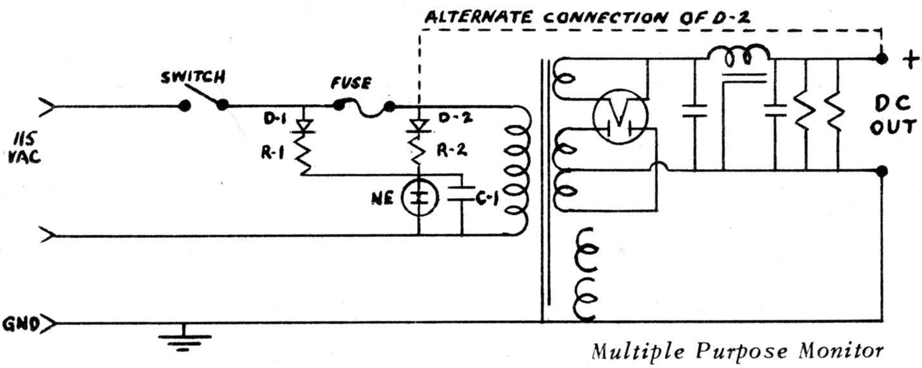
Signalite
APPLICATION NEWS
from the desk of

Ed Bauman, Chief Engineer

Vol. 3 No. 4

In this issue ...



Multiple Purpose Monitor Lamp . . . See Page 157.

Tell us how you use - or would like to use neon glow lamps - and receive a Signalite Owl Eye Nite Lite free. See readers' Forum section beginning on Page 157.

A UNIQUE FREQUENCY DIVIDER AND STAIRCASE GENERATOR

By: A. B. Cistola
IBM Space Guidance Center
Manufacturing Research
Owego, N. Y.

INTRODUCTION

Very often in electronic systems, a need arises for a voltage to be divided into equal steps. Staircase generators normally used for this purpose generally involve 1 or 2 transistors and perhaps a dozen other components. In this article a circuit, which reduces the number of components and also serves a double purpose as a frequency divider, is discussed. When functioning as a frequency divider the circuit separates out the odd number of pulses, for instance, 3's, 5's, 7's, etc. Thus the circuit eliminates the need for decoding logic usually associated with binary systems in order to separate out odd counts.

CIRCUIT DESCRIPTION

The basic circuit is shown in Figure 1. The input potentiometer R1 is a 10-turn pot controlled by a vernier dial. Its purpose is to supply a variable amplitude of the input square wave voltage to the series-resonant L1, C1 combination. The inductor L1 should have a high "Q" factor since the voltage which is developed across L1 must be high enough to fire the neon bulb. The combination of R2 and C2 serve as an integrator, aside from the normal duty of R2 as a current limiter.

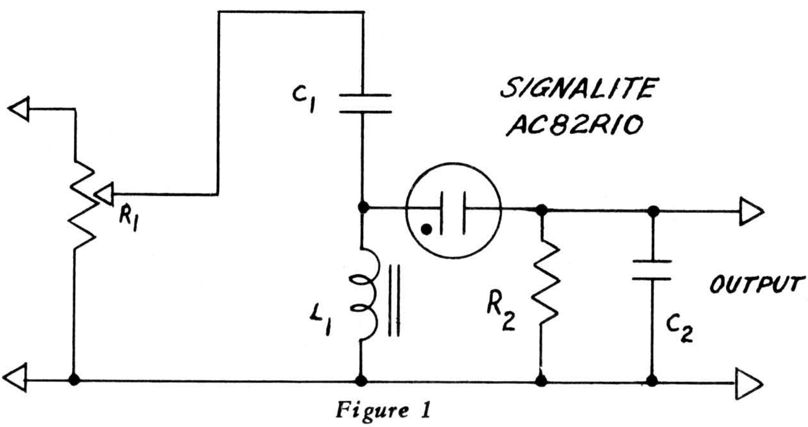


Figure 1

THEORY OF OPERATION

The circuit is capable of operating in two distinctive modes. Namely as a frequency divider and as a staircase voltage generator. The mode of operation is determined by the range of the input voltage (See Chart 1).

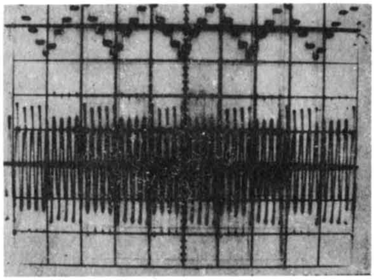


Figure 2

When a square wave voltage on the order of 54 volts or so is applied to resonant circuit L1, C1 the voltage across L1 is sufficiently high enough to cause current pulses to flow through R2 due to the firing of the neon bulb. Capacitor C2 will accumulate a charge of such polarity that it will be series-opposing the input voltage for breakdown to occur in the one direction, but series-aiding the input voltage for breakdown to occur in the opposite direction. Assuming that breakdown is occurring on the positive going pulses, the immediate result is that no current will flow through the bulb on negative going pulses. (See Figure 2.) For every positive going input pulse an additional charge will accumulate on C2 until the voltage across C2 in series aiding with the negative going voltage across L1 is enough to cause a discharge through the bulb in the opposite direction. When this happens all the negative going input pulses will reduce the accumulation of positive charges on C2, go through a zero level and build up in the negative direction until a point is reached where C2 will again discharge through the bulb, with the series aiding positive going pulses. (See Figure 3.)

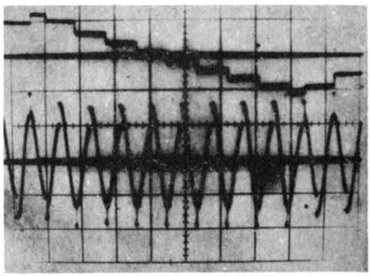


Figure 3

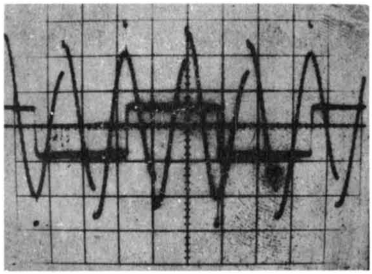


Figure 4

This cycle will recur at a definite time interval. The number of step levels in a staircase is changed by changing the pot setting in small increments. (See Chart I). As the input voltage is reduced various staircases of increasing step levels and peak to peak amplitudes will be generated. A point will be reached, however, where a further decrease of input voltage will not be sufficient to cause bulb current to flow on every positive or negative going cycle. This is the voltage at which the circuit will start operating in the frequency divider mode. (See Figure 4).

When the input voltage across L1 and C1 is in the order of 40 volts or so, the voltage across L1 will take a number of cycles to build up to a sufficient level to fire the bulb. The L-C circuit acts as a heavy load immediately upon application of the input signal and requires some time constant to build up. (See Figure 4.) After about 1-1/2 input cycles have occurred the voltage across L1 will be sufficient to fire the bulb. A charge will develop across C2 due to current flow through R2, in the order of 1 volt (peak to peak). When the bulb discharges the voltage across L1 is lowered to some voltage which is below the maintaining voltage of the bulb. After 1-1/2 more input cycles have occurred again the bulb will fire in the opposite direction causing a 3 to 1 count of the input square wave to be developed across C2. Frequency division by 5's, 7's and 9's are obtained by reducing the input voltage through R1 in small increments.

Figure 5

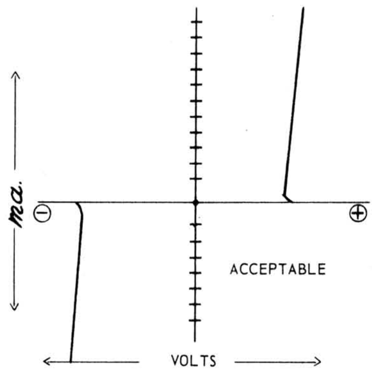


Figure 6

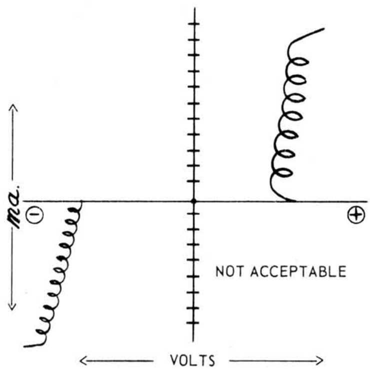
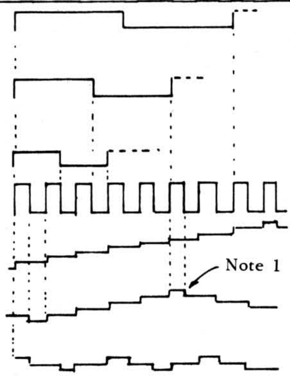
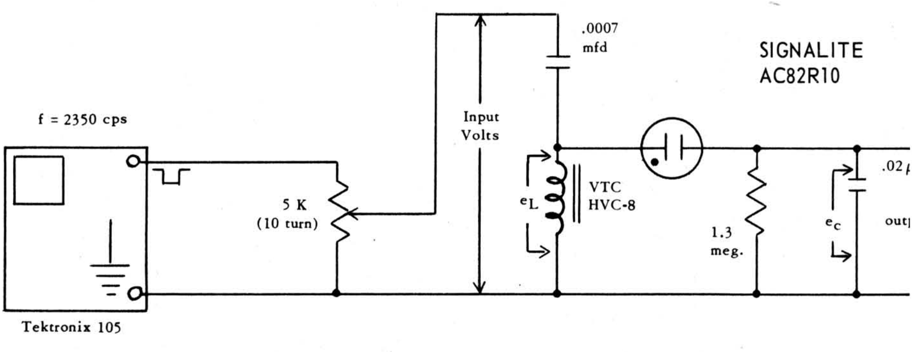


CHART I

Circuit Function	Input Volts (P-P)	Output Wave Shape	Output Amplitude (P-P Volts)	Remarks
Freq. Divider	32		1.0	7's Count
	36		1.0	5's Count
	40		1.0	3's Count
	Input Sq. Wave			
Staircase Generator	44		13	10 steps @ 1.3V ea. *
	50		10	6 steps @ 1.6V ea. *
	54		6	3 steps @ 2V ea. *

* Staircases with 4, 5, 7, 8 and 9 step levels can also be generated at intermediate input voltage settings.

Typical figures obtained from following circuit:



NOTE 1: The duration of the staircase level when slope changes is equal to ½ cycle of input square wave. Other levels are equal to a full cycle of input square wave.

A WORD ABOUT SELECTING THE COMPONENTS

In order to insure proper operation of this circuit the neon bulb characteristics should meet the following specifications:

1. It should have a large difference between breakdown and maintaining voltages.

2. It should be checked on a curve tracer for cleanliness of breakdown curve. (It should not display an erratic curve.)

3. It should have as close tolerance as possible on breakdown and maintaining voltage levels in both positive and negative directions, otherwise there will be a slight misalignment between positive going and negative going step levels.

All three of the above specifications can be checked on a transistor curve tracer. Figures 5 and 6 show good and bad traces. The inductor should have a quality factor (Q) as high as possible.

All of the above requirements are met by the AC82R10 tube manufactured by Signalite Inc., Neptune, N.J. Breakdown voltage is plus or minus 100 volts with a tolerance of 3 volts, maintaining voltage is plus or minus 82 volts with a tolerance of 1 volt. The tube exhibits no negative resistance from .5 ma to 10 ma.

The signal generator should have a sufficient amount of drive to be able to handle loading of circuit.

*

NEW BULLETIN REFERENCES GAS DISCHARGE DEVICES

A new Product Reference Bulletin, No. 301, has just been issued by Signalite Inc. cataloging typical gas discharge tubes and devices. Included are the main performance parameters for typical two-element Spark Gaps, Triggered Spark Gaps, Microwave Noise Sources and Miniature Microwave Noise Generators.

Dimensional drawings are shown for representative two-element and triggered Spark Gaps covering the most popular voltage ranges. The Microwave Noise Sources and Miniature Microwave Noise Generators listed include the principal electrical and microwave characteristics.

Product Reference Bulletin No. 301 is available upon request from the Special Products Division in care of Signalite Application News, 1933 Heck Avenue, Neptune, N. J. 07753.

In the last issue of the Application News, we announced that Signalite had broadened its range of gas discharge tube products to include spark gaps, noise sources, and other devices formerly produced by the Red Bank Division of Bendix. To further acquaint you with some of these products, we are presenting here a discussion of spark gaps and their use in electronic equipment. The author, Keith Olson, has been engaged in the design, development and production engineering of gas discharge tube devices for more than 11 years.

SPARK GAPS PROVIDE BUILT-IN SYSTEM COMPONENT PROTECTION AND ACTIVE SWITCHING

By: Keith Olson
Manager, Special Products Div.
Signalite Inc.

For many years designers of electronic equipment have turned to the spark gap as a last resort when some internal fault or externally applied power surge has caused a failure or threat of failure in the equipment. Recent developments and progress in the design and process control of hermetically sealed spark gaps now provide the equipment designer with components for protective or active switching in his circuit which can reduce the cost of his equipment and improve its reliability.

The spark gap, as a protective or energy transfer device, is a switch which presents very high unfired impedance, 10^9 ohms or greater, to a circuit and low operating impedance (ohms or fractions of an ohm) in its normal operation. High and low voltage switching requirements in electronic equipment vary from fast acting protection of other components during fault conditions to transfer of energy under controlled conditions. The necessity for protection is constantly increasing as the cost of power components increases and as the required sizes, and consequent overvoltage ratings, become smaller.

The two electrode spark gap operates in two distinct modes. As mentioned above it presents a near infinite impedance to the circuit when in a non-conducting mode. When operating in the conducting or transient arc mode, it presents a near short. In this latter case when the breakdown voltage is exceeded, the tube drop across the gap falls to a very low value, typically 10's of volts for currents of hundreds to thousands of amperes. The current passed through the gap is totally circuit dependent, similar to any other gas discharge device operating in an arc mode.

When a safety gap is used in a circuit where the normal operating voltage is below the extinguishing voltage of the gap, the gap will recover its hold-off characteristics after the voltage surge has passed. In cases where a heavy follow-through current continues after the surge has passed, the continuous dissipation rating of the gap must be high enough that the gap will sustain this current until a circuit breaker or a fuse can operate.

The source energy which is available for discharge in the gap circuit will be dissipated totally in the spark gap unless a series resistance is included. By the inclusion of such a series resistance, it is possible to extend the use of lower energy spark gaps to higher energy circuits. For example, a typical tube drop might be 30 volts for a peak current of 3000 amps with a resultant effective gap impedance of .01 ohm. Therefore, if a one ohm resistor were to be installed in series with the gap with constant current conditions, the gap would only be dissipating about 1 % of the total energy available.

Current and voltage waveforms for typical applications of safety gaps may serve to illustrate a few basic circuit design considerations.

In Figure 1 a spark gap is mounted across a radar pulse transformer secondary that has a normal repetitive pulse voltage applied across it. A series of magnetron misfires cause a buildup of voltage across the pulse transformer secondary which could become many times the normal level. This spurious voltage causes the gap to discharge and conduct the transient current through it as shown in Figure 2. As soon as the transient has passed and the magnetron starts firing again, the normal magnetron current flow is restored, since the normal voltage is less than the cut-off pulse voltage level of the gap.

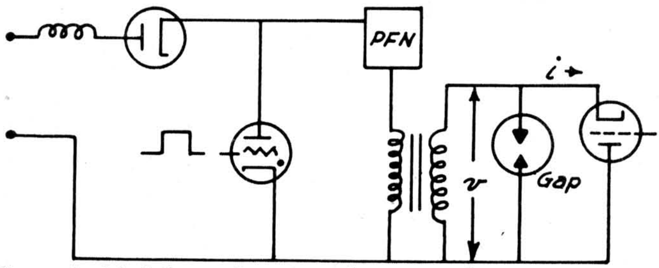


Figure 1: Modulator Circuit Utilizing Spark Gap Protection.

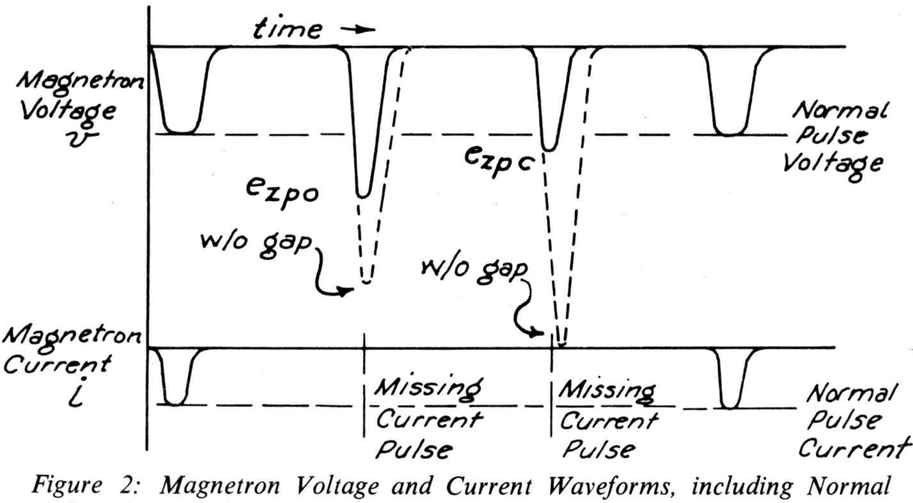


Figure 2: Magnetron Voltage and Current Waveforms, including Normal and Misfire Conditions.

In the case of power mains and low impedance power supplies, the current may not drop below this cut-off pulse voltage level after a single fault. It then becomes necessary to provide a circuit breaker or fuse to terminate operation. Figure 3 shows a gap protecting a distribution transformer and the load components. The line voltage and current waveforms are shown in Figure 4. A spurious transient pulse voltage may be caused by any of several reasons, such as lightning discharges, a short circuit in an inductive load, induced voltages from external transmitters, line transients from the primary circuit, etc. The line current is shown at the normal level, then at the higher than normal level during the period of spark gap conduction, and finally terminated by the operation of the circuit breaker. Figure 3 shows the use of safety gaps to protect costly capacitors from overload.

The addition of a third electrode to the spark gap produces a unit which can be triggered and used as a circuit components to permit high levels of stored energy to be switched in fractions of a microsecond. These

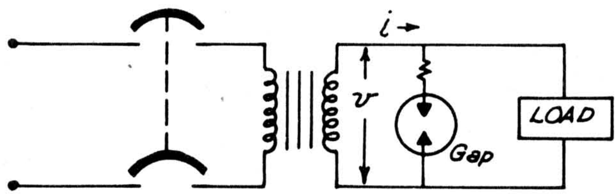


Figure 3: Power Line Utilizing Spark Gap Protection.

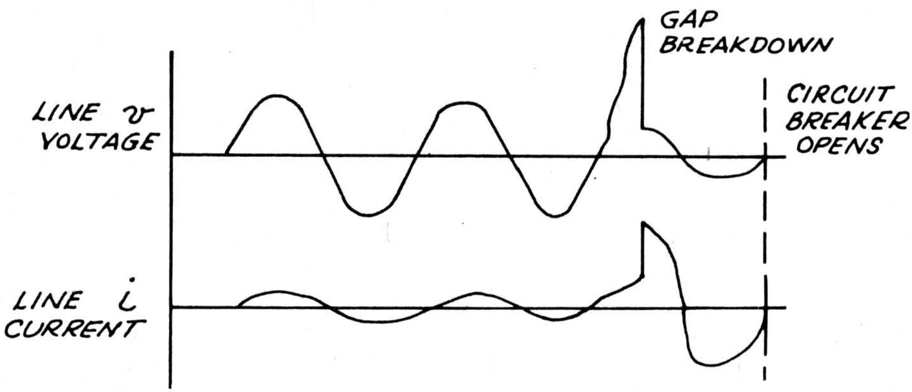


Figure 4: Line voltage and Current Waveform, including Normal and Spurious Pulse Conditions.

high levels of stored energy can be switched on command by low energy control pulses. Triggered spark gaps require no standby power, are relatively small in size, and are extremely rugged for severe environmental requirements. They are useful to fire exploding bridge-wire circuits on command, to trigger flash tubes for use with lasers and high speed photo-

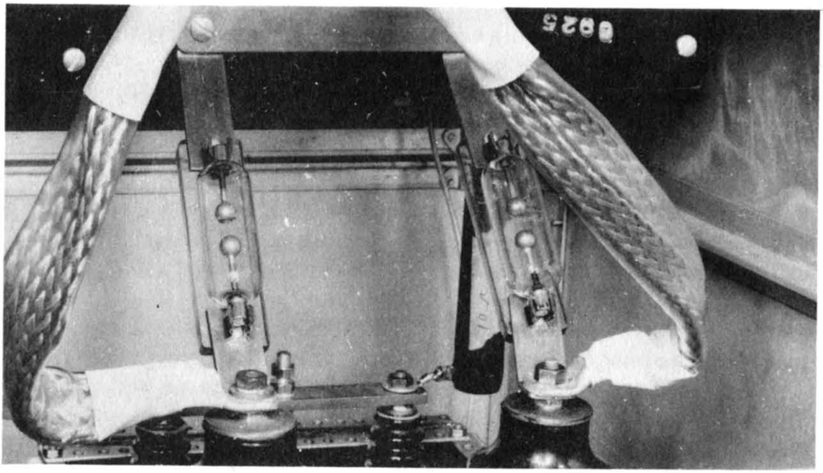


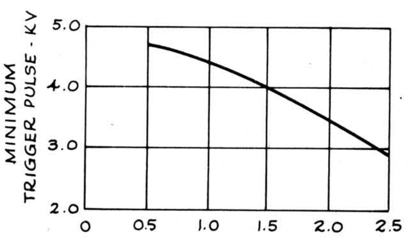
Figure 5

graphy, to create pinch discharges, to protect against currents faults by means of electronic crowbars, or to make available cold cathode pulse modulator drivers, as well as many other uses.

The triggered gaps are principally high energy, high current devices. Therefore, the electrodes are made of refractory metals, very high conductivity metals, or mixtures of these metals depending upon the amplitude and width of the current pulse to be carried by the gap. In many cases, stainless steel electrode supports are used to minimize the external effects of oxidizing or corrosive atmospheres.

The body insulator and the trigger insulator generally are ceramic for maximum electrical insulation and maximum resistance to nuclear environments. There are also triggered gaps available with glass bodies for applications in which the energy dissipation requirements and environmental extremes are less severe.

As with the two-electrode gap, the triggered gap presents a near infinite impedance to the circuit when unfired. That is, when the voltage applied across the main electrodes is less than the firing voltage of the gap, the circuit is unchanged by the presence of the gap. When a signal of proper value is applied to the trigger thus allowing the main gap discharge to take place, the tube drop falls to values of the order to tens of volts for currents of thousands of amperes. The trigger voltage required to cause main gap breakdown decreases as the applied voltage to the main gap increases, as is shown in the typical relationship depicted in Figure 6.



Minimum Trigger Pulse vs. Applied Main Gap Voltage (Typical).

Figure 6

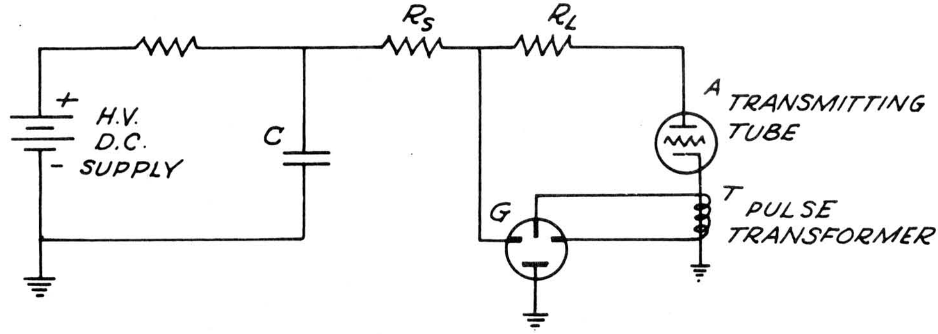


Figure 7: Typical Electronic Crowbar Application.

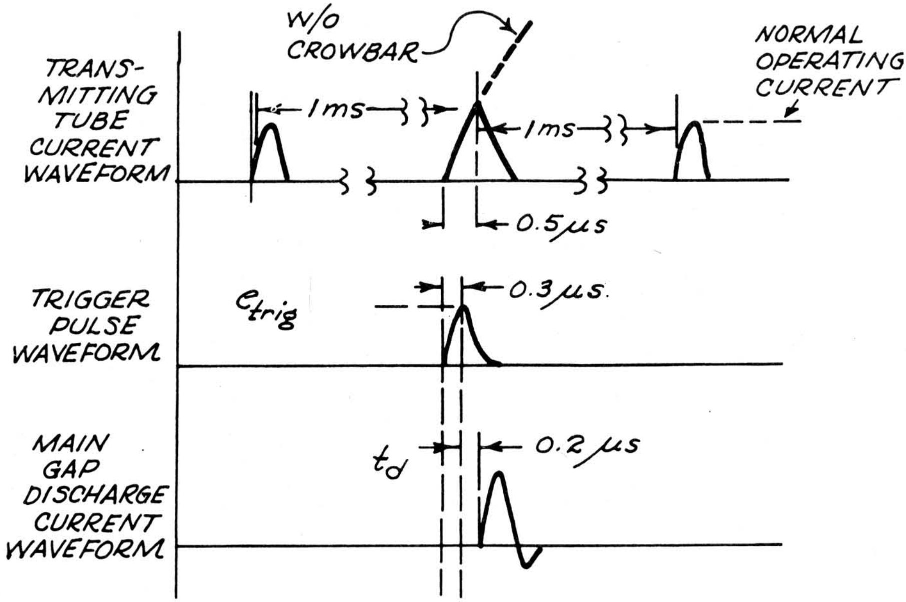


Figure 8: Various Waveforms of Crowbar Circuit.

An illustration of the use of the triggered spark gap in a typical electronic crowbar application is shown in Figure 7. The high vacuum transmitting tube, A, arcs from grid to plate inititating a fast rising current arc. The capacitor, C, is capable of supplying sufficiently high current to totally destroy the tube unless the plate supply is crowbarred in a sufficiently short period of time. The initial rise of the current surge provides a trigger pulse through pulse transformer, T, to the protective triggered gap, G.

The fault current wave form, the trigger pulse waveform, and the main gap discharge waveform, are shown in Figure 8. Crowbarring of plate supply in this example is accomplished in a total time of 0.5 μsec. The time delay of the gap is 0.2 μsec and a delay in the pulse transformer is 0.3 μsec. The duration and magnitude of the fault current has been sufficiently limited within the tube, A, to be harmless and the energy stored in the capacitor, C, has been dissipated in the gap instead of in the tube.

Triggered spark gaps are produced in many shapes, sizes and rating to fit a variety of applications. Figure 9 shows a triggered gap used as a switch in a high-energy capacitor bank. In addition to standard configurations many special gaps have been developed. For example, there are

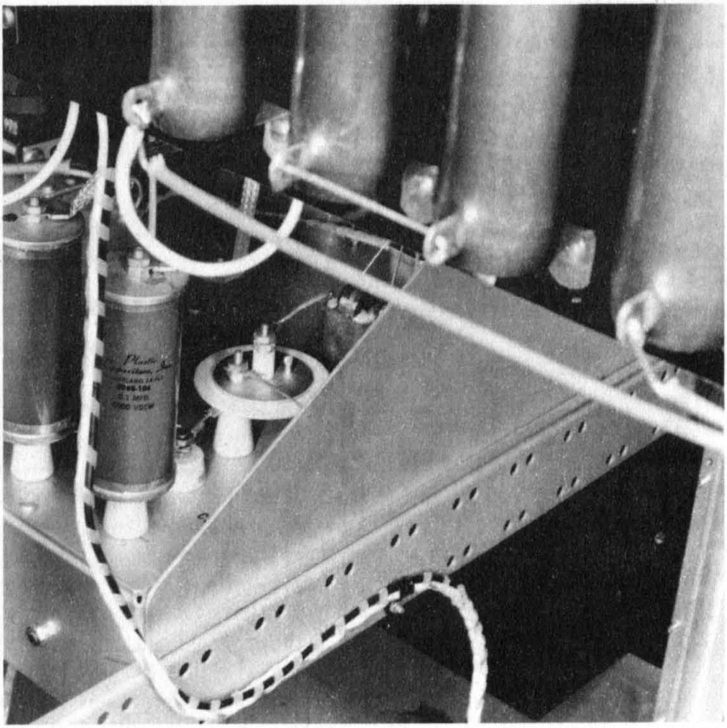


Figure 9

available ceramic-metal gaps with dual triggers which have been developed for use in applications requiring an ultra-high degree of reliability by providing redundant triggers. The trigger pulse can be applied to both triggers simultaneously or to either one individually.

In the past some equipment designers have looked upon the spark gap as a last resort type of component to be used only when all else has failed. Much discomfort, expense and time can be saved, however, by providing for the use of spark gaps in the initial design of the equipment.

This approach not only increases the reliability of the equipment, but also permits frequent cost reductions in the purchase of other components for the system inasmuch as the spark gap eliminates many of the worst conditions a designer may have to anticipate.

The Special Products Division of Signalite in continuing the practice of applications assistance that has been in effect for years with regard to the use of glow lamps. Any questions concerning spark gaps or noise sources, any suggestions regarding applications, any circuit design assistance that may be required may be brought to the attention of Keith Olson, Manager of the Special Products Division with full assurance that it will be promptly handled.

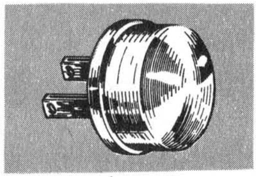
*

Send Us Your Glow Lamp Application

The use of the neon glow lamp as a reliable circuit component has dramatically increased the need for application information. We are asking that you:

1) Send application examples—both general and specific

2) Send application problems or solutions to problems that we publish



A Signalite Owl Eye Nite Lite for the home will be sent free to each person who sends us an application, a problem or a solution.

CAN YOU SOLVE THIS ? ?????

FAIL–SAFE INDICATOR OR ALARM CIRCUIT

Gentlemen:

Recently my gas furnace pilot light went out unknown to me. Upon return after a weekend trip I found the house quite cold (near freezing). Perhaps an application for your neon light would be to indicate when the pilot light has gone out.

Harold Ludtke
Minneapolis, Minnesota

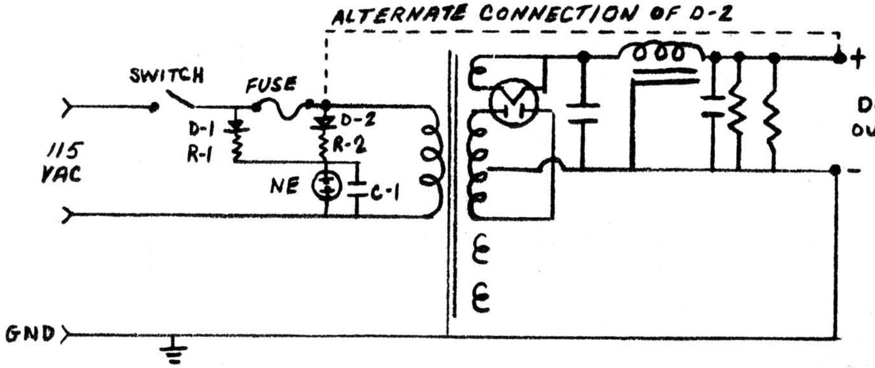
YOUR GLOW LAMP APPLICATION FORUM

It is Signalite's policy to publish letters based on their intrinsic interest only. We do not necessarily agree with all comments and suggested uses and will upon occasion wait for your reaction before taking editorial space for ours.

MULTIPLE PURPOSE MONITOR LAMP

Dear Mr. Bauman:

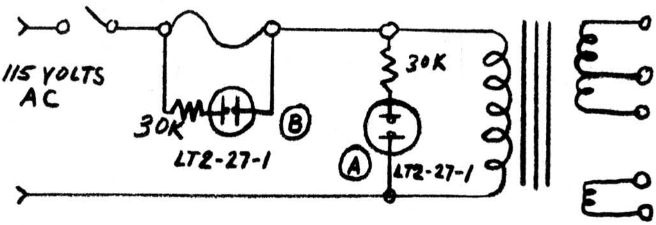
The circuit below indicates a neon lamp having three states. "ON" and "OFF" have the usual AC input indications, but a flashing lamp indicates a blown fuse or other fault.



Resistor R-2 (30K) determines average lamp current for a long life. Capacitor C-1 sets a flicker rate, to high to be easily noticeable. Resistor R-1 (470K) is then selected to set the "FAULT" flash rate. The silicon signal diodes must have very low reverse leakage, suitable inverse voltage rating but supply little forward current.

In some cases, D-2 may be connected to a power supply output or other point. The "FAULT" or flashing might indicate such faults as a defective rectifier.

E. A. Deck
Palo Alto, California



Ed Note:

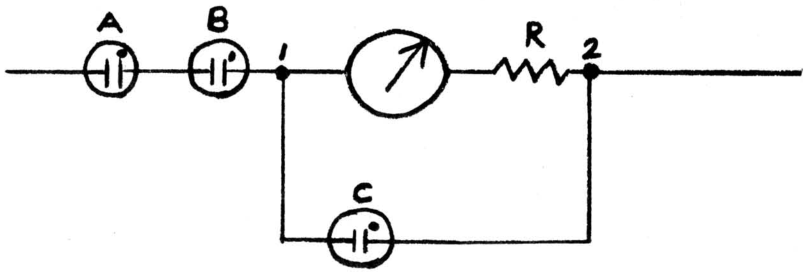
An alternative approach might be to use two neon lamps and resistors to indicate the fuse status, as shown above. One lamp (A) with a 30K resistor would be connected across the transformer. This lamp would be "on" whenever the power switch is closed and the fuse is good. A second neon lamp and resistor assembly (B) would be connected across the fuse. This lamp would be "off" under normal conditions but would light if the fuse was blown and the power switch was "on".

GLOW LAMP APPLICATION IN VOLTMETER CIRCUIT

Gentlemen:

In a circuit where it is necessary to read a voltage on an expanded scale meter, the below circuit could be used. Neon lamps A and B would fire before any voltage could be read on meter M. If the voltage increased still further to the point where the meter would be damaged, the voltage drop across the meter and resistor R could be adjusted to fire lamp C at meter M's full scale reading. This would give a visual indication of over-voltage and also reduce the voltage $V_{1,2}$ until the circuit was disconnected.

R.C. Graham
Radio Corporation of America



Ed. Note

Extremely accurate suppressed zero voltmeters with high reproducibility can be made using our DC and AC subminiature voltage regulators. Specifications for some of these units were given in supplement 1. Copies are available.

MARKERS AND BUOYS

Dear Mr. Bauman:

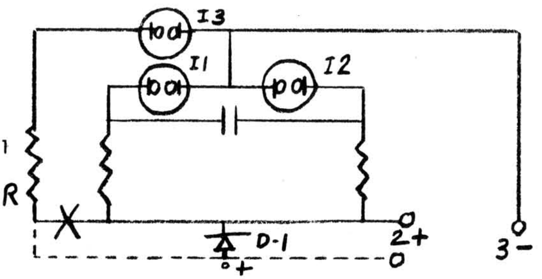
An almost endless number of signals can be made using neon glow lamps in simple circuits.

These circuits are useful on markers and buoys where each must be identified at night.

Referring to Figure 1, I3 serves as the pilot light, using a NE51H if operated on A.C. or 150 V.D.C. and 20 Kilohms series resistance. If I3 is supplied with D.C. below 150V a NE51 is used with 56 Kilohms series resistance.

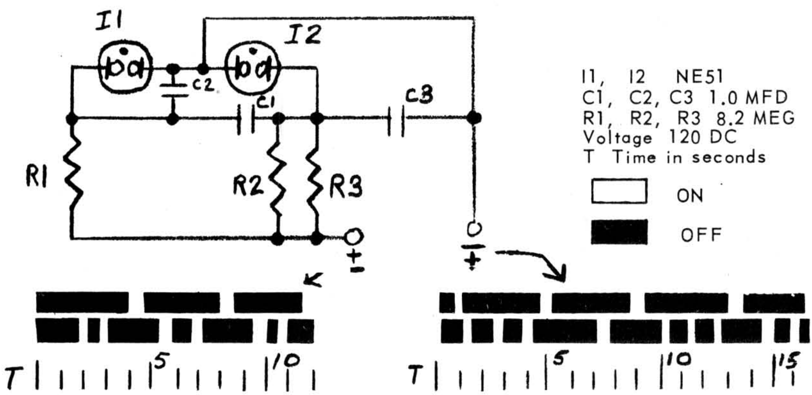
The pilot light in these circuits is steady and brighter than the identifier signal lights; thereby giving much greater visibility.

Fig. 1



Terminals 2 & 3 for DC, 1 & 3 for AC-DC break circuit at X add dashed line for AC-DC.
For DC operation only, omit rectifier 11, 12, NE51
13 NE51 or NE51H } see text
R 56KΩ or 20KΩ
D1 Silicon Rectifier

Fig. 2



It is interesting to note that;

Neons can give alternately different number of flashes (see Figure 2).

When neon identifier circuits are installed in a number of markers or buoys they should be designed to vary widely in signal characteristics, so identification will be positive. Small variations due to component tolerances and dark effect need not be considered.

Charles W. Forster
San Diego, California

Ed. Note:

In Fig. 1, A-C is used instead of D-C, input connections are then made between terminasl 3 and dashed terminal 2.

If you have a circuit design problem involving the use of glow lamps, or have developed a circuit in which glow lamps are important for design and/or economic reasons, we would like to discuss your application in a future issue of this newsletter.

Applications which in the opinion of Signalite have significant interest will also be brought to the attention of the editors of leading technical publications for consideration as articles and featurettes. Your by-line and company credit will be given with your permission.

* * * * *

For immediate technical application or circuit design assistance, you may contact Ed Bauman directly at:

TWX: 201-775-2255 TEL: 201-775-2490

* * * * *

For information about Signalite Neon Glow Lamps for circuit component and/or indicator applications, for specifications on lamps, for general information about Signalite and its products, call us at any of the following telephone numbers:

Phoenix, Arizona	(602) 254-8889	Detroit, Michigan	(313) 862-2225
Los Altos, Calif.	(415) 967-8998	Neptune, New Jersey	(201) 775-2490
Los Angeles, Calif.	(213) 466-4464	Albuquerque, N. Mex.	(505) 256-0884
Central City, Colorado	(303) 582-2671	Cincinnati, Ohio	(513) 521-2290
No. Miami, Florida	(305)PL1-5566	Cleveland, Ohio	(216) 333-2585
Chicago, Illinois	(312) 763-2131	Columbus, Ohio	(614) 488-9731
Indianapolis, Indiana	(317)FL9-5374	Dayton, Ohio	(513) 298-9546
Fort Wayne, Indiana	(219) 743-4411	Portland, Oregon	(503)CA2-7337
Louisville, Kentucky	(502) 893-7303	Seattle, Washington	(206)MU2-7337

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