Chapter VII

SURGE AND SIGNAL PROTECTORS

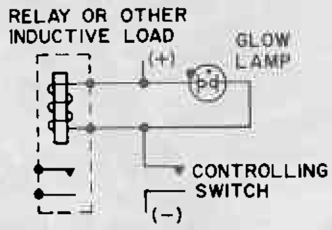
Neon lamps frequently find applications where it is necessary to prevent transient or recurrent voltage pulses from damaging more sensitive components or where the circuit must be isolated from stray or spurious signals or noise. Three characteristics are essential to this application. First, the component must remain open-circuited until the applied voltage or pulse exceeds a predetermined ignition point. Second, it must be able to conduct moderately high currents without damage to itself. And third, it must have a finite and known extinguishing point high enough so that circuit operation may continue uninterrupted. All of these characteristics, as has been discussed earlier, are inherent in the neon glow lamp.

Among the many applications in this area is the prolonging of life for switch contacts used with relays and other inductive devices.

When the current flowing through an inductive load is suddenly stopped, a counter electromotive force is developed which theoretically may reach an infinitely high voltage at the instant of switching. In normal practice, the limitations imposed by leakage resistance and capacitance will prevent this voltage from exceeding 10,000 volts. This voltage is sufficient, however, to break down across the air gap between the open contacts, creating an arc which tears away some of the metal and shortens the contact life.

This problem has been eliminated in many cases by the addition of a simple neon glow lamp to the circuit. The lamp is placed across the relay coil as shown in Figure 7-1. When nonconducting, it does not affect normal circuit operation.

Under the build up of the counter emf as the contacts are opened, the lamp is ionized. The stored energy in the coil then discharges very rapidly through the lamp. The voltage across the coil is held to the maintaining voltage of the lamp until such time as the coil counter emf falls below this maintaining voltage. At that point the lamp will extinguish.



7-1 Protection of relay contacts from counter emf

When the lamp is operating, the voltage is maintained at a sufficiently low level to prevent arcing across the open contacts of a relay.

The effect of the current surges on lamp life and lamp characteristics is a function of the amplitude and rate of the surges. Under normal conditions in circuits with relay switches the duration of the surge is of such a short time that extremely high amplitudes can easily be tolerated without serious detriment to the life of the lamp.

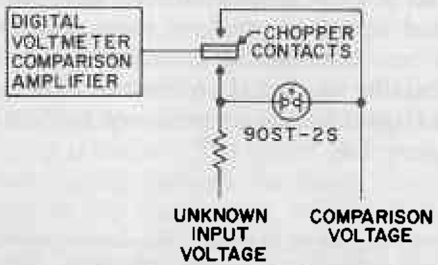
Choice of the specific neon glow lamp to be used in this type of application will depend on the inductance, the operating voltage and the current of the relay in the circuit. It is important to remember, however, that the maintaining voltage of the lamp must be higher than the relay operating voltage. Currently available lamp types have been designed with maintaining voltages from 50 to 150 volts dc. Initial breakdown voltages range from about 65 to 250 volts dc.

A specific use of glow lamps to absorb momentary surges to isolate unwanted signals or spurious noise, and to operate as off-on switches was described by Leonard M. Scholl in his discussion on reliability in digital voltmeters.[1] The product was the Model 484 Digital Voltmeter produced by Non-Linear Systems Inc. (Figure 7-2)

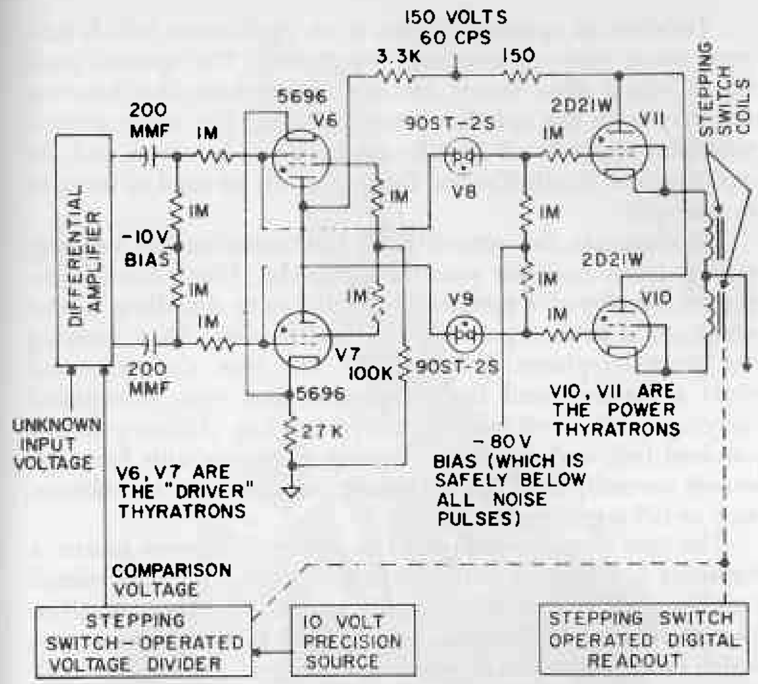
1. Scholl, Leonard M., Project Manager, Non-Linear Systems Inc., "Providing Low Cost Reliability in Digital Voltmeters," *Signalite Application News*, Vol. 2, No. 5.

7-2 Photo digital voltmeter

The neon lamps were used in two separate circuits in the voltmeter. In a circuit similar to that shown in Figure 7-1, the neon lamp was used for chopper contact protection. This circuit was part of the differential amplifier and provides a bypass for high voltages around chopper contacts. During range switching in digital voltmeters, momentary high voltages are often applied to chopper contacts which would cause arcing if not protected. The lamps do not affect digital voltmeter operation during normal measurements because they are effectively open-circuited when extinguished. (Figure 7-3)



7-3 Protection of chopper contacts from momentary high voltage



7-4 Neon lamps as a coupling network

The second application for neon glow lamps in the voltmeter was to provide for reliable firing of the thyratrons to pulse stepping switches. The driver thyratrons are set to be fired by an input of 1 millivolt to the amplifier. When the driver thyratrons are ignited, they cause the neon lamps to switch on and ignite the power thyratrons. The power thyratrons are biased off by a high negative voltage to avoid being fired by noise pulses created by pulsing the stepping switches. Since the 90ST2S lamps are such effective on-off switches, they greatly simplify using a high negative bias voltage. The neon lamps very effectively isolate the driver thyratrons and the amplifier from these noise pulses.

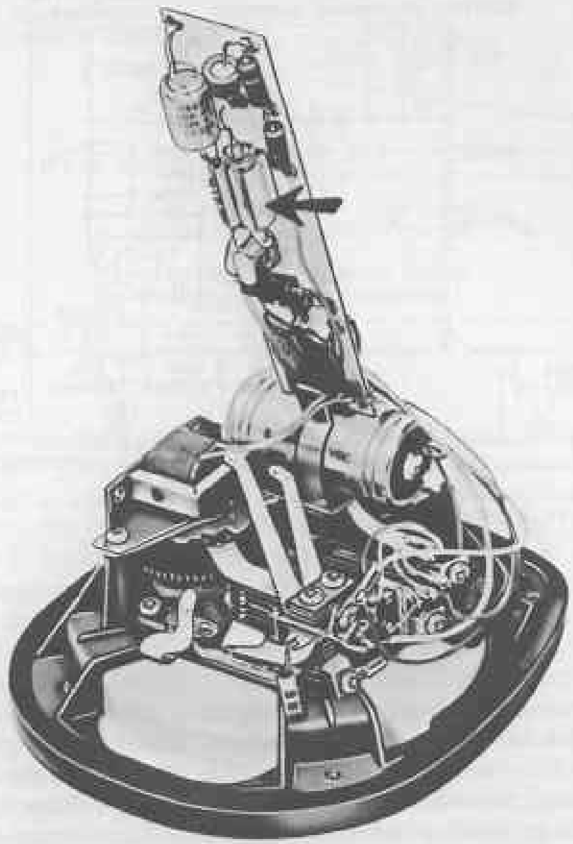
Isolation of spurious signals is an application which concerns many types of electronic equipment. The specific manner in which glow lamps are used to perform this function will vary with the specific circuit at hand. The same general principles apply to all specific applications, however, and the experience of North Electric Company can be used to serve as an example.[2]

To eliminate the conventional electromechanical bell signalling device used for years in telephones, North Electric engineers developed a miniaturized solid state signalling device which could be incorporated into the Ericofon (TM) standing one piece telephone. (Figure 7-5) The new electronic unit emits a pleasant and highly efficient tone with exceptional carrying quality, without the nerve jangling stridency of the standard bell, and one that is readily distinguishable from the sounds normally heard in the vicinity of telephone substations, such as talking or music.

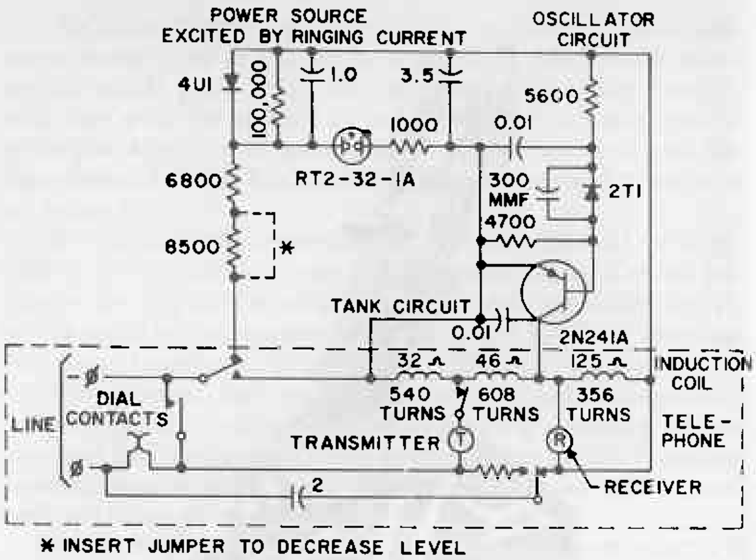
The tone ringer is comprised basically of a power source, a transistor blocking oscillator circuit, and a tank circuit which together couple actuating signals to the telephone receiver. The 20 cycle ringing signals are coupled to the power source which in turn provides a pulsating dc output causing the oscillator to operate. The oscillator operates at the mechanical resonant frequency of the receiver. The power source includes series resistance connected between the terminals.

A rectifier is placed in parallel with a resistor to provide unidirectional current flow in the direction indicated. A network including a first branch capacitor connected in parallel with a resistor, and a second branch including a series-connected capacitor, resistor and type RT2-32-1A glow lamp connected in parallel with a capacitor, provide the signal output for controlling the operation of the blocking oscillator circuit. The oscillator circuit includes a conventional P-N-P transistor and produces sine wave output signals of variable amplitude which cause the diaphragm of the receiver to vibrate, generating the melodious tone call signal. The tank circuit is connected to the collector circuit and includes two of the induction coil windings for positive feedback, a third being wound in the opposite direction.

2. Pickett, Robert, Director Technical Marketing, North Electric Co. and Bauman, Edward, Signalite Inc., "Glow Lamp Prevents Operation By Transient Signals," *Signalite Application News*, Vol. 3, No. 1; and Bauman, Edward, "Glow Lamp Prevents Telephone Dial Tapping," *Electronic Design*, December 21, 1964.



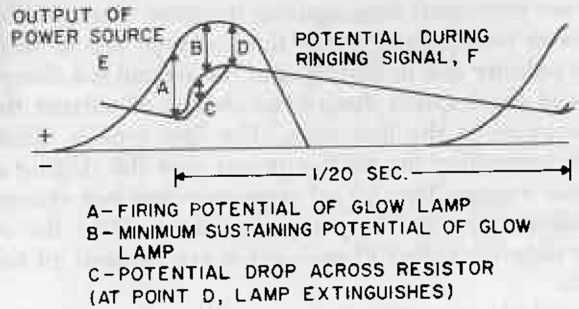
7-5 Photo telephone tone signalling device



7-6 Electronic tone ringer circuit

In operation the ringing voltage across the telephone line is of sufficient value, when rectified and filtered, to be greater than the firing voltage of the glow lamp. This causes the lamp to ignite and immediately settle to its sustaining voltage, allowing a voltage buildup across the capacitor. This voltage is applied to the tone oscillator circuit. As the ringing voltage across the line decreases to a value less than the sustaining voltage of the lamp, the lamp goes out and the capacitor discharges through the tone oscillator. (See Figure 7-7)

This is shown graphically in Figure 7-7. Curve F, indicated as Potential During Ringing Signal, represents the potential which appears across the capacitor connected in parallel with the glow lamp. Curve E, indicated as Output of Power Source, represents the voltage which appears across the capacitor (3.5 mf) connected in series with the glow lamp, and is the voltage



7-7 Voltage and current relationships in electronic tone ringer

applied to the oscillator circuit. During ringing, the incoming voltage is rectified and filtered by the power source. The dc voltage is stored in the 1 mf condenser. When this voltage reaches the firing potential of the neon glow lamp (A on the curve), the lamp will ignite and begin to conduct to complete a charging circuit through the 3.5 mf condenser. During this time the potential difference between the 1 mf and 3.5 capacitor consists of the maintaining potential of the lamp, which is a constant, and the potential drop across the 100 ohm resistor, which is a variable represented by C on the curve. As the 3.5 mf capacitor becomes fully charged, the potential drop across the lamp and resistor decreases until it is below the maintaining potential of the glow lamp, which then extinguishes. The 3.5 mf capacitor supplies power to the oscillator circuit.

From curve E it can be seen that, if the capacitor (3.5 mf) is chosen so that it never becomes completely discharged between ringing frequency cycles, the potential will gradually drop between positive half cycles to a low value, and rise again to a maximum value during the next half-cycle in a continuous manner. This introduces variation in amplitude, or a "warble," into the tone, producing a melodious and pleasant sounding signal.

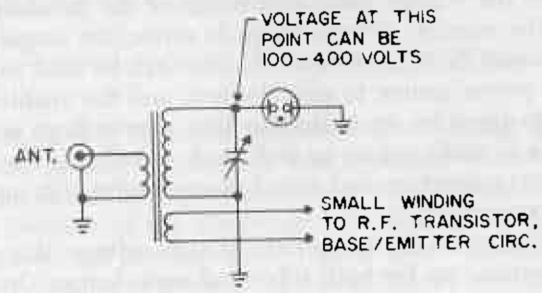
To guard against spurious signals on the telephone line passing into the circuit and affecting the electronic tone signalling device, the device is connected so that transient pulses on the line are prevented from igniting the glow lamp. These transients are of two distinct types: the first type is a 48 volt peak of either polarity due to dialing, and the second is a sharp spike or series of short spikes due to the change of current through the inductance of the line relay. The first type is eliminated simply by extending the dialing pulses over the ringing circuit and power source. The 1.0 mf capacitor does not charge to a value sufficient to fire the neon glow lamp. With the second type the negative spikes of each cycle are shunted off through the diode.

To preclude operation of the signalling device by the positive short spikes, the 1 mf capacitor and 6800 ohm resistor are selected for a value that provides a time constant of such duration that the capacitor cannot charge to a value sufficient to fire the glow lamp. Thus, the lower frequency spikes of shorter duration are shunted through the diode, and the higher value spikes of short duration are accumulated momentarily by the capacitor and then discharged through the 100 K resistor without operating the signalling device.

Breakdown voltage of the neon glow lamp is critical and must be held within narrow limits to prevent dial tapping throughout the life of the telephone.

The RT2-32-1A lamp used in this circuit handles 18 milliamps, an unusually large amount of current for a lamp of this size. Its reliability and long life were proven at North Electric during a test program which produced the equivalent traffic of a busy telephone for 40 years of operation.

Various transistorized communication receivers, particularly mobile and marine, are often subjected to severe overloads at their antenna terminals. The voltage levels which can be created at the receiver's input by the high powered transmitter on an adjacent vehicle are often able to destroy the tuned circuits immediately connected thereto. The resonant rise of voltage of such circuits is conveniently limited to 50 volts or so by the use of a low voltage glow lamp, and this fact, coupled with the typical 10 or 12 to 1 step-down at the transistor input terminals of such an input coil, is sufficient to protect typical R.F. transistors.



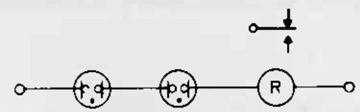
7-8 Transistor input protection

At first glance, it appears that damage could be done to the transistor during the instant immediately following the beginning of a dangerous power burst before the lamp had a chance to light. Two factors, however, are in our favor at this point.

1. The transistor input diode is generally of sufficient thermal capacity that we can safely wait until the glow lamp would normally be expected to light.

2. The glow lamp in fact ignites much more rapidly with R.F. voltage than it does with a dc step function.

During the design of special test equipment it is often necessary to protect either the tested unit or the test equipment, or both from higher than normal voltages. These high voltages can be caused by misconnection of the equipment or of the tested unit. One way to provide this protection is to put neon glow lamps in series with a sensitive relay across the terminals to be protected as shown in Figure 7-9.



7-9 Relay isolation network

When the voltage exceeds the sum of the breakdown voltages of the number of neon lamps in series, the lamps will ionize and cause the relay to operate. This can be used to de-energize the power source to stop the test, and the visible glow of the lamps provides an indication that over-voltage is present. This idea is usable on ac as well as dc circuits. It can be used to protect voltmeters and transformers under test against incorrect connections.

Depending on the magnitude of over-voltage, this can be a severe application for both relay and neon lamps. One advantage, however, is that the relay is isolated from the circuit by 500 megohms until the overvoltage appears. If the relay is used to turn off the power source, a reasonable number of operations is expected.