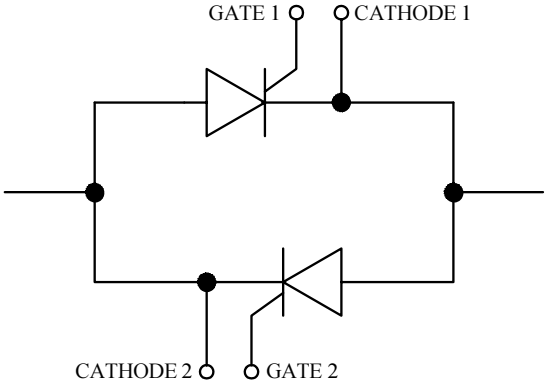


Figure 2. "Inverse parallel" configuration.

ZERO-CROSS CONTROL:

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 1027A always applies an odd number of "on" half 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

$$\% \text{ Load Power} = \frac{\text{Number of electrical half-cycles that power is applied}}{\text{Total number of electrical half-cycles}}$$

TABLE 1. Load power timing

From the 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: At 85% power there are 5 sequences of 23 half cycles on, and 4 half cycles off, which provide 85.185% power and then a sequence of 21 half cycles on, and 4 half cycles off, which provides 84% power.
Average power of total sequence is 85%.

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 3 through 5 show the total current as a function of time for three controllers, with and without Sync-Guard and various load powers.

WHEN USING THE SYNC-GUARD FEATURE, THE mA CONTROL SIGNALS MUST BE ISOLATED FROM EACH OTHER.

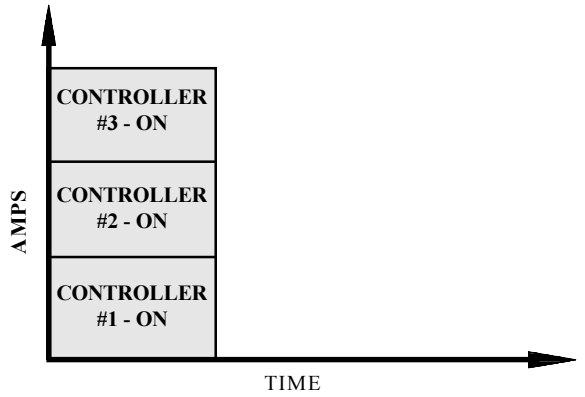


Figure 3. Three controllers providing 33.3% power operating synchronously.

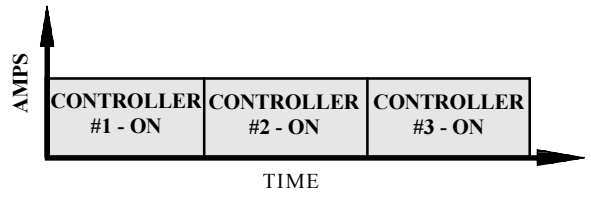


Figure 4. Three controllers providing 33.3% power each, with sync-guard.

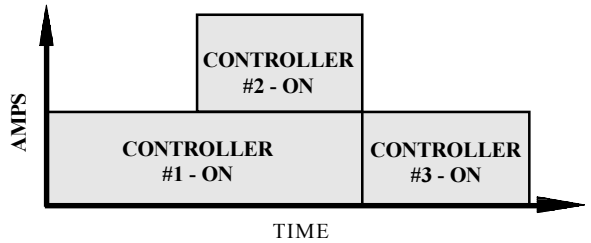


Figure 5. Three controllers with synch-guard, two providing 33.3% power & one providing 66.6% power.

Refer to figure 7 on page 6 for connections when using sync-guard on multiple model 1027A's.Use only one load resistor for each group of controllers connected in this manner.

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 6 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 on page 2.

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 1027A.

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

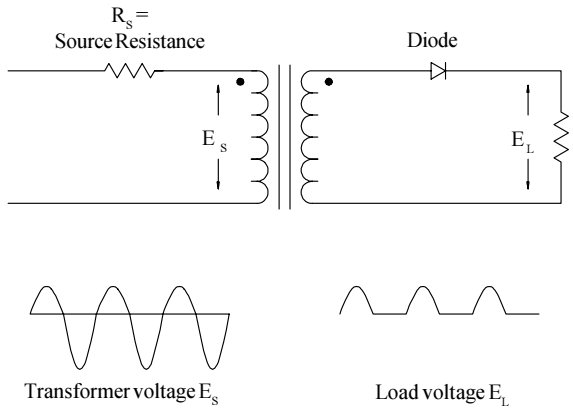


Figure 6. DC components in the secondary induce DC voltage in the primary causing transformer saturation.

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:	1400 volts peak

SCR SURGE CURRENT AND I^2t RATING:

Controller rating	peak 1 cycle non-repetitive I_{tsm} @ 125°C	I^2t rating @ 125°C
50 & 80 Amps	1750 Amps peak	15,000 A^2s
120 Amps	1900 Amps peak	18,000 A^2s
160 Amps	4000 Amps peak	80,000 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.

INSTALLATION:

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

MOUNTING AND LOCATION:

The 50 and 80 amp controller must be mounted on a vertical surface with the fins oriented so that air may flow between them. The preferred orientation of forced air cooled controllers is on a vertical surface with the fan blowing the air upward through the heatsink. The controller should be used in an environment that is free from dust and contaminates and which will not exceed 125°F.

POWER CONNECTIONS:

Figures 8 & 9 on page 6 show the electrical connections. The line and load connectors are rated for wire sizes from #6 to 250 MCM. The table of recommended tightening torques as related to wire size can be found on page 6.

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 120 to 125% of the maximum load current. Control Concepts maintains an inventory of most fuses and fuse holders. Technical personnel are available to answer questions regarding fuse applications.

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 it's connected load.

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 electrical installation drawings (Fig 8 & 9 on page 6.)

The connectors are rated for use with wire sizes from 6ga to 250MCM.

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.

MOUNTING DIMENSIONS:

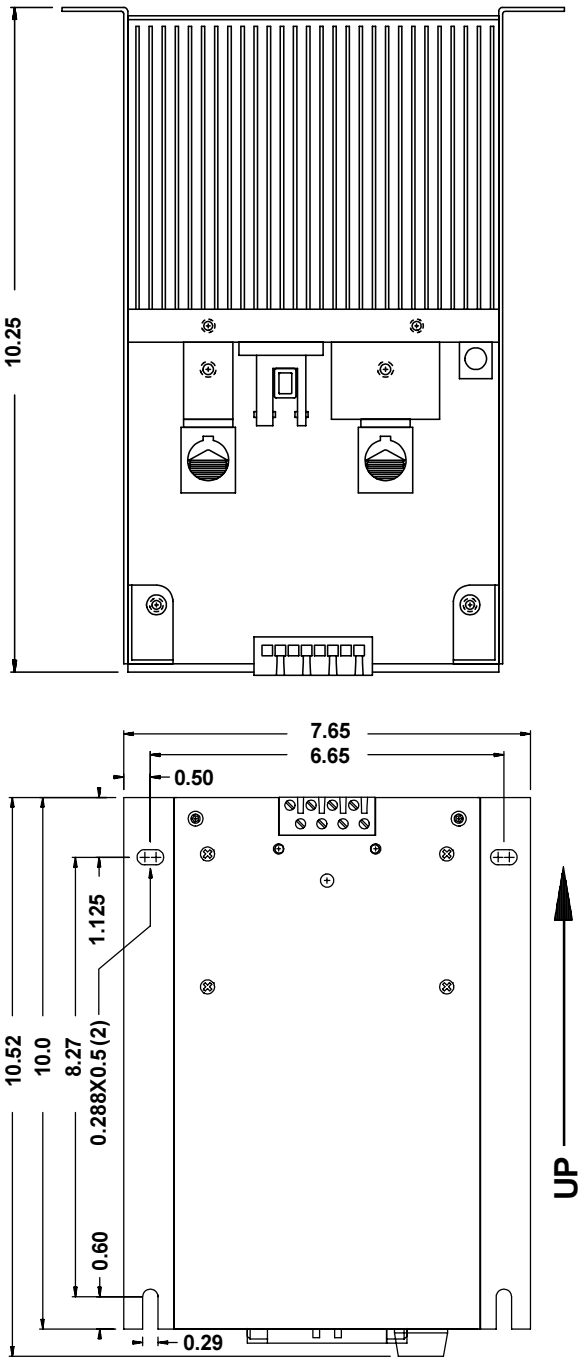


Figure 7. Installation drawing for 50 to 160 Amp models.
It is important that the 50 & 80 Amp models, which have no fan, be mounted vertically so that air may flow freely between the fins.

CONTROL CONNECTIONS:

Connect the control wiring as shown in figure 10.

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 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 above 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.

VOLTAGE INPUT:

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

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

mA INPUT:

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

AUTO/MANUAL & RUN IDLE CONTROL:

Several circuits by which auto/manual control can be implemented are shown in fig. 9 on page 8.

The SCR controller can be switched from a "RUN" command to an "IDLE" command as shown on page 8 by either the use of a manual switch or other automatic switching devices.

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 electrical installation drawing on page 5.

The connectors are rated for use with wire sizes from 6ga to 250MCM.

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 continuous good electrical conductivity.

Recommended tightening torque for the line 1 and load 1 connectors:

AWG or Circular Mills	Torque inch-pounds
6ga	100
4ga	100
2ga	125
1ga	125
1/0	150
2/0	150
3/0	200
4/0	200
250MCM	250

POWER CONNECTION DIAGRAMS:

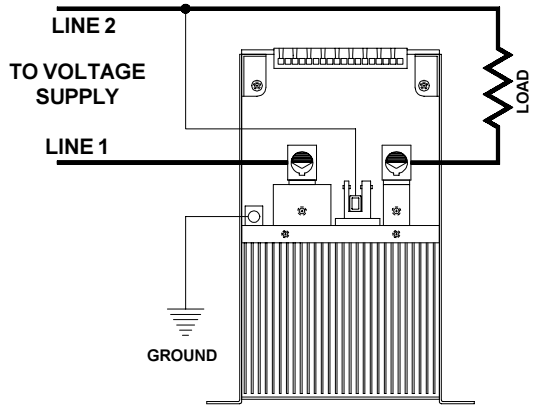


Figure 8. Power connections.

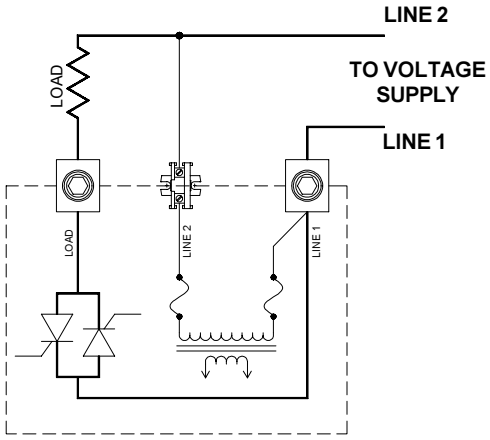


Figure 9. Power path.
Note: Fuses and a disconnect are recommended in the voltage supply lines.

CONTROL CONNECTIONS

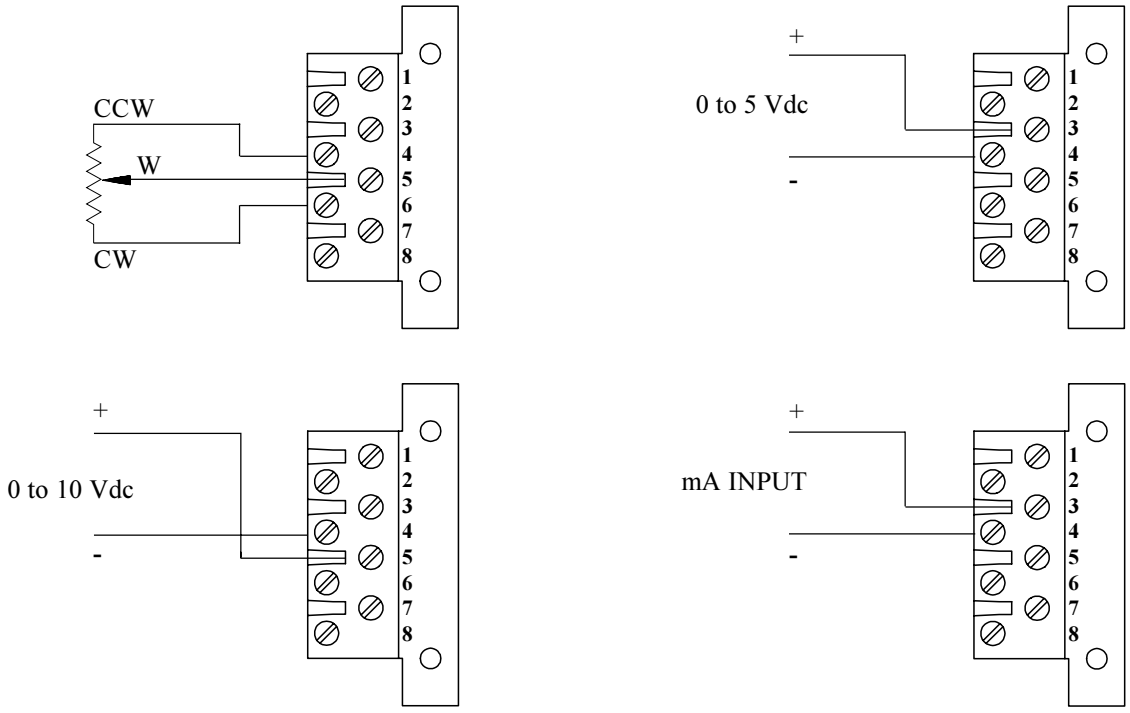


Figure 10. Command Signal Connections

SYNC-GUARD CONNECTIONS:

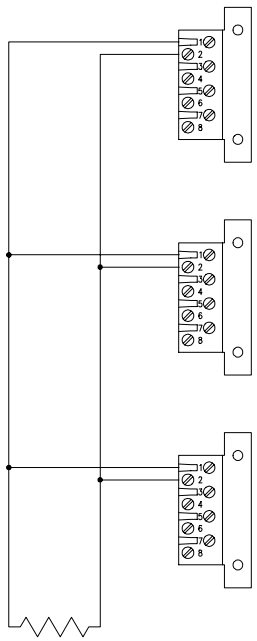
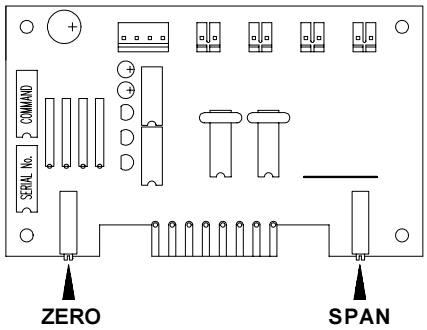


Figure 11. Sync-Guard Connections

ADJUSTMENTS:



SPAN AND ZERO ADJUSTMENT:

The Span and Zero pots have been factory calibrated and should not require any further adjustment.

If adjustment becomes necessary, please use the following procedure.

1. With no command signal applied, adjust the potentiometer labled "ZERO" on the circuit until the LED is just off and no voltage is applied to the load.
2. With full command signal applied, adjust the potentiometer labled "SPAN" until the LED is just on continuously and the desired maximum voltage is applied to the load.
3. The span and zero adjustments may interact, therefore, it may be necessary to repeat steps 1 and 2.

MULTIPLE CONTROL CONNECTIONS:

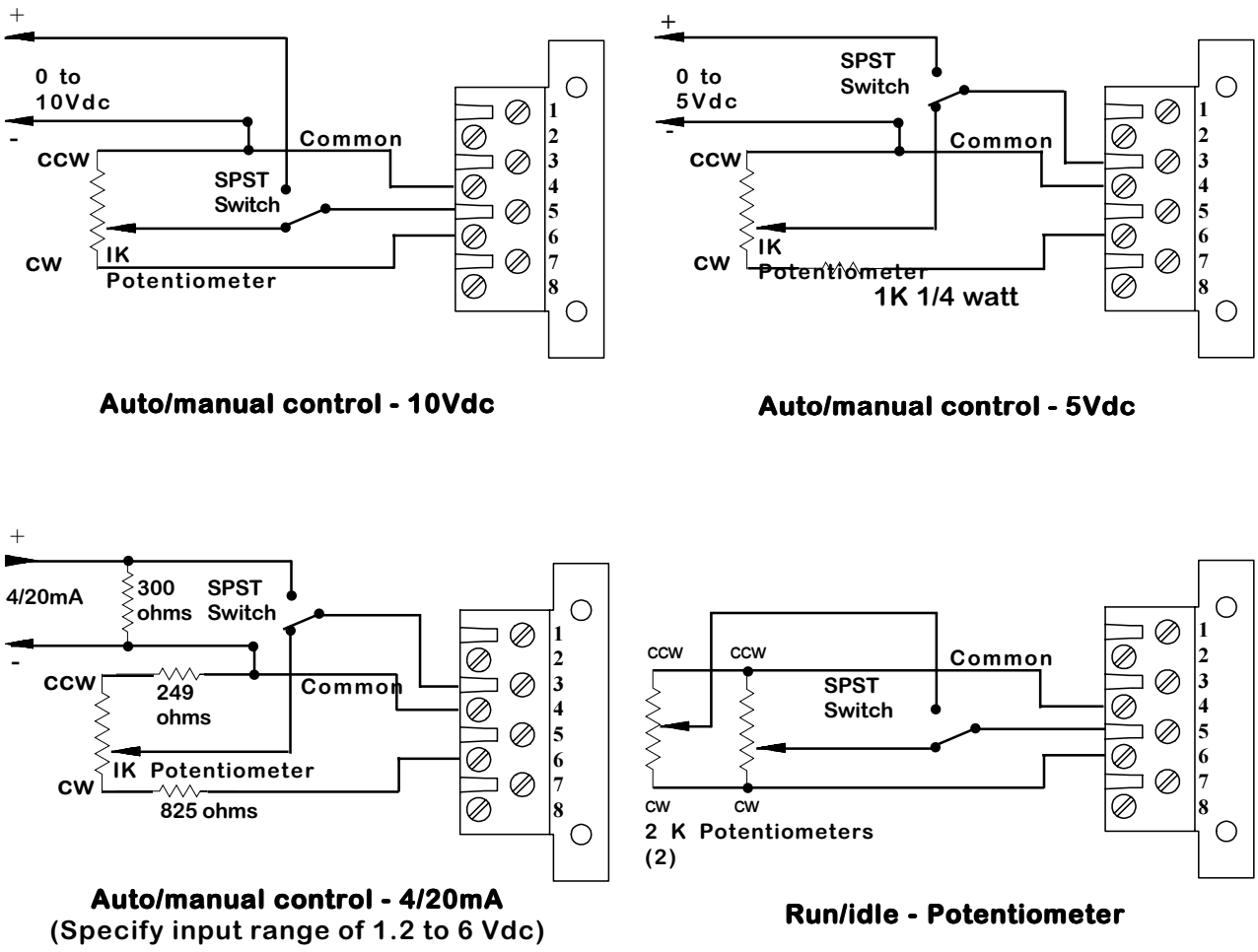


Figure 12. Methods of controlling the model 1027A with multiple command signals.

STARTUP:

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.

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

TROUBLE SHOOTING:

USE EXTREME CAUTION TO AVOID ELECTRICAL SHOCK

DO NOT ATTEMPT TO OPERATE THE CONTROLLER WITH THE SCR 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 it's connected load.

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

No load power and command indicator does not function.

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 and 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 7.)
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.

RECOMMENDED SPARE PARTS.

SCR Modules:

Frame size	Control Concepts Part #
50A	28325-0395-514
80A	28325-0395-514
120A	28345-0410-514
160A	28345-0413-514

Firing circuit: 1027A-**FC**-**X/X**mA
FC specifies firing circuit only.
X/X specifies the milliamp control signal, if desired. (for example "4/20mA)"

It is recommended that the controller and the load be protected by 600Volt semconductor fuses:

Frame size	Fuse size	Control Concepts Part #
50A	60A	42110-0460-360
80A	100A	42110-0460-410
120A	150A	42110-0460-415
160A	200A	42110-0460-420

The control transformer is protected by two 600Volt fast acting class CC fuses

Frame size	Fuse size	Control Concepts Part #
50A	1/4A	42130-0460-125
80A	1/4A	42130-0460-125
120A	1/2A	42130-0460-150
160A	1/2A	42130-0460-150