Signalite DIVISION OF GENERAL INSTRUMENT CORPORATION
1933 HECK AVENUE, NEPTUNE, NEW JERSEY 07753

TP TRANSIENT PROTECTORS

Our gas discharge devices frequently find their way into applications where they are used to prevent transient or recurrent voltage surges from damaging more sensitive components, or where the circuit must be isolated from spurious signals or noise.

Three characteristics are essential to this application. First, the component must remain an open circuit until the surge exceeds the breakdown voltage of the lamp. Second, it must be able to conduct moderately high current without damage to itself. And third, it must have a final breakdown and extinguishing voltage high enough to allow the circuit to continue operation without interruption.

To satisfy these requirements, Signalite has developed the TP line of gas diodes. These high energy gas discharge devices which operate in the arc mode are not like the cold cathode tubes or indicators that operate at low energy levels in the glow discharge mode. The TP's operate intermittently for transient protection and should never be operated under continuous d.c. conditions as the extremely high power would quickly destroy the device.

Transients may appear from two types of sources; generated from within the circuit itself or transmitted into the circuit from an external source.

The internally generated transients are primarily due to intentional, or unintentional switching, this includes the normal switching of components in an inductive circuit, or the failure of some component, resulting in a voltage surge. Examples of these are:

Inductor of any type
Motors, generators, relays
Solenoids, contactors
Spark over on switch contacts and other components acting within a CRT or other tubes

Some typical external sources are:

Static discharge
Lightning
Shorting or interruption of current in power lines

These external sources affect communication lines such as telephones, telegraph, CATV and data processing lines, as well as power lines. All antenna installations of any type are prime targets for natural phenomena.

In DC circuits, the source of the transient is primarily due to the characteristics of the load being switched. When switching power to a capacitive load, a current surge may result for the time needed to charge the capacitive component of the load.

(continued)

For an inductive load if current is interrupted, a high voltage surge will occur since the inductive component of the load tends to resist any change in current. Voltage and current surges which are the result of switching capacitive and inductive loads are primarily sources of circuit transients.

In AC circuits where the switching action is not synchronized with the AC potential, varying transients will be generated as the AC potential is applied, or removed from across the load.

COMPARISON OF VARIOUS TRANSIENT PROTECTORS

	GDD's	ZA & MA TYPE MOV's	TRANS ZORBS	DO-13 ZENERS
BV (dc)	65-450	14-475	6.1-190	
Ipk (max)	1 Ka	2 Ka	139-5.5	5.7
Energy (joules)	.7	.6-15	.2	1.65
Price (100K est)	.10 ea	.11-32 ea	-	.35-.45 ea.
Temp (°C)	-15 +75	-40 +85 (50% derate @ 100°)	-65 +175	-55 +100

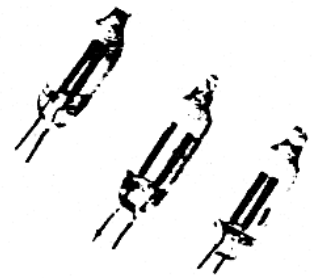
A gas discharge device acts primarily as a voltage switch and because of the switching action the energy dissipated within the device is minimal. The balance of the energy contained in a transient is dissipated in the resistive components of the circuit, including the wiring. Zener diodes varistors and other semi-conductor devices dissipate the energy within the bulk of the materials of the device itself. The electrical energy is converted to heat and this heating effect is normally destructive to the normal operation of the device.

The data sheet outlines the typical specifications an engineer can expect from our TP's, but this is only part of the story. Many questions will be raised, or should be, for the proper selection of a protective device of this sort relates closely to the actual application. To help you in this regard, Pete Oddo and Mario Ciasulli are at your disposal, telephone (201) 775-2490.

SIGNALITE DIVISION
GENERAL INSTRUMENT CORPORATION
1933 Heck Avenue, Neptune, New Jersey 07753 • Area Code 201-775-2490 • TWX 201-775-2255

TRANSIENT PROTECTORS

A 1/4 INCH DIAMETER GAS-FILLED DISCHARGE TUBE DESIGNED TO OPERATE IN THE ARC-MODE PROVIDING TRANSIENT PROTECTION IN LOW ENERGY APPLICATIONS.



FEATURES

*LOW COST
*VOLTAGES 75-450 VDC

DISSIPATION

*ENERGY TO 1 JOULE
*PEAK PULSE CURRENT TO 2 KA

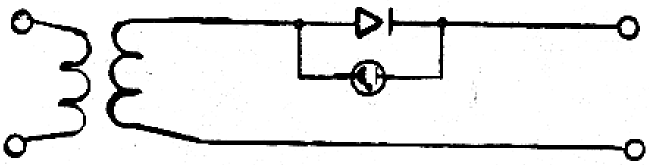
APPLICATIONS

*SOLID STATE CONTROLS
*SOLID STATE TUNERS
*COMMUNICATION EQUIPMENT
*CONTACT ARC SUPPRESSION
*INSTRUMENTATION
*CATV AMPLIFIERS
*CRT PROTECTION
*AUTOMOTIVE IGNITION SYSTEMS

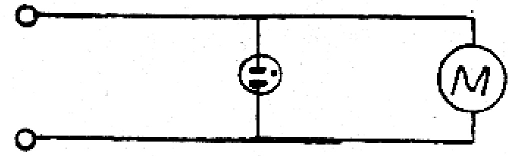
DEVICE	BREAKDOWN VOLTAGE VDC (1) <100 V/S	BREAKDOWN VOLTAGE PULSE KV @ 5 KV/µs	PEAK (2) CURRENT CAPABILITY	PEAK ENERGY DISSIPATION	INTERELECTRODE CAPACITANCE (Typ)	INSULATION (3) RESISTANCE (Min)	LIFE OPS. (4)	MOL	LEADS (5) (Tinned)
TP75	75	0.5 max	2KA	1 joule	1.0 pfd	10,000 MegΩ	7500	1.0"	1.0"
TP100	100	0.5 max	2KA	1 joule	1.0 pfd	10,000 MegΩ	7500	1.0"	1.0"
TP125	125	0.5 max	2KA	1 joule	.9 pfd	10,000 MegΩ	5000	1.0"	1.0"
TP150	150	0.5 max	2KA	1 joule	.9 pfd	10,000 MegΩ	5000	1.0"	1.0"
TP200	200	0.5 max	2KA	1 joule	.8 pfd	10,000 MegΩ	3500	1.0"	1.0"
TP250	250	1.0 max	2KA	1 joule	.8 pfd	10,000 MegΩ	3500	1.0"	1.0"
TP300	300	1.5 max	2KA	1 joule	.7 pfd	10,000 MegΩ	2500	1.0"	1.0"
TP350	350	1.5 max	2KA	1 joule	.7 pfd	10,000 MegΩ	2500	1.0"	1.0"
TP400	400	1.5 max	2KA	1 joule	.6 pfd	10,000 MegΩ	2000	1.0"	1.0"
TP450	450	2.0 max	2KA	1 joule	.6 pfd	10,000 MegΩ	2000	1.0"	1.0"

NOTES:

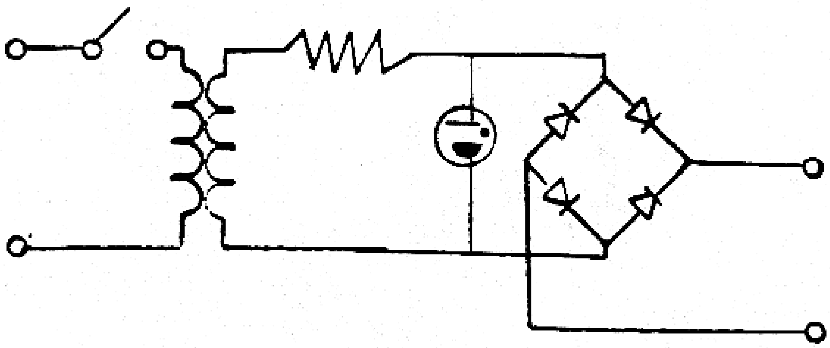
(1) All voltages plus or minus twenty percent up to 150V, higher voltage units plus or minus fifteen percent.
(2) At a 1.5/10 microsecond wave front.
(3) Seventy-five hundred megohms at end of life.
(4) Life shown is the minimum number of times the device can be subjected to a 1KA 1.5/10 microsecond wave front without causing the DC breakdown voltage to change more than 25 percent.
(5) All dimensions are plus or minus one sixteenth of an inch tolerance.



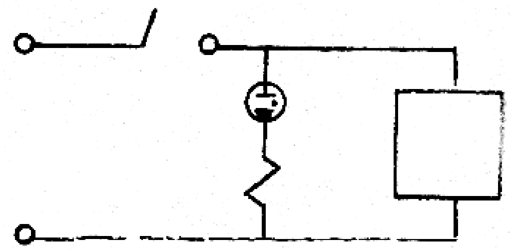
DIODE/RECTIFIER PROTECTION



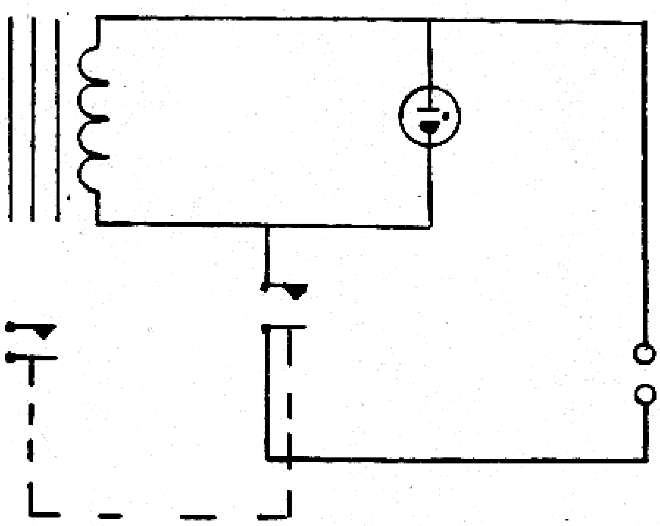
METER PROTECTION



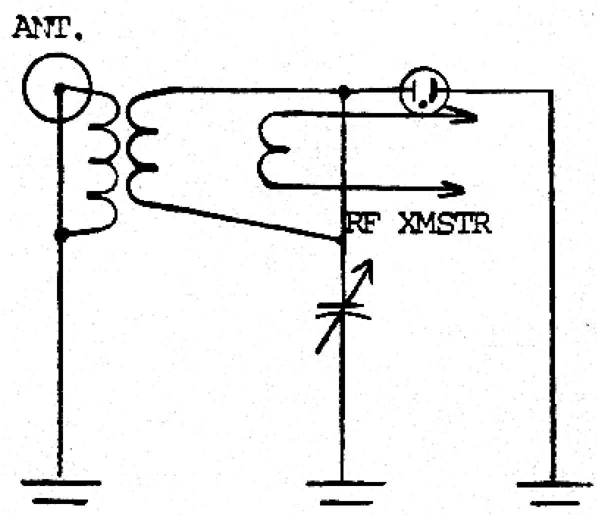
AC POWER SUPPLY PROTECTION



AVIONICS PROTECTION



RELAY PROTECTION



RECEIVER PROTECTION

W. J. Evanzia
Associate Editor

SEE PAGES 14 & 15
OF CATALOG FOR
THESE DEVICES

Neons outshine zeners as high voltage regulators

by Thomas W. Wolstencroft
Signalite

Because many applications require closely controlled high voltage supplies, it is sometimes necessary to use complex circuitry to regulate the power supply, or to install zener diodes in the system.

A major improvement was recently made in the design and manufacture of cold cathode neon gas tubes whereby their breakdown and maintaining voltage characteristics can be held to extremely close tolerances. These tubes provide regulation, predictably and reliabily, to within ±1 volt. They are small, inexpensive, simple to install, rugged, and long lived. Relatively insensitive to vibration and shock or thermal cycling, they hold their close tolerances for up to 50,000 hours of continuous operation. Temperature coefficients range as low as −2 mv/°C, which is at least two orders of magnitude lower than solid state devices.

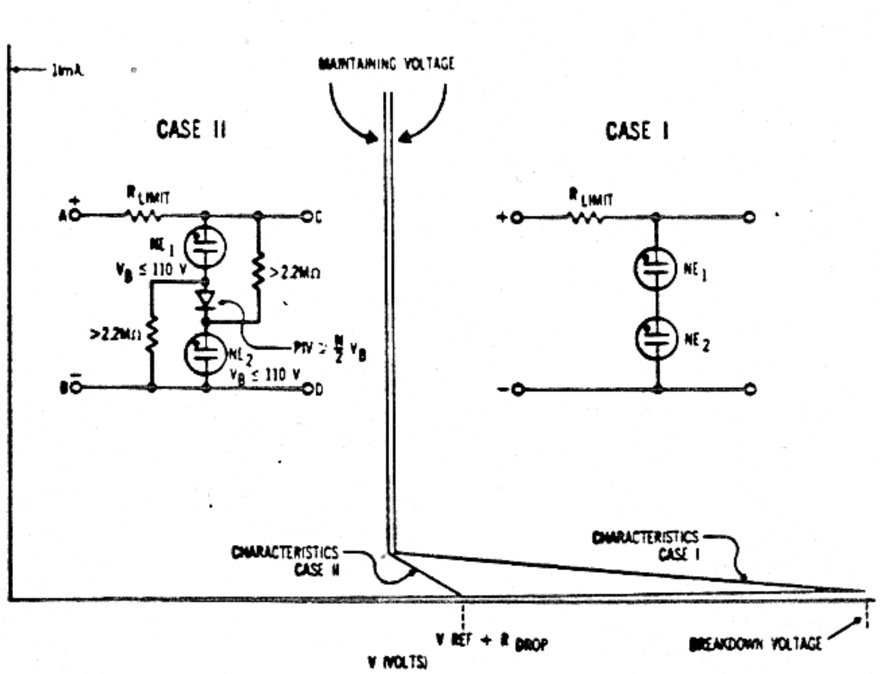


Fig. 2. The neon gas diodes are stacked in series for voltage control. In Case 1, the required breakdown voltage is the sum of the breakdown voltages of the individual tubes; the maintaining voltage is the sum of the maintaining voltage of the tubes. In Case 2, the required breakdown voltage level is that of the individual neon.

The case for neons

Neons operate as voltage regulators or reference sources in the 82 to 145 v range. They can be stacked to regulate higher voltages and to provide multiple voltage taps. There are two important reasons why designers should consider neons instead of zeners. The silicon in zeners has a low thermal mass that makes them susceptible to unrecoverable damage. (Overheating due to current surges is often a cause of zener diode failure.) And the zener uses the reverse characteristices of a semiconductor diode. Thus, high voltage gradients at the zener's barrier region can cause breakdown and instantaneous failure.

The neon gas diode's reference voltage is analogous to the zener diode's breakdown voltage. At the 82 to 145 voltage level, the ±1 v (max) reference swing is less than that specified for zeners. According to published Jedec specifications, a ±5% breakdown voltage swing is the best that zeners offer. In addition, the zener diode's breakdown voltage is temperature dependent. Therefore, in critical systems, it may be necessary to determine ambient operating temperatures before selecting a device. On the other hand, the neon diode's firing voltage is about 35% greater than its reference voltage. This necessitates higher supply voltages than would be required for an equivalent zener diode.

Signalite's ZD-5268-C diode maintains an 82 v ±1 v reference over current variations of 0.25 ma to 7 ma (Fig. 1) without the need of additional circuit elements. If a designer prefers to use zeners instead of neons to ob-

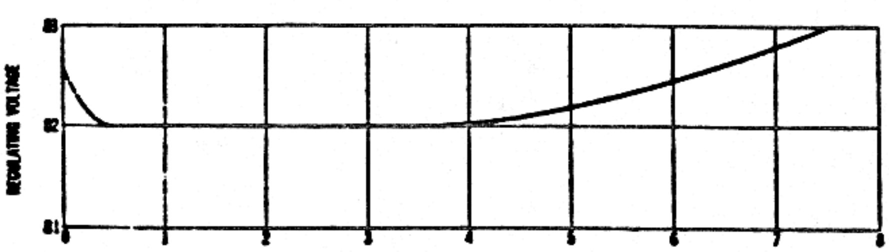


Fig. 1. Typical regulation curve for an 82 v neon gas tube.

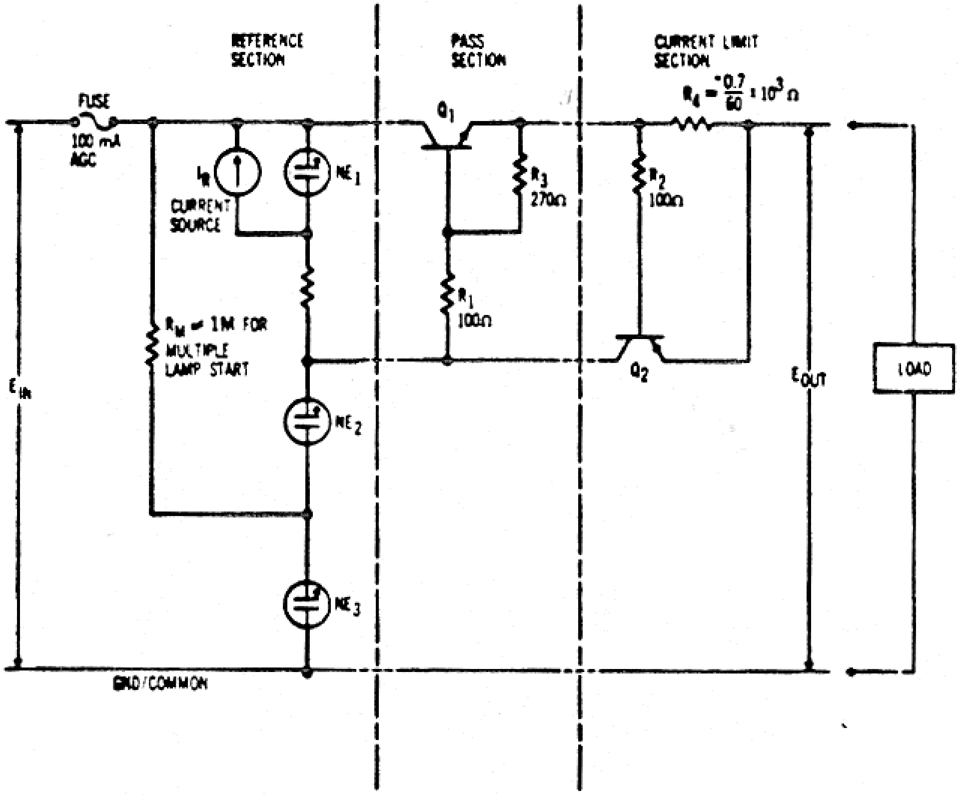


Fig. 3. In this three-section regulated power supply, neon gas tubes and solid state devices are used to provide high output current. The 1 megohm resistor puts the full input voltage across the non-ionized neon tube and insures the breakdown voltage is exceeded.

tain this regulation capability, he would have to select a zener with better than 1% tolerance. This is expensive because ovens may have to be used to insure a stable operating temperature and compensate for the zener's characteristic thermal drift. Or the designer would have to provide a constant current source to the zener. This insures a stable reference level, but it's expensive because of the additional circuitry required for the current source.

Two other neon gas tube diode characteristics are important to circuit designers: an extremely low thermal drift of −2 to −10 mv/°C (depending on the tube type) that virtually eliminates thermal drift design problems, and also an ability to handle power surges in excess of 50 w without failure.

Stacking for higher voltages

There are two stacking techniques that can be used to obtain higher reference/regulation voltages. The first is simply to place two or more tubes in a series (Case I in Fig. 2). However, this configuration has a serious drawback — the supply voltage must rise to the sum of the breakdown voltages of the individual tubes.

A second method requires additional passive components, but it eliminates the large overvoltage required to break down the reference tube string. The characteristics of this method approach those of a zener diode. The circuit configuration illustrated in Case II of Fig. 2 operates as follows. Assume NE_1 and NE_2 are ZD-5268-C devices with a typical breakdown voltage of 102 vdc (110 v max), a reference voltage level of 82 vdc at 2.0 ma, a regulation current range of 0.25 to 7.0 ma and a temperature coefficient of −2 mv/°C. Further, assume a slowly rising dc voltage is applied to points A and B. When the applied voltage exceeds the breakdown voltage of the individual tubes, they will fire and conduct very small currents of approximately 0.05 μa. As the supply now approaches the design reference level, the tubes will conduct more and more current until $V_{REF} + R_{lim}$ drop is reached. At that point, the amount of current

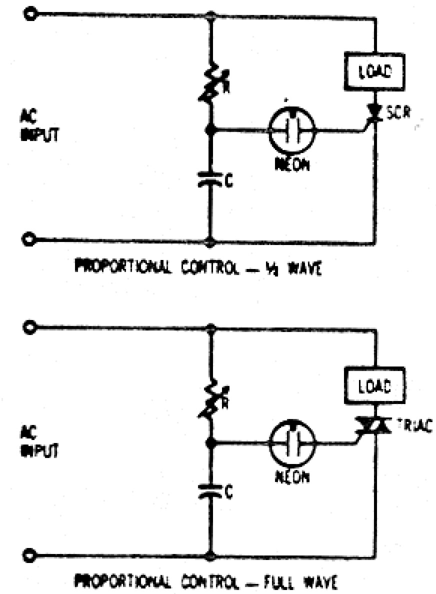


Fig. 4. Neon gas tubes can be used to trigger SCR's and triacs. In the top schematic, the neon fires and triggers the SCR during the positive half cycle of ac input wave. In the bottom schematic, the neon provides the gate pulse during both periods of the input waveform. In both circuits, resistor R controls the phase angle at which the gas diode fires.

conducted is determined by R limit. This produces a reference voltage at C and D of 164 v ±1 v. The graph illustrates the voltage/current characteristic for both circuits.

A three section power supply is illustrated in Fig. 3. Neon gas tubes and solid state devices are used to provide a high current, closely regulated power source. Basically, the neon string operates in a manner similarly to that described for Case II of Fig. 2.

The circuits in Fig. 4 show how neons can be used to trigger SCR's and triacs. An SCR fires when its anode is positive relative to its cathode. Thus, it works on one-half of

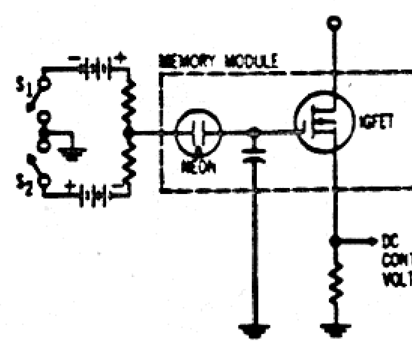


Fig. 5. The neon gas diode couples the directional signals from function switches S_1 and S_2 to the FET amplifier.

DESIGN TRENDS

Neon-Lamp Triggering of SCR's

ROBERT MCKENNA
Semiconductor-Components Division
Texas Instruments Incorporated
Dallas, Texas
EDWARD BAUMAN
Signalite Incorporated
Neptune, New Jersey

SILICON CONTROLLED RECTIFIERS are often used in applications involving proportional power control with a conventional power supply (60 cps). Such applications include heater controls, motor speed controls, and light dimmers. In spite of the varied natures of the systems involved and the different sizes of SCR's (determined by the load requirements), all of the applications require some kind of phase-shifting gate circuit. Neon lamps in synchronized relaxation oscillators provide a practical answer to this problem.

If certain precautions are observed, the SCR can be triggered very satisfactorily by pulses. Since the SCR is a bistable device, a pulse of short duration will cause it to switch from the blocking state to the conducting state. However, a certain minimum amount of energy (or charge) is required, and with inductive loads a minimum triggering pulsewidth (depending on the latch-in current and the rise time of the load current) is necessary. Figure 1 shows the amount of gate current necessary for triggering versus gate pulsewidth for a typical SCR for industrial applications. The curve is drawn on the assumption that the load is resistive. It shows that a pulsewidth greater than 10 μsec should be used under normal circumstances. When inductive loads are involved, however, the pulsewidth must be longer than the anode-current rise time to the latch-in current level.

The A057B neon glow lamp manufactured by Signalite is designed to operate with a 75-ma recurrent peak surge current with a 10-percent duty cycle and is capable of providing sufficient triggering energy for most SCR's. Figure 2 shows the gate-current waveshape when a 0.1-μf capacitor is discharged through the A057B lamp. The 40-μsec pulsewidth is sufficient to trigger SCR's in the TI 40AO series for controlling resistive, capacitive, and most inductive loads, such as universal motors. When more highly inductive loads must be controlled, a larger capacitor may be used if a limiting resistor is added in series with the neon lamp to limit its peak current to 75 ma.

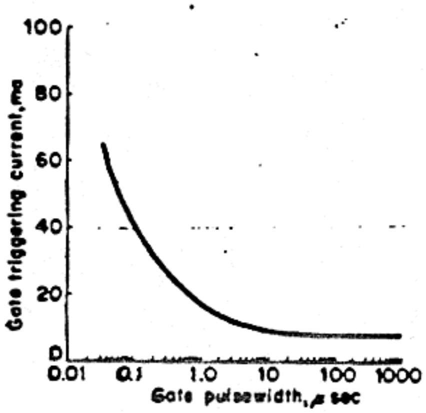


Fig. 1—Triggering current versus pulsewidth for a typical SCR.

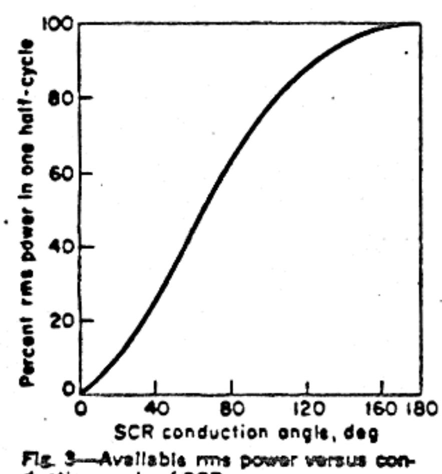


Fig. 3—Available rms power versus conduction angle of SCR.

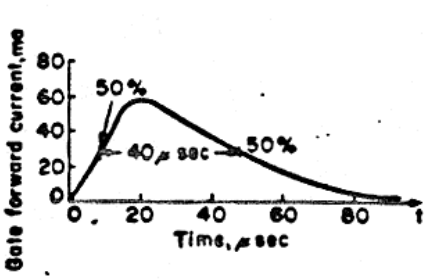


Fig. 2—Typical waveshape of gate triggering current.

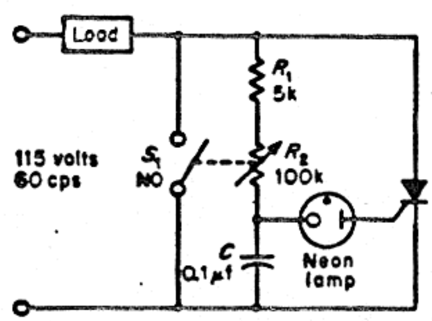


Fig. 4—Half-wave proportional-control circuit.

Figure 3 shows the rms power supplied to a load by an SCR triggered by a phase-shift circuit of the type shown in Fig. 4. This basic circuit is capable of providing a minimum conduction angle of approximately 40° and a maximum conduction angle of about 150°. A range of 24 to 95 percent of the available power in a half-wave circuit is thus supplied to the load.

Resistors R_1 and R_2 (Fig. 4) combined with the capacitor form the time-delay circuit. During a positive half-cycle of the supply, the capacitor charges at a rate determined by the combined resistance of R_1 and R_2. When the voltage across C reaches the breakover voltage of the neon lamp (typically 75 volts) the lamp goes back to a maintaining voltage of approximately 53 volts, allowing the capacitor to discharge into the SCR gate. Since the SCR is capable of conduction in only one direction, it can supply only one half-cycle of the sine-wave current to the load. Switch S_1 is connected mechanically to the potentiometer so that it closes at the end of the clockwise rotation of the potentiometer applying full power to the load.

The symmetrical circuit shown in Fig. 5 uses two RC circuits with a common resistance to control the firing point of the two neon lamps which trigger the SCR's. Diode D_1 provides a bypass around C_2 to supply the charging current to $R_1R_2C_1$ on the positive half-cycle of the supply, and D_2 performs a similar function on the negative half-cycle. When this circuit is used for incandescent-light dimming, a small amount of flicker may occur during the first stages of conduction at low light levels. This can be due to a variation in the values of C_1 and C_2, or to the breakover voltages of the neon. The effect can be avoided by reducing the minimum conduction angle to a point where flickering does not occur when the potentiometer is at its lower limit and S_1 opens and closes.

The LC filter reduces the radio-frequency interference caused by the fast turn-on of the SCR's. The 150-μh value for the inductor is a minimum and might have to be increased to 500μh or more for critical applications. The 0.06-μf capacitance is nominal and may be increased, but a maximum of 0.1μf is necessary to prevent unusually high surge current from destroying the SCR at turn-on. This filter is designed for lighting and appliance applications, but it is not necessary when the load is highly inductive (a universal motor, for instance). Usually the interference caused by motor commutation is significantly higher than that due to the SCR switching.

In motor controls, R_1 should be adjustable so that the maximum resistance may be set to provide a minimum conduction angle for the SCR's. This permits setting the minimum speed of the motor above the point where operation is not smooth.

Another version of the symmetrical control circuit (Fig. 6) uses a single timing circuit that provides 120 pps to the SCR gates through the pulse transformer T_1. Since the same timing circuit fires both SCR's in this circuit, unsymmetrical firing problems such as those mentioned above are eliminated. Due to the alternate positive and negative voltages applied to the capacitor, and because of the change in the magnitude of these voltages before and after the neon bulb fires, this circuit operates with a hysteresis characteristic. As the resistance of R_2 is decreased from its maximum value, the charge on the capacitor is increased with each half-cycle. When the charge is sufficient to fire the neon lamp, the SCR is fired, aborting the control-circuit voltage so that on the next half-cycle the capacitor starts charging at a lower point and reaches the neon firing voltage earlier in the cycle. The potentiometer resistance can then be increased to retard the SCR firing point, producing the hysteresis effect. The transformer used in this circuit is a Sprague model 31Z286 which has a turns ratio of 1:1:1 and a primary inductance of 10 μh. It is designed for SCR triggering circuits but here its characteristics are not critical. For instance, a transformer with a 1:1:1 ratio and 40 turns per winding on a ferrite or soft core may also be used.

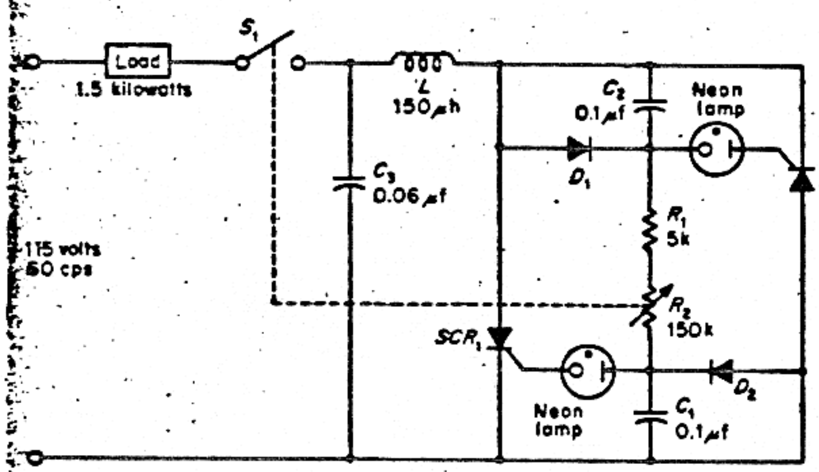


Fig. 5—Direct-coupled symmetrical-control circuit.

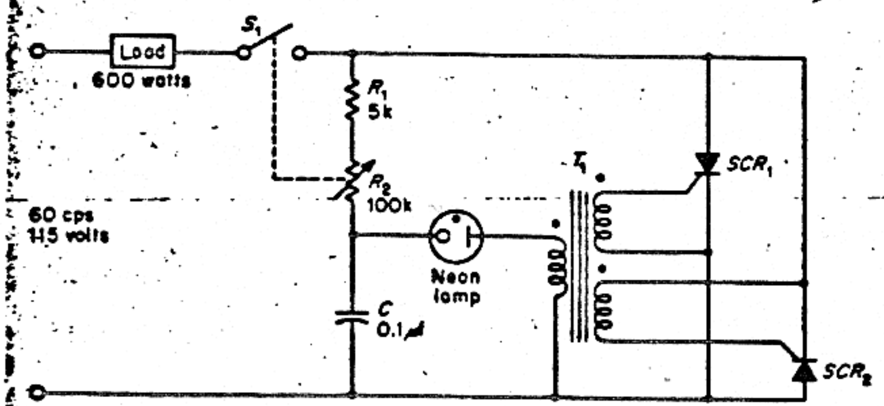
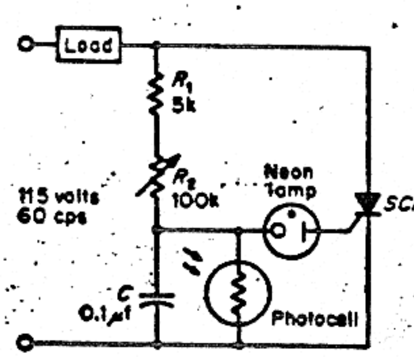


Fig. 6—Transformer-coupled symmetrical control.

Fig. 7—Control circuit using photocell for triggering.



As shown in Fig. 7, a dimming circuit controlled by a photocell can be obtained by adding a cadmium-sulfide cell across the timing capacitor of the circuit in Fig. 4. The photocell dark resistance is approximately 1 megohm which has very little effect on the phase-shift circuit, but the light resistance of less than 1 kilohm is sufficient to prevent the capacitor from charging up to the level of the neon firing voltage. This results in an out-of-phase, light-controlled dimmer. The light level may be set manually by adjusting R_2 when the CdS cell is dark so that, as the cell is exposed to light, the load dims gradually until it is completely off. The component values in this circuit may be varied to change the light sensitivity. To reduce the sensitivity, a photocell with a higher light-resistance range may be used and a resistor may be added in series with the cell or the value of the capacitance may be increased (with appropriate changes in R_1 and R_2). Reversing the changes in component values increases the circuit sensitivity.

There are many possible variations of the circuits described here. Transistors may be used in the timing circuit to permit the use of feedback control. However, in circuits of this type, the stability of the firing angle becomes more critical and, since this stability is directly dependent on the stability of the neon lamp, it becomes a critical component. ▲

THREE COMMON TYPES OF VOLTAGE REGULATORS					
Characteristics	Large gas tube regulator Type VR90	Zener Diode 91 v Low tol	Zener Diode 1 w High tol	Submin gas tube regulator Low tol	Submin gas tube regulator High tol
Regulation tolerance	±3%	±20%	±5%	±20%	±1%
Approximate temperature coefficient	−15 mv/°C	135 mv/°C		−3.5 mv/°C	
Approximate size	ST12 Tube	DO-7 to TO-3 can, or lug type to 1½" long by ½" dia.		T-2 bulb 1⅙" long	
Reliability (life)	2000 hours	30,000 hours		50,000 hours	
Stability	May exhibit jump characteristics	Excellent		Excellent	
Voltage range	3%	2%		1%	
Current range	5 to 40 ma	0.25 to 7 ma		0.25 to 7 ma	
Shock & vibration	Must be isolated from vibration and shock	Good		Good	
Installation	Socket	Solderable leads		Solderable leads	
Mounting position restrictions	Must be upright in certain applications	None		None	

the ac wave, or a maximum phase angle of 180 degrees. A triac, on the other hand, functions on both halves of the ac wave, provided a gate pulse is supplied during both periods.

In both examples, the resistor-capacitor combination determines the time at which the voltage across the lamp reaches the breakdown point. When the neon fires, it discharges the capacitor through the gate circuit and the SCR or triac turns on. Of course, this assumes the anode of the SCR is positive. On the negative half cycle, the SCR is reverse biased, and cannot turn on. Triac circuits differ in that they can be turned on with either positive or negative pulses. Both SCR's and triacs turn off as the input ac waveform goes through zero.

By varying resistor R, the neon can be made to reach its firing voltage earlier or later in each half cycle and, therefore, the SCR's (or triac's) output varies in proportion to the phase angle of the applied ac wave. (The resistor can be a potentiometer, as in the case of a motor speed control, or a thermistor, as in the case of a heat control, or other similar variables.)

The simple circuit shown in Fig. 5 uses a gas device to switch low level signals. This type is often used in remote controllers or with short or long term erasable memories, where it might be desired to store a program or other data for three, four, or more days before erasing. In this circuit, when either function switch closes, the neon lamp conducts and the capacitor's charge is made either positive or negative in response to the desired direction of control. The FET transistor follows the capacitor voltage, and provides the variable dc control voltage.

In addition to these applications, neon gas diodes can be used in timing circuits, in photo choppers, as surge protectors, and in many other control applications.

The low cost alternative

Cold cathode neon diodes provide the circuit designer with an excellent alternative to zener diodes and other more complex and expensive components and circuitry. Where voltage regulation within ±5 v, and especially within ±1 v is required, the cold cathode neon diode is preferable, based on reliability as well as cost considerations. As reference voltage sources, the neon devices' precise output makes them more desirable for most applications within their wide voltage range. ⊕