Signalite

Glow Lamps

- Cold Cathode Diodes
- Voltage Regulators
- Neon Indicators

SIGNALITE DIVISION
GENERAL INSTRUMENT CORP.

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NEON INDICATORS

COLD CATHODE DIODES/ VOLTAGE REGULATORS

Diode Quick Reference Guide

Design Current (Avg.) ma	50V	100V	150V	200V	250V Plus
	A263C				
10.0	A149, A163, A163B	A012A	A226, A012A	A349, A316, A051, A053	A208
6.0	A230, A230D, 3AJ, 5AH, 5AHA, 5AHE, 5AHF				
5.0					
4.5			A171		
4.0	A233A	A158, A081A	A066A, A094D, A342		
3.5	A194				
3.0	A361	A340			
2.5	A331, 3AH, A332, A072C, A328, A278, A163	A066B, A658D, A221C, A329, A330, A257, A120, A224	A106	A009A, A297 A153, A287	
2.0	A204, A286, 5AJ	2AC			
1.5	A211, A211B, A073			A280	
1.0	A321, A229, A223,	4AD, 4AE,		A094C	
0.5	A038	A348			
0.4	3AG	A110B			
0.3	A016, A059, A079, A173, A091, A092, A093, A287, A215, A159, A039, A309, 5AB, 5AB-A, 5AB-B, 5ABC, 2AA, 3AD, 5AG, 5AGA,				

Breakdown Voltage (min.)

Note:

Reasonable care has been taken in the preparation of the specifications listed herein to assure technical correctness, however, it is the responsibility of the buyer to determine the suitability of the devices in his application and circuit. Signalite assumes no responsibility or consequences for their use!

Specifications subject to change without notice.

Evaluating and Applying Neon Glow Lamps

The neon lamp known to industry for many years is basically a negative glow discharge device. It consists of two closely spaced electrodes housed in a glass envelope filled with rare gas. When a sufficient amount of voltage is applied across the terminals of a neon lamp, it exhibits what is called breakdown characteristics; that is, the voltage across the lamp drops very quickly to a reduced level which is called its maintaining voltage. When this condition occurs, there is the appearance of a glow surrounding the negative electrode. As can be seen, the glow lamp exhibits characteristics making it useful as a circuit component as well as an indicator.

Ionization Time

The amount of time it takes for the lamp to start conducting after application of the breakdown voltage is known as the ionization time. If the applied voltage is just equal to the lamp's specified breakdown voltage, this time may be hundreds of milliseconds. However, if the applied voltage is 30% or greater than the breakdown voltage, the ionization time may be as low as 10 microseconds. Fig. 1 illustrates ionization time vs. percent over voltage for typical lamp operating in 5 to 50 ft. candles of light.

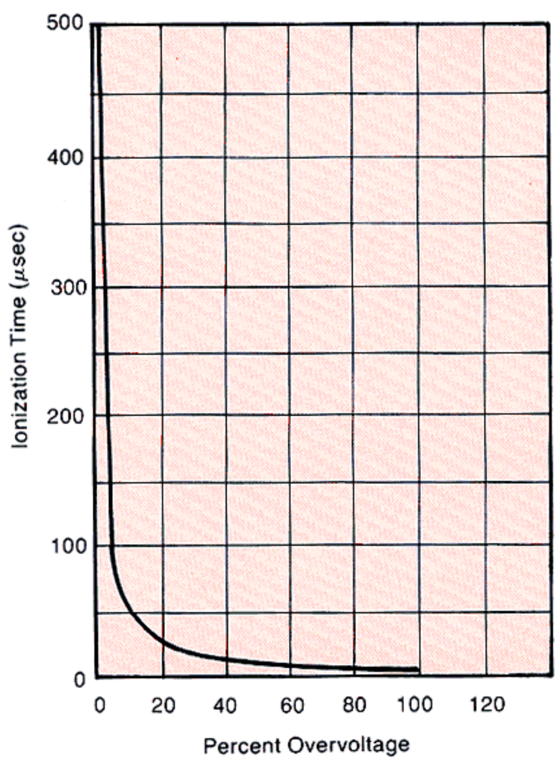


FIGURE 1

Ballasting

All neon glow lamps require ballasting in the form of a resistor in series with the lamp. The value of the resistor depends on the applied voltage, current, and desired lamp characteristics.

Electrostatic and RF Effects

There are also external conditions which affect the operation of neon glow lamps. For example, the existence of an electrostatic field in the vicinity of the glow lamp will noticeably affect its performance. Such a field may decrease the rated breakdown voltage, and cause the lamp to ignite at levels significantly below normal. Electrostatic fields have no effect on maintaining voltage characteristics. High intensity radio frequency can cause the neon lamp to ignite with no applied voltage. These characteristics in themselves suggest other possible applications.

Other External Effects

Temperature

Neon lamps exhibit a negative temperature characteristic, normally about 40 to 50 millivolts per degree Centigrade. In a voltage regulator, this temperature coefficient may be as low as 1.5 millivolts per degree C. This change is small compared to zener diodes. The normal operating temperature specifications for electronic circuitry of −60°F to +165°F are perfectly acceptable to neons.

Dark Effect

When glow lamps are subjected to a darkened environment, their breakdown voltage rises and their ionization time increases. Signalite manufactures glow lamps which are dark compensated which substantially reduces this undesirable effect.

Light Output

Light output of neon lamps in circuit applications is usually not a matter of prime importance, except when being used with photocells. However, the fact that the lamp does glow when it is operating can be used as an indicator of circuit operation. Also, since the glow in a direct current application is confined to the cathode (or negative electrode), this characteristic can be used to determine polarity.

Light emitted by standard brightness neon lamps averages .06 lumens per milliamp while higb brightness lamps average .15 lumens per milliamp. However, high brightness lamps have higher current ratings giving typically 8 times more brightness for equivalent life. The light itself is confined mainly to the yellow and red regions of the spectrum, between 5200 and 7500 Angstroms. A band in the infrared region between 8200 and 8800 Angstroms is also emitted.

Rated Life Expectancy

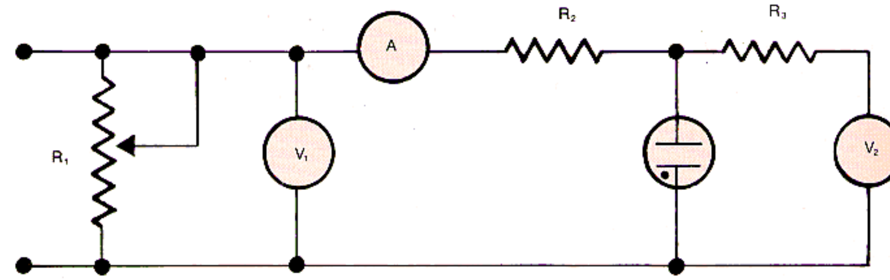
In most circuit applications, neon glow lamps are not on all of the time. In such applications, only the time during which the lamp has current passing through it determines the useful life. If this period is a short duration, as in pulsing applications, the rated life will have to reflect the fact that the lamp's useful life is not being consumed while it is inoperative. In many applications, the actual rated life, i.e. calculated operation time of the lamp, will exceed by many times the estimated lifetime of the equipment or circuit in which the lamp is installed.

The life expectancy of a neon glow lamp, of course, depends on the operating conditions of the lamp. Operating at above design current results in shorter life, while operating below design current results in an increase in life. Generally, the current for neon lamps may vary from .1 milliamp to 10 milliamp. If the lamp is installed in a circuit where it will be subject to pulsing, the peak current, pulse wave shape and pulse duration all will have their effect on lamp lifetimes. Lifetimes predominantly range from 1,000 to 50,000 hours of continuous operation.

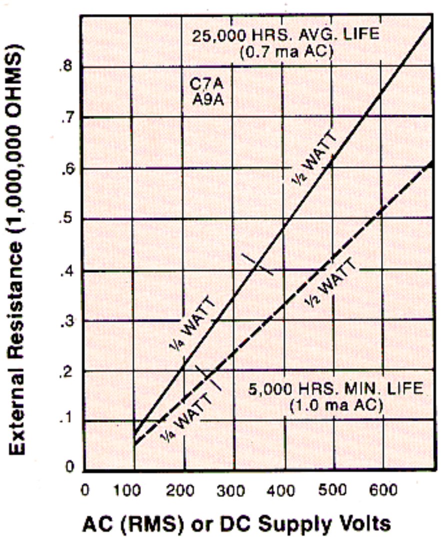
Circuit for Measurement of Breakdown, Maintaining, Extinguishing Voltage and Lamp Current

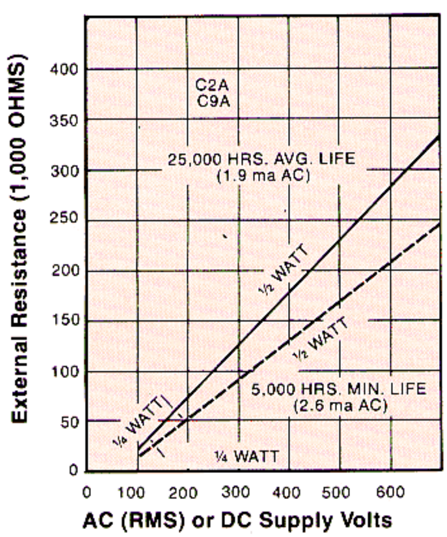
A-C test voltage shall be 60 cycles per second sine wave having a root-mean-square (rms) summation of the harmonic components that does not exceed three percent of the fundamental.

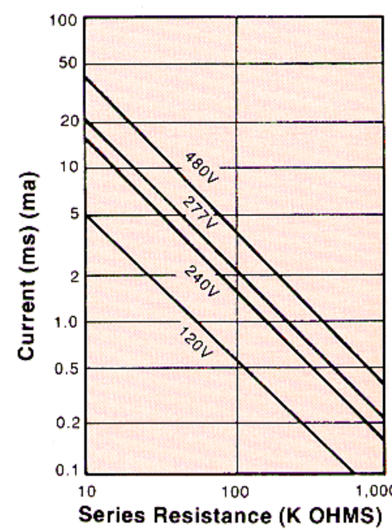
D-C test voltage shall have a ripple of less than 0.1 percent.



R_1 — Resistance Divider.
V_1 — Voltmeter.
A — Ammeter (impedance less than 1.0% of series impedance R_2). For A.C. measurement use thermocouple meter.
R_2 — Series Resistor (magnitude suitable for lamp under test).
R_3 — Resistor (10 to 30 megohms) to be used to suppress tendency of lamp to oscillate only when using electrostatic voltmeter.
V_2 — Voltmeter (VTVM or electrostatic, 10 megohms or more input resistance).

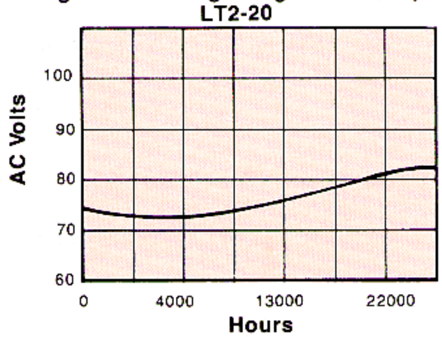




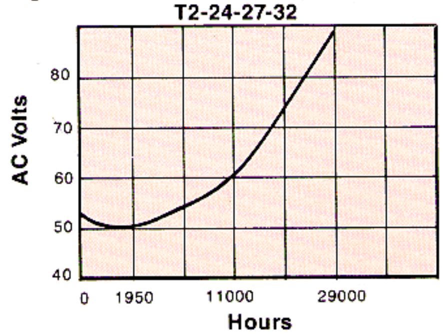


Standard Brightness Lamp Current vs. Series Resistance (at 120V, 240V, 277V and 480V line).

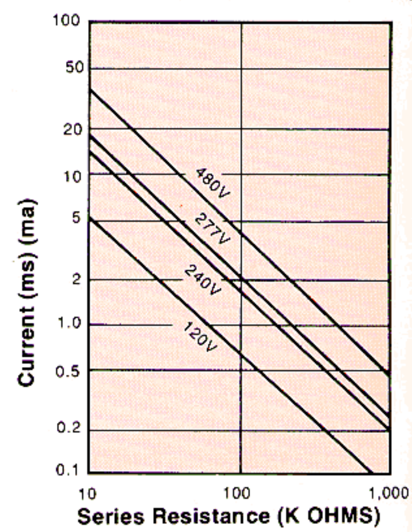
Typical Average Breakdown Voltage vs. Time High Brightness Lamps LT2-20



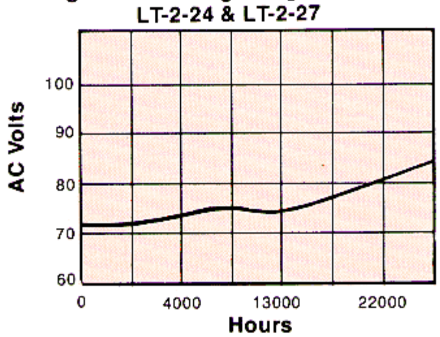
Typical Average Breakdown Voltage vs. Time Standard Brightness Lamps T2-24-27-32



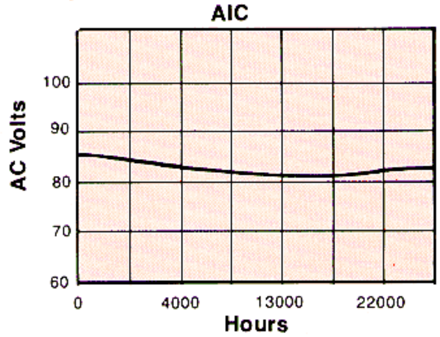
High Brightness Lamp Current vs. Series Resistance (at 120V, 240V, 277V, and 480V line).



Typical Average Breakdown Voltage vs. Time High Brightness Lamps LT-2-24 & LT-2-27



Typical Average Breakdown Voltage vs. Time High Brightness Lamps AIC



STANDARD BRIGHTNESS LAMPS

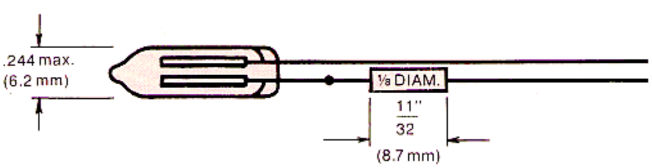
Signalite Type	ASA #	Breakdown Voltage (max.) A.C.	D.C.	Rated Life Hours (Avg.)	Series Resistance (Ohms)	Circuit Volts	Watts Nom.	Glass Dimensions Outside Length (max.) Inch (mm)	Wire Terminal Length (±1/16) Inch (mm)
A1B	A1B	65	90	25,000	220,000	105-125	1/25	1/2" (12.7)	1" (25.4)
T2-20-1	—	65	90	25,000	100,000	105-125	1/15	5/8" (15.9)	1" (25.4)
**NE2V	A2B	65	90	25,000	100,000	105-125	1/15	3/4" (19.1)	2" (50.8)
T2-24-1	A7A	65	90	25,000	100,000	105-125	1/15	3/4" (19.1)	1" (25.4)
T2-24-2 (NE 2E)	A9A	65	90	25,000	100,000	105-125	1/15	3/4" (19.1)	2" (50.8)
T2-27-1	A5A	65	90	25,000	100,000	105-125	1/15	27/32" (21.4)	1" (25.4)
T2-27-2 (NE 2A)	A3A/A2A	65	90	25,000	100,000	105-125	1/15	27/32" (21.4)	2" (50.8)
*T2-32-1	A6A	65	90	25,000	75,000	105-125	1/10	1" (25.4)	1" (25.4)
NE-2	A1A	65	90	25,000	150,000	105-125	1/17	1" (25.4)	1" (25.4)

Notes: *Electrodes are 12mm long for longer illuminated length.
**NE2V has a small amount of radio active additive to reduce dark effect.

HIGH BRIGHTNESS LAMPS

Signalite Type	ASA #	Breakdown Voltage (max.) A.C.	D.C.	Rated Life Hours (Avg.)	Series Resistance (Ohms)	Circuit Volts	Watts Nom.	Glass Dimensions Outside Length (max.) Inch (mm)	Wire Terminal Length (±1/16) Inch (mm)
A1C	A1C	95	135	25,000	47,000	105-125	1/7	1/2" (12.7)	1" (25.4)
LT2-20-1	—	95	135	25,000	30,000	105-125	1/4	5/8" (15.9)	1" (25.4)
LT2-24-1	C3A	95	135	25,000	30,000	105-125	1/4	3/4" (19.1)	1" (25.4)
LT2-24-2 (NE 2H)	C2A	95	135	25,000	30,000	105-125	1/4	3/4" (19.1)	2" (50.8)
**NE2U	A3C	95	135	25,000	30,000	105-125	1/4	3/4" (19.1)	2" (50.8)
LT2-27-1	C4A	95	135	25,000	30,000	105-125	1/4	27/32" (21.4)	1" (25.4)
LT2-27-2	C5A	95	135	25,000	30,000	105-125	1/4	27/32" (21.4)	2" (50.8)
*LT2-32-1	C6A	95	135	25,000	22,000	105-125	1/3	1" (25.4)	1" (25.4)

Notes: *Electrodes are 12mm long for longer illuminated length.
**NE2U has a higher amount of radio active additive than the C2A.
All high brightness lamps have a small amount of radio active additive to reduce dark effect.

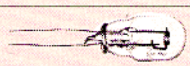
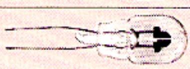


All above lamps are available with attached resistor as typically shown in above diagram, as well as to exact customer specifications.

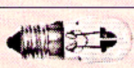
The following notes are common to all standard brightness lamps and high brightness lamps.

Available with different resistor values to meet customer requirements for life and brightness. May be used on higher voltages in series with proper value resistor. D.C. life is 60% of A.C. values.
Lamps supplied with cleaned copper finish. May be furnished tinned.

WIRE TERMINAL INDICATOR LAMPS

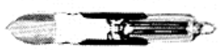
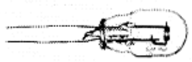
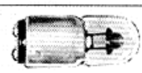
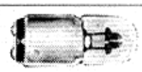
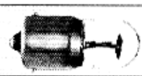
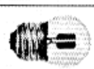
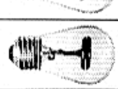
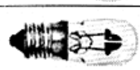
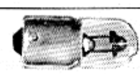
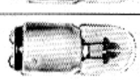
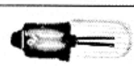
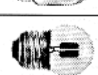
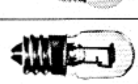
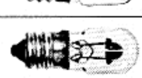
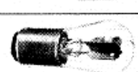
Signalite Type		ASA#	Breakdown Voltage (max.) A.C.	D.C.	Series Resistance (Ohms)	Rated Life Hours (Avg.)	Circuit Volts	Watts (Nom.)	Base	Bulb	Notes	Max. Overall Length Inches (mm)
NE7		B4A	55	75	30,000	7,500	105-125	1/4	Wire Terminal	T4-1/2	—	1-1/4" (31.8)
NE54		F2A	65	90	30,000	7,500	105-125	1/4	Wire Terminal	T4-1/2	—	1-1/4" (31.8)

ARGON GLOW LAMPS

Signalite Type		ASA#	Breakdown Voltage (max.) A.C.	D.C.	Series Resistance (Ohms)	Rated Life Hours (Avg.)	Circuit Volts	Watts (Nom.)	Base	Bulb	Notes	Max. Overall Length Inches (mm)
AR3		J2A	80	115	15,000	150	105-125	1/4	Cand. Screw	T4-1/2	(1)	1-17/32" (38.9)
AR4		J3A	80	115	15,000	150	105-125	1/4	D.C. Bayonet	T4-1/2	(1) (2)	1-1/2" (38.1)
AR9		K4A	80	115	200,000	50	105-125	1/25	Wire	T2	(1)	1" (25.4)

Notes: 1. Ultraviolet output drops to 50% at above rated hours.
2. External resistor, not included.

BASED NEON GLOW LAMPS

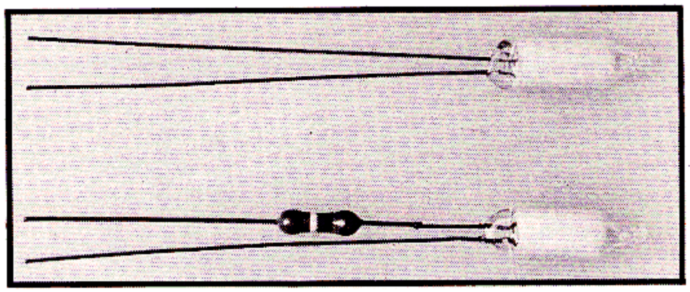
Signalite Type		ASA#	Breakdon Voltage (max.) A.C.	Breakdon Voltage (max.) D.C.	Series Resistance (Ohms)	Rated Life Hours (Avg.)	Circuit Volts	Watts (Nom.)	Base	Bulb	Notes	Max. Overall Length Inches (mm)
NE2D		C7A	65	90	100,000	25,000	105-125	1/15	S.C. Midget Flange	T2	(1) (3) (5) (6)	15/16" (23.8)
NE2J		C9A	95	135	30,000	25,000	105-125	1/4	S.C. Midget Flange	T2	(1) (2) (3) (5)	15/16" (23.8)
NE3		8AA	65	90	200,000	15,000	105-125	1/25	Telephone Slide	T2 Round	(1) (3) (5) (7)	1-11/16" (42.7)
NE4		8AB	65	90	100,000	15,000	105-125	1/15	Telephone Slide	T2	(1) (3) (5) (7)	1-3/4" (44.5)
NE5		8AC	65	120	200,000	3,000	105-125	—	Telephone Slide	T2	(2) (3)	1-11/16" (42.7)
NE7		B4A	55	75	30,000	7,500	105-125	—	Wire Terminal	T4-1/2	(1) (3) (5) (8)	1-1/4" (31.75)
NE16		7AA	55	75	—	1,000	105-125	—	DC Bayonet	T4-1/2	(2) (3)	1-1/2" (38.1)
NE17		B5A	55	75	30,000	7,500	105-125	1/4	DC Bayonet	T4-1/2	(1) (3) (5)	1-1/2" (38.1)
NE21		B6A	55	75	30,000	7,500	105-125	1/4	SC Bayonet	T4-1/2	(1) (3) (5)	1-1/2" (38.1)
NE30		J6A	60	85	4,800	10,000	105-125	1	Medium Screw	S11	(3) (4)	2-3/16" (55.6)
NE32		L6A	60	85	4,800	10,000	105-125	1	DC Bayonet	G10	(1) (3) (5)	2-1/8" (54.0)
NE34		R2A	65	90	3,500	10,000	105-125	2	Medium Screw	S14	(3) (4)	3-1/2" (88.9)
NE40		R6A	65	90	2,200	10,000	105-125	3.5	Medium Screw	S14	(3) (4)	3-1/2" (88.9)
NE42		R9A	65	90	2,200	10,000	105-125	3.5	DC Bayonnet	S14	(3) (4)	3-5/16" (100.0)
NE45		B7A	65	90	30,000	7,500	105-125	1/4	Candle Screw	T4-1/2	(3) (4)	1-17/32" (38.9)
NE47		B8A	65	90	30,000	7,500	105-125	1/4	SC Bayonet	T4-1/2	(1) (3) (5)	1-1/2" (38.1)
NE48		B9A	65	90	30,000	7,500	105-125	1/4	DC Bayonet	T4-1/2	(1) (2) (3) (5)	1-1/2" (38.1)
NE51		B1A	65	90	200,000	15,000	105-125	1/25	Miniature Bayonet	T3-1/4	(1) (3) (5)	1-3/16" (30.2)
NE51H		B2A	95	135	47,000	25,000	105-125	1/7	Miniature Bayonet	T3-1/4	(2) (3) (5)	1-3/16" (30.2)
NE54		F2A	65	90	30,000	7,500	105-125	1/4	Wire Terminal	T4-1/2	(1) (3) (5)	1-1/4" (31.75)
NE56		4A	60	85	30,000	10,000	210-250	1	Medium Screw	S11	(3) (4)	2-3/16" (55.6)
NE57		F3A	55	75	30,000	7,500	105-125	1/4	Candle Screw	T4-1/2	(3) (4)	1-17/32" (38.9)
NE58		F4A	55	75	100,000	7,500	210-250	1/2	Candle Screw	T4-1/2	(3) (4)	1-17/32" (38.9)
NE79		R1A	65	90	7,500	10,000	105-125	1	DC Bayonet	S7	(3) (4)	2" (50.8)
NE84		K1A	95	135	30,000	25,000	105-125	1/4	Miniature Telephone Slide	T2	(1) (2) (3) (5)	1-1/32" (26.2)

Notes:

1. May be used on circuits of higher voltage provided proper external resistor is used.
2. High brightness lamps with a small amount of radio active additive to reduce dark effect.
3. D.C. life approximately 60% of A.C. values.
4. Resistor included in base.
5. External resistor, not included.
6. Meets Mil. Spec. MS25252.
7. Lamp must fall free through a .310" dia. cylinder ½" long.
8. For D.C. operation, center electrode is negative.

Color Glow Lamps

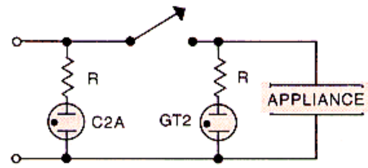
Signalite Color Glow Lamps are available in orange/red and green for indicator applications where more than an "on" status is required. A designer now has the ability to emphasize multiple functions by using different colors, i.e., on/off, go/no-go; the various stages of a timing cycle are indicated below.



Indicators—in a Choice or Combination of Colors

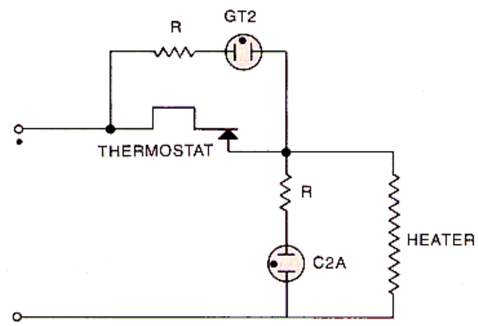
On/Off Function

A green glow lamp indicates that a device is turned on and red to indicate the appliance cord is connected to power. This color-coded system adds an extra safety feature to such appliances as irons, drills, soldering irons, electric saws, etc.



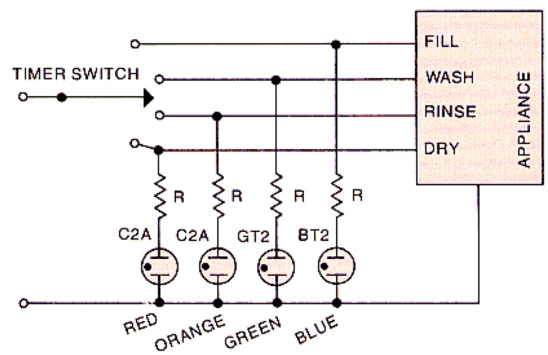
Dual-State Go/No Go Function

Use a red Signalite glow lamp on an electric coffee maker to indicate that the thermostat is closed (heater on). When the proper temperature is reached, the thermostat opens, the red glow lamp and heater go off and green glow lamp goes on to indicate the coffee is ready.



Multiple Functions

Use four different colored Signalite Glow Lamps to indicate multiple operations of an electric clothes washer. The timer is used to automatically switch the lamps.



In addition to the green, other colors can be created through the use of filters, for example:

RED —use a medium red such as Edmund Scientific #823

YELLOW —use a yellow/green such as Edmund Scientific #878

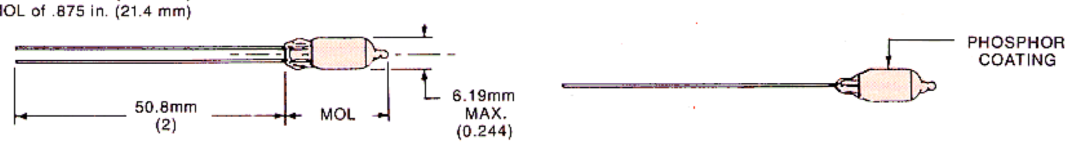
ORANGE —use a Signalite high brightness lamp

PINK —use a Signalite standard brightness lamp

Should a lens be required or a higher brightness desired, Edmund's orange filter #818 can be used and for a deeper pink Edmund's no color blue #850 can be used.

Signalite Type	Gas	Breakdown Voltage (max.)		Series Resistance Ohms	Rated Life Hours (avg.)	Circuits Volts		Nominal Watts	Nominal Current (ma)	Base
		AC	DC			AC	DC			
GT2	Neon with Green phospher coating	95	135	30,000	50,000	105	125	1/3	1.9	Wire Terminal

The GT2 lamp is designed for operation at 1.9 milliamperes, ac or dc. They may flicker below this level.
The GT2-20 has an MOL of .700 in. (15.9 mm)
The GT2-27 has an MOL of .875 in. (21.4 mm)



Signalite

Circuit Components

Voltage Regulators

Application Ideas

- Counters
- Voltage Regulation
- Voltage References
- Voltage Dividers
- Digital Readouts
- Oscillators
- Coupling Devices
- Switches
- Memory
- Surge Protectors
- Limiters
- Logic Circuits
- Timing
- SCR Triggering
- Pulse Generators
- Photo-cell Drivers
- Flip-Flops
- Gating
- Relays
- Time Delay
- Photo Choppers
- Amplifiers


Signalite
APPLICATION NEWS
REGULATING VOLTAGE TO VIDICON TUBES

Signalite Application News

is used to communicate new and proven techniques and applications of Signalite's neon lamps and gas discharge tubes. Signalite Application News provides a forum for an exchange of ideas to keep the design engineer aware of the versatility of neon lamps and their many applications. Copies are available from your Signalite representative or by contacting Signalite.

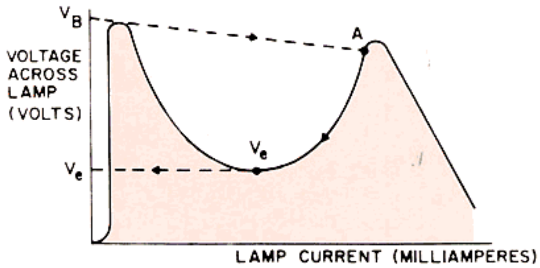
SIGNALITE A Division of General Instrument Corporation

Applications

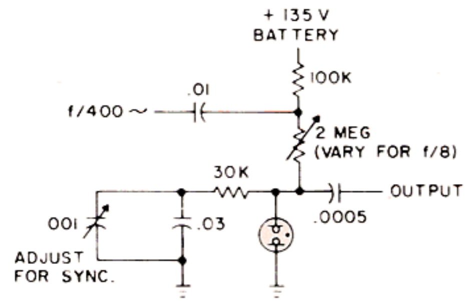
			Signalite Application News Vol./No.	Signalite Type No.
TELEVISION	Voltage Regulator	Vidicons	3/#2, 5/#1	Z82R7 Z133R6
		Photomultipliers	3/#2	
	Memory Circuits		2/#2, 4/#3	Z84R2
	Remote Control	Volume Color Hue (Tint)		A287
	Pulse Shaper	Horizontal Vertical		
	Feedback-H.V.			
APPLIANCES	Timers	Fixed	3/#3, 5/#3, 1/#3	A039A
		Controlled by Variable	2/#2, 1/#2	A243
	SCR Proportional Controls	Blenders Hand Tools	2/#5, 2/#4, 5/#2	A230
SUPPRESSORS	Suppressors (other)		1/#1	A240F
	AC Line		2/#1, 4/#1	TP series
	Lighting—Telephone Line—Low Energy			A280
	Bi-Lateral Clippers—Semiconductors, F.W. Bridge			A240F
INSTRUMENTS	Choppers—D.C. to A.C. Low Level	Transformer	6/#2	A083, ½ white
		Photocell	6/#2, 2/#2	
	Binary Decoding—With Photocell—To Nixie, Etc.		3/#3	A059
	Switches—With Photocell		4/#1, 4/#2, 2/#1 2/#2, 3/#2	A059
	Frequency Divider	Clocks Ring Counters Organs	2/#5, 2/#2, 2/#4, 3/#4 2/#6, 5/#2, 4/#2, 6/#1	A257
	Voltage Regulators—Power Supplies		2/#4, 5/#1, 2/#2 3/#3, 3/#2, 5/#3	All regulators
	Audio Pass	Interrogation Remote Sensing	3/#1	A280
	Moving Signs . . . Stock Market, Etc.			A230
	Displays—Alpha Numeric			A230
ENERGY TRANSFER	Electronic Match for Stoves, Etc.		4/#4	A258
	Flash Tube Triggering		5/#2, 3/#3	A258
	Mechanical Activating			
TELEPHONE EQUIPMENT	Automatic Number Identification		4/#1, 5/#5, 1/#3	

Cold Cathode Diodes/ Voltage Regulators
Two Elements Circuit Components
Reference/Regulators/ Three Element Trigger
Glow Lamps/Design/ Operation/Application
Warranty/Owl

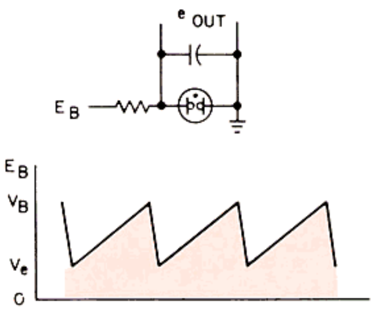
Bistable characteristics of glow lamps



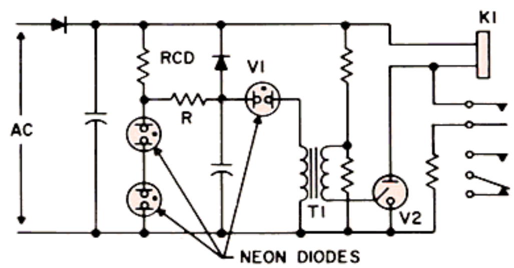
Scale-of-8 frequency divider



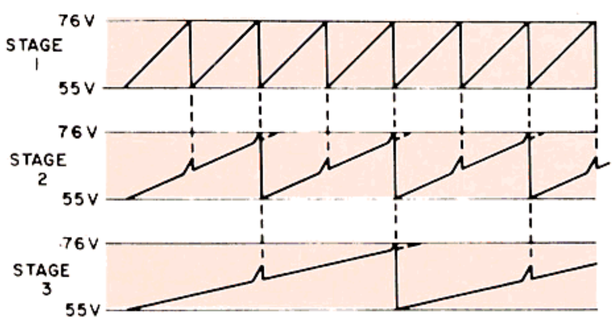
Oscillator circuit and waveform



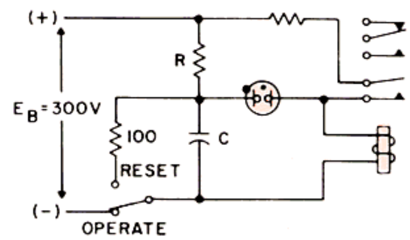
Time delay relay



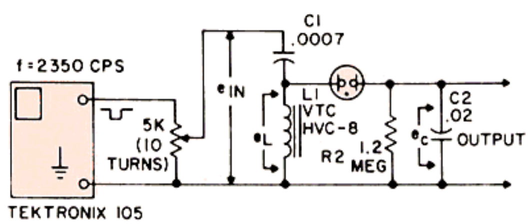
How frequency dividing is accomplished



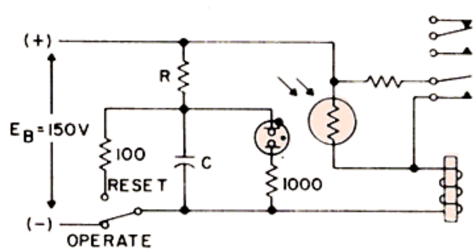
Use of neon-timer output to operate relay



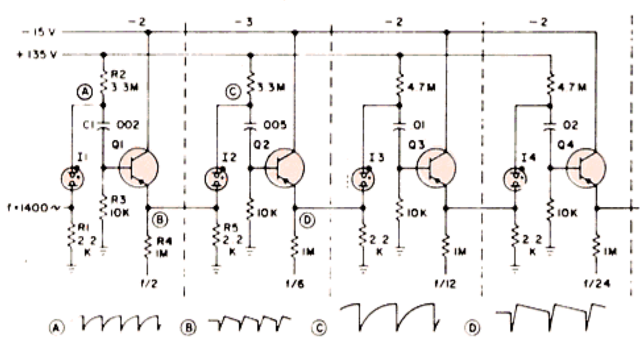
Staircase generator



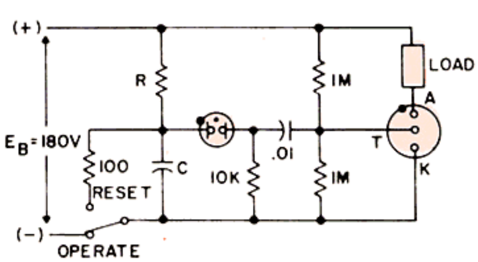
Use of neon-timer light output to operate photocell



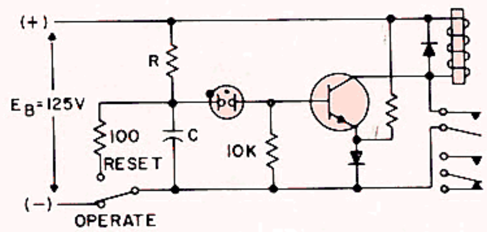
Frequency divider circuit



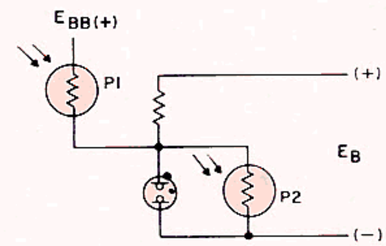
Use of neon-timer output to pulse thyratron



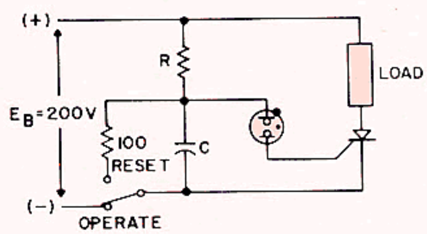
Use of neon-timer to operate transistor



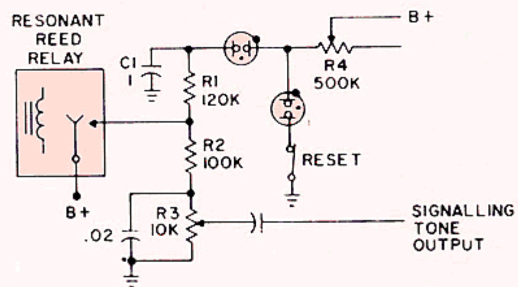
Operation of memory switch by photocells



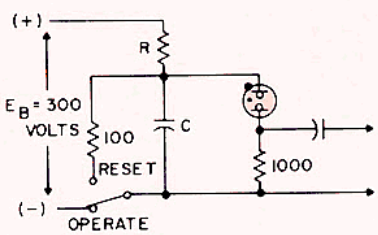
Use of neon-timer to operate SCR



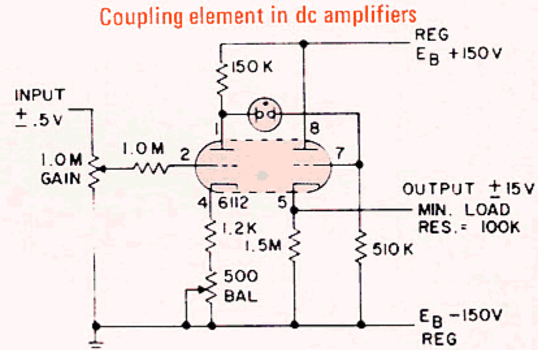
Station call memory circuit



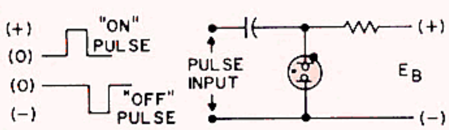
Memory switch with single input



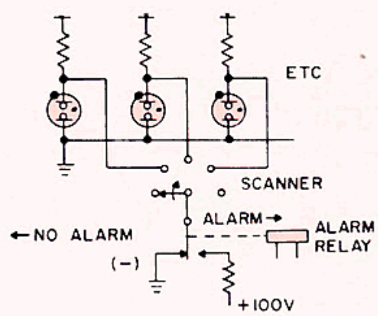
Coupling element in dc amplifiers



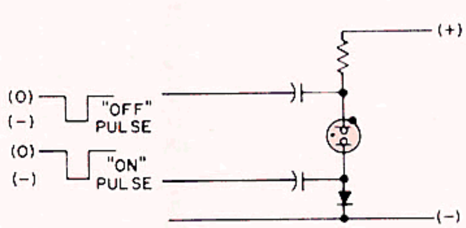
Neon-timer pulsing circuit



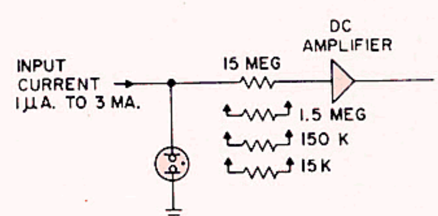
Scanning annunciator



Memory switch with separate on and off input



Voltage limiter circuit



2 ELEMENT CIRCUIT COMPONENTS

Signalite Type	Breakdown Voltage VDC	Maintaining Voltage VDC	Design Current ma (AVG)	Extinguishing Voltage VDC	Average Life Hours	Notes	Dimensions See Fig. 1 Table A	Lead Size inch (mm)	Lamp MOL inch (mm)
A304	64 max.	—	—	—	—	1,2,3,4	N	—	—
A286	65 max.	44-60	1.5	—	—	1,3	N	—	—
A243A	60-70	—	5.0	—	—	—	—	1" (25.4)	1" (25.4)
A290	63-67	—	—	—	—	1	C	—	—
A223	63-72	48-56	0.5	—	—	1,2,3,4	B	—	—
A096	64-70	53 min.	0.1	—	—	1,3,4	G	—	—
A321	65-74	52-62	0.5	50	—	1,3,5,14	G	1" (25.4)	27/32" (21.4)
A039A	66-72	50-60	0.3	—	5,000	1,2,3,4,14,20	G	—	—
A343	66-74	50-60	0.3	48	—	—	—	1" (25.4)	27/32" (21.4)
A230D	60-75	62 max.	5.0	—	—	1,3	L	—	—
A016	65-75	50-60	0.3	—	—	1,3,8	G	1" (25.4)	27/32" (21.4)
A204	63-76	60 max.	1.5	—	2,000	1,3,4,11	L	—	—
A215	60-80	48-58	0.3	—	5,000	1,4,12	A	1" (25.4)	½" (12.7)
A059	64-80	50-60	0.3	—	—	1,3,8	G	—	—
A089	60-70-80	—	—	—	—	3,9	B	—	—
A090	60-70-80	—	—	—	—	1,3,9	G	—	—
A243	68-76	—	5.0	—	—	1,2,3,6,14,20	L	1" (25.4)	1" (25.4)
A287	58-80	60 max.	0.3	—	5,000	1,2,20	G	—	—
A038	68-85	50-60	0.6	50	15,000	1,4	G	—	—
A149	70-82	50-65	6.0	50	—	1,3,18	V	—	—
A233A	55-90	44-54	3.5	—	—	1	Q	—	—
A173	70-90	60 max.	0.3	—	5,000	1,2,3,4,12	G	—	—
A073D	75-90	—	—	—	—	7	B	—	—
A050	70 max.	—	—	—	—	1,4	B	—	—
A079	70 max.	58 max.	0.3	47	7,500	1,3,4,12	G	1" (25.4)	27/32" (21.4)
A382	70 max.	60 max.	5.0	—	—	—	—	1" (25.4)	1" (25.4)
A194	73 max.	53	3.0	49	—	1,15	—	—	—
A308	74 max.	—	—	—	—	17	—	—	—
A211	75 max.	60 max.	1.0	—	7,500	1,2,12	G	—	—
A211B	75 max.	60 max.	1.0	—	—	—	E	—	—
A229	75 max.	60 max.	0.5	—	—	1,4	G	—	—
A066	80 max.	0	0.3	—	—	1,16	—	—	—
A230	80 max.	62 max.	5.0	45	5,000	1,2,3,4,11	L	1" (25.4)	15/16" (23.8)
A245	80 max.	—	1.2	—	—	—	N	—	—
A351	80 max.	62 max.	5.0	—	—	—	—	1" (25.4)	15/16" (23.8)
A091	90 max.	57-61	0.3	—	—	1,3,6	G	—	—
A092	90 max.	53-57	0.3	—	—	1,3,4	G	—	—
A093	90 max.	61-65	0.3	—	—	1,3,7	G	—	—
A203	90 max.	—	—	—	—	7	R	—	—
A315	90 max.	—	—	—	—	20	B	—	—
A322	90 max.	—	—	—	—	20	N	1" (25.4)	15/16" (23.8)
A376	90 max.	60 max.	0.4	—	—	—	—	1" (25.4)	24/32" (19.1)
A151	92 max.	—	—	—	—	—	S	—	—
A167	92 max.	—	—	—	—	20	E	—	—
A219	98 max.	—	—	—	—	1	E	—	—
A009	100 max.	—	—	—	—	1,3,4	R	—	—
A173A	80-100	60 max.	0.3	—	—	1,4	G	—	—
A244	100 max.	—	—	—	—	1,2,4,14	B	—	—
A066B	105 max.	75 max.	2.0	—	—	1,3,15	—	—	—
A072	105 max.	—	—	—	—	1,4	E	—	—
A331	85-105	60-73	2.0	—	—	1,3,5,14	J	1½" (38.1)	27/32" (21.4)
A072C	90-106	60-75	2.0	—	—	1	E	2" (50.8)	24/32" (19.1)
A328	90-110	60-75	2.0	—	—	1,3	E	2" (50.8)	24/32" (19.1)
A305	104-112	—	2.0	52	—	1,4,14	B	1" (25.4)	24/32" (19.1)
A333	112 max.	—	—	—	—	1,3,5,14	G	—	—
A329	115 max.	60-75	2.0	—	—	1,3,5,14	G	1" (25.4)	27/32" (21.4)
A330	115 max.	60-70	2.0	—	—	1,3,5,14	B	—	—
A221C	100-120	65-75	2.0	—	—	1,3,4,22	B	1" (25.4)	24/32" (19.1)
A332	94-115	75 max.	2.0	—	—	1,3,5,14	G	—	—
A385	95-115	55-75	2.5	—	—	—	—	1" (25.4)	24/32" (19.1)
A296	100-125	—	—	—	—	1,2	E	—	—
A278	90-130	59-80	2.5	55	—	1,2,4	E	—	—
A032A	95-130	61-70	2.0	—	—	1,10,18	U	—	—
A384	95-135	60-80	2.0	—	—	—	—	1" (25.4)	24/32" (19.1)
A158D	100-135	55-80	2.0	—	—	1,3,4	S	—	—
A201	113-135	—	—	—	—	1,2,3,4	G	—	—
A226	115-140	60-70	6.0	55	—	1,5,14	G	1" (25.4)	27/32" (21.4)
A142A	135 max.	—	—	—	—	1,2,3,10,22	D	—	—
A158E	135 max.	—	2.0	60	—	1,3,4	S	2" (50.8)	1" (25.4)
A165	135 max.	—	—	—	—	1	E	—	—
A170B	135 max.	55-80	2.0	—	—	—	—	2" (50.8)	15/16" (23.8)
A319	135 max.	—	—	—	—	1,7,17	—	—	—
A340	115-140	55-70	2.5	55	—	—	—	1" (25.4)	27/32" (21.4)
A104	120-145	—	—	—	—	1,3,5	G	—	—
A257	125-145	65-80	2.0	—	—	1,3,4	G	—	—
A012A	126-146	60-70	6.0	—	10,000	4	B	—	—
A081A	120-150	60-80	3.0	—	3,000	1	G	—	—
A170	150 max.	80 max.	2.0	—	—	1,4	S	2" (50.8)	1" (25.4)
A224	150 max.	80 max.	2.0	—	—	1,3,4	N	1" (25.4)	15/16" (23.8)

2 ELEMENT CIRCUIT COMPONENTS

Signalite Type	Breakdown Voltage VDC	Maintaining Voltage VDC	Design Current ma (AVG)	Extinguishing Voltage VDC	Average Life Hours	Notes	Dimensions See Fig. 1 Table A	Lead Length inch (mm)	Lamp MOL inch (mm)
A341	140-160	60-75	3.0	55	—	—	G	1" (25.4)	27/32" (21.4)
A090A	130-170	—	—	—	—	1,4	R	—	—
A327	170-200	—	—	—	—	3,10	H	—	—
A342	170-200	60-75	3.0	55	—	—	G	1" (25.4)	27/32" (21.4)
A009A	200 max.	130 min.	2.0	—	—	1,2,20	R	—	—
A053	205 min.	90 max.	6.0	—	—	3	G	—	—
A280	205 min.	—	—	—	—	2,8	N	—	—
A389	190-210	—	—	—	—	—	K	2" (50.8)	27/32" (21.4)
A416	190-215	—	—	—	—	—	G	1" (25.4)	27/32" (21.4)
A380	200-220	—	—	—	—	—	K	2" (50.8)	27/32" (21.4)
A258	200-230	—	—	—	—	2,10	M	—	—
A258C	200-230	—	—	—	—	2,10,21	M	—	—
A316	210-230	80 max.	6.0	—	—	1,7,14	G	—	—
A388	210-230	—	—	—	—	—	G	2" (50.8)	27/32" (21.4)
A297	200-240	125-150	2.0	—	—	1,3	G	—	—
A051	205-250	80 max.	6.0	—	7,500	3,4	G	—	—
A208	225-300	80 max.	6.0	—	500	2,3,13	G	1" (25.4)	27/32" (21.4)
A240F	360-440	200	—	—	—	—	L	1" (25.4)	15/16" (23.8)
NE76	68-76	50-60	0.4	50	—	—	—	1" (25.4) 1½" (38.1)	1" (25.4) —
NE99	60-80	52-62	0.3	—	—	—	A	1" (25.4)	½" (12.7)
NE98	65-80	—	0.3	—	—	—	E	2" (50.8)	24/32" (19.1)
NE86	50-90	55 min.	1.5	—	—	—	N	1" (25.4)	1" (25.4)
NE23	60-90	60 max.	0.3	—	—	—	G	1" (25.4)	27/32" (21.4)
NE83	60-100	65 max.	10.0	—	—	—	N	1" (25.4)	1" (25.4)
NE97	110-140	60-80	0.5	—	—	—	G	1" (25.4)	27/32" (21.4)
NE96	120-150	60-80	0.5	—	—	—	G	1" (25.4)	27/32" (21.4)
5AB-B	62-72	50-60	0.3	—	—	—	G	1" (25.4)	27/32" (21.4)
3AG-B	65-73	52-62	0.4	50	—	—	—	2" (50.8) 1¾" (44.5)	24/32" (19.1) —
5AG-A	68-76	50-60	0.4	—	2,000	—	B	1" (25.4)	24/32" (19.1)
2AA	60-80	52-62	0.3	—	7,500	1	A	1" (25.4)	½" (12.7)
5AG	64-80	50-60	0.3	—	2,000	—	B	1" (25.4)	24/32" (19.1)
3AD	65-80	57 avg.	0.3	—	—	—	E	2" (50.8)	24/32" (19.1)
5AH-F	70-80	52-63	5.0	—	5,000	—	L	1" (25.4)	15/16" (23.8)
5AH-A	60-85	50-65	5.0	—	5,000	—	L	1" (25.4)	15/16" (23.8)
5AH-B	75-85	45-60	5.0	—	—	—	L	1" (25.4)	15/16" (23.8)
5AJ	55-90	57 avg.	1.5	—	—	—	L	1" (25.4)	15/16" (23.8)
3AG	60-90	58 avg.	0.4	—	2,000	1,2,11	E	2" (50.8)	24/32" (19.1)
5AB	60-90	50-70	0.3	—	—	—	B	1" (25.4)	24/32" (19.1)
3AJ	60-100	59 avg.	5.0	—	—	—	B	1" (25.4)	24/32" (19.1)
3AJ-C	60-100	59 avg.	5.0	—	—	—	E	2" (50.8)	24/32" (19.1)
5AH	60-100	65 max.	5.0	—	—	—	L	1" (25.4)	15/16" (23.8)
5AH-E	60-100	59 avg.	5.0	—	—	—	—	2" (50.8)	15/16" (23.8)
5AH-C	75-100	50-65	5.0	—	—	—	L	1" (25.4)	15/16" (23.8)
2AC	125 max.	—	1.5	—	—	1	A	1" (25.4)	½" (12.7)
3AH	75-135	60-80	2.0	—	2,000	—	E	2" (50.8)	24/32" (19.1)
4AD	105-135	60-80	0.5	—	3,000	—	G	1" (25.4)	27/32" (21.4)
4AE	120-150	60-80	0.5	—	3,000	1	G	1" (25.4)	27/32" (21.4)

TABLE A DIMENSIONS FOR CIRCUIT COMPONENTS

	L (MAX.)		A		C		D (MAX.)	
	In	mm	Inches	mm	Inches	mm	Inches	mm
A	½	12.7	1 ± 1/16	27	1 ± 1/16	27	.244	6.2
B	¾	19.1						
C							.236	6.0
D			1¾ ± 1/32	44.5 ± 0.8	2 ± 1/16	50.8 ± 1.6	.244	6.2
E			2 ± 1/16	50.8 ± 1.6				
F	27/32	21.4	⅜ ± 1/32	9.5 ± 0.8	⅜ ± 1/32	9.5 ± 0.8		
G			1 ± 1/16	25.4 ± 1.6	1 ± 1/16	25.4 ± 1.6		
H			1⅛ ± 1/32	28.6 ± 0.8	2 ± 1/16	50.8 ± 1.6		
J			1½ ± 1/32	38.1 ± 0.8	1½ ± 1/32	38.1 ± 0.8		
K			2 ± 1/16	50.8 ± 1.6	2 ± 1/16	50.8 ± 1.6		
L	15/16	23.8	1 ± 1/16	25.4 ± 1.6	1 ± 1/16	25.4 ± 1.6		
M	1	25.4	⅞ ± 1/32	22.2 ± 0.8				
N			1 ± 1/16	25.4 ± 1.6				
P			2¼ ± 1/16	57.2 ± 1.6	2¼ ± 1/16	57.2 ± 1.6		
Q	1 1/16	27.0	3 ± 1/16	76.2 ± 1.6	3 ± 1/16	76.2 ± 1.6		
R			1 ± 1/16	25.4 ± 1.6	1 ± 1/16	25.4 ± 1.6		
S	1 3/16	30.1	2 ± 1/16	50.8 ± 1.6	2 ± 1/16	50.8 ± 1.6		
T	1 3/16	30.2	1 ± 1/16	25.4 ± 1.6	1 ± 1/16	25.4 ± 1.6		
U	27/32	21.4	9/16 ± 1/32	14.3 ± 0.8	1⅛ ± 1/32 W-RES.	28.6 ± 0.8		
V	1	25.4	1⅜ ± 1/32 W-RES.	34.9 ± 0.8	⅜ ± 1/32	9.5 ± 0.8		

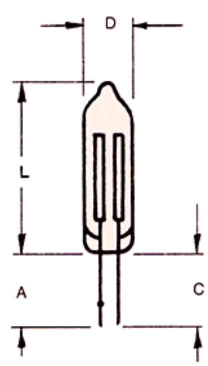


FIG. 1

TABLE B

LAMP	LEAKAGE RESISTANCE (OHMS)	LAMP	LEAKAGE RESISTANCE (OHMS)
A009A	5×10^9	A287	1×10^{12}
A039A	2×10^{10}	A309	1×10^9
A167	1×10^9	A315	1×10^{10}
A243	1×10^{10}	A322	1×10^8

NOTES:
1. Dark Effect Reduced
2. Tinned Leads
3. Pre-Aged
4. Anode Identified by Green Dot
5. Anode Identified by Black Dot
6. Anode Identified by Blue Dot
7. Anode Identified by Red Dot
8. Anode Identified by Orange Dot
9. Split Into Two Ranges With Anode Identified With: Orange Dot for VB 60-70 and Brown Dot for VB 70-80
10. Anode Identified by Shorter Lead
11. End of Life is A 5V Increase In Max. Breakdown or Maintaining Voltage
12. End of Life is A 6V Increase In Max. Breakdown or Maintaining Voltage
13. End of Life is a 10V Increase in Max. Breakdown of Maintaining Voltage
14. Breakdown in Total Darkness
15. Based—Telephone Slide Type (Dimensions, see NE-4)
16. Based—Telephone Slide Type (Dimensions, see NE-3)
17. Based—Midget Flange Type
18. Resistor Welded to Lead
19. Regulator
20. Leakage Resistance is Measured, See Table B
21. Potted in RTV-Silastic
22. Ionization Time Test
23. Corona Test

A261 NEON DISPLAY LAMP

- Signalite A261 is designed to replace digital readout tubes as numeral 1, + and − readouts.
- Specific uses for over-range, plus and minus positions in digital voltmeters and other digital readout equipment.
- Features excellent light output, long life, low cost and offers space savings.

Breakdown Voltage	Maintaining Voltage	Design Current	Circuit Voltage	Life	Corona Length	Envelope MOL Inch (mm)	Dimensions Envelope Max. Dia. Inch (mm)	Lead Length Inch (mm)
90 vdc max.	75 vdc max.	1.5 ma	150 vdc min.	2000 hours (continuous)	.55″ (approx.) 14 mm	1.3125″ (33.3)	.244″ (6.2)	1.0″ ±.0625 (25.4 ± 1.6)

Notes: • Tinned Leads • Pre-Aged • Dark Effect Reduced • 90% Corona Coverage • Anode (+) Identified by Green Dot

V SERIES VOLTAGE REGULATOR AND REFERENCE TUBES

- temp. coef. less than 15 mv/°C
- life greater than 20,000 hours
- stacking capability for higher voltage regulation

Signalite Type	Breakdown Voltage vdc max.	Reference Voltage Meas. At		Current Range* For Regulator	Operating Current ma		
		vdc	ma	ma	Max.³	Min. as Shunt Reg.	Min. in Parrallel with a Capacitor
V83R4	115	83 ± 2	1.5	0.25—4.0	6.0	0.25	0.4
V84R2	115	84 ± 2	1.0	0.15—2.0	3.0	0.15	0.35
V91R2	125	91 ± 2	1.0	0.1 —2.0	3.0	0.1	0.3
V103R2	135	103 ± 2	0.8	0.2 —2.0	3.0	0.2	0.25
V110R4	170	110 ± 2	1.5	0.5 —4.0	6.0	0.5	0.95
V115R4	155	115 ± 2	0.8	0.15—4.0	6.0	0.15	0.3
V116R2	150	116 ± 2	0.6	0.12—2.0	3.0	0.15	0.3
V139R1.9	190	139 ± 4	0.5	0.3 —1.9	3.0	0.3	0.6
V143R1.9	255	143 ± 4	0.5	0.3 —1.9	3.0	0.3	0.6

Z SERIES VOLTAGE REGULATOR AND REFERENCE TUBES

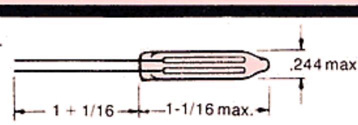
Signalite Type	Breakdown Voltage vdc		Reference Meas. Voltage at		Current Range² for Regulator	Temp. Coeff.	Operating Current ma			Life Expectancy	Typical Variation at 250 Hours
	Max.	Typical	vdc	ma	ma	mv/°C	Max.³	Min. as Shunt Reg.	Min. in Parallel with a Capacitor	Hours	%
Z82R7	110	102	82 ± 1	2.0	0.25- 7.0	−2	10.0	0.25	0.45	30,000	<0.2
Z82R10	115	105	82 ± 1	2.0	0.3 -10.0	−2	14.0	0.3	0.7	30,000	<0.3
Z82R15	118	107	82 ± 1	2.0	0.5 -15	−2	17.0	0.5	0.9	30,000	<0.5
Z83R4	110	100	83 ± 1	1.5	0.25- 4.0	−2	6.0	0.25	0.4	30,000	<0.2
Z84R2	110	100	84 ± 1	1.0	0.15- 2.0	−2	3.0	0.15	0.35	30,000	<0.2
Z91R2	118	110	91 ± 1	1.0	0.1 - 2.0	−3.5	3.0	0.1	0.3	30,000	<0.3
Z91R4	120	111	91 ± 1	1.5	0.2 - 4.0	−3.5	6.0	0.15	0.35	30,000	<0.3
Z91R7	130	120	91 ± 1	1.5	0.25- 7.0	−3.5	10.0	0.25	0.4	30,000	<0.3
Z91R10	135	122	91 ± 1	1.5	0.25-10	−3.5	12.0	0.25	0.5	25,000	<0.3
Z100R12	150	140	100 ± 1	3.0	0.6 -12.0	−9	14.0	0.7	1.8	30,000	<0.6
Z103R2	130	115	103 ± 1	0.8	0.2 - 2.0	−4.5	3.0	0.2	0.25	20,000	<0.4
Z103R4	130	120	103 ± 1	1.0	0.2 - 4.0	−4.5	5.0	0.2	0.25	20,000	<0.6
Z110R4	165	155	110 ± 1	1.5	0.5 - 4.0	−9	6.0	0.5	0.95	30,000	<0.4
Z115R4	150	140	115 ± 1	0.8	0.15- 4.0	15	6.0	0.15	0.3	20,000	<0.3
Z115R6	155	145	115 ± 1	1.5	0.5 - 6.0	15	9.0	0.5	2.0	20,000	<0.3
Z116R2	145	138	116 ± 1	0.6	0.12- 2.0	15	3.0	0.15	0.3	20,000	<0.3
Z139R1.9	185	175	139 ± 3	0.5	0.3 - 1.9	−10	3.0	0.3	0.6	20,000	<0.35
Z143R1.9	220	195	143 ± 3	0.5	0.3 - 1.9	−10	3.0	0.3	0.6	20,000	<0.2

*Stacking capability for higher voltage regulation.

Notes:
¹Limits for less than two volt variation.
²Limits for less than one volt variation.
³Maximum continuous current without permanent damage to tube.

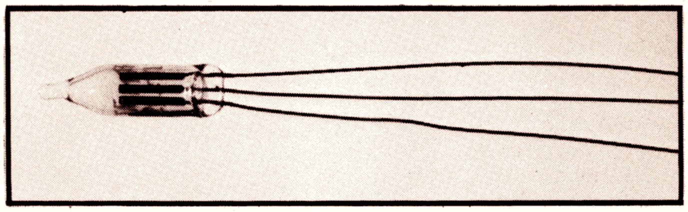
Equilibrium condition reached within 2 minutes after ignition is common to all Voltage Regulators and Reference Tubes.

Red dot denotes anode or + terminal. Leads are hot tin dipped.



Three Element Trigger Tubes

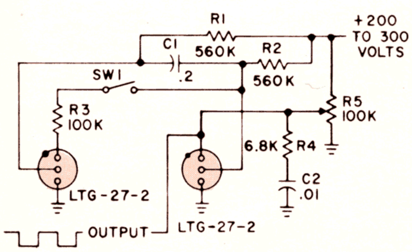
Signalite Three Element Trigger Tubes are used for high speed applications. The speed is derived from the fact that the tube is ionized by a keep-alive current flowing between the trigger and cathode. Keep-alive currents are generally in the microamp range and therefore high values of resistance are used in the circuit providing the added advantage of high impedance.



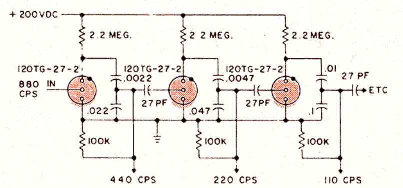
Specifications — Three Element Trigger Tubes

	NE77	TRJ 250	TRQ 250	120 TG-27-2	180 TG-27-1	LTG 27-2
Recommended Circuit Volts (outer electrodes)	190-250	150-185	190-230	96-120	165-200	160-180
Recommended Trigger Starting Volts (T-C)	190 min.	103 min.	116 min.	65 min.	80 min.	90 min.
Range in Trigger Starting Voltage	90-140	103 ± 5	116 ± 6	65-82	80-102	90-114
Design Current — continuous operation	.5 ma	2 ma	2 ma	.5 ma	2 ma	2 ma
Operating Voltage — cathode to anode	70-90	96 ± 2	100 ± 2	60-80	60-80	70-90
Hold Off Voltage — outer electrodes	189	149	189	95	164	159
Life (avg. hours)	400	25,000	25,000	5,000	4,000	5,000
MOL (max.)	1-1/16″	1-1/16″	1-1/16″	27/32″	27/32″	27/32″
		25.4 ± 1.6 min.			21.4 ± 1.6 min.	

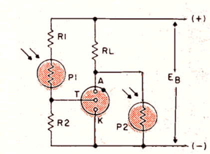
3-element lamp oscillator



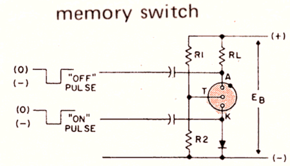
3-element lamp frequency divider



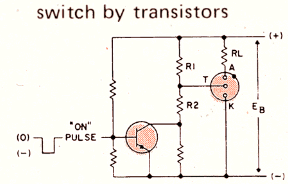
Operation of 3-element lamp memory switch by photocells



Cathode-driven 3-element lamp memory switch



Operation of 3-element lamp memory switch by transistors



ZD Series Regulators

They are ideal for use in constant voltage, wave form clipper, surge absorber, voltage limiter, etc. circuits.

This Signalite ZD series of regulators offers significantly better TC and voltage regulation than solid state devices.

Electrical Specifications @ 25°C., Regulation ± 1V

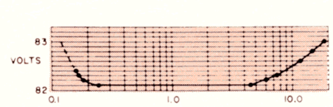
Signalite Type	Jedec Number Reference	Breakdown Voltage vdc Max.	Breakdown Voltage vdc Typ.	Reference Voltage Vdc	Reference Voltage @ ma	Current Range for Regulators ma	Temperature Coefficient mV/OC
ZD5268	IN5268	110	102	82	2.0	0.25-7.0	−2
ZD5270	IN5270	118	110	91	1.0	0.1 -2.0	−3.5
ZD5271	IN5271	130	115	103	0.8	0.2 -2.0	−9
ZD5272	IN5272	165	155	110	1.5	0.5 -4.0	+15
ZD5273	IN5273	150	140	115	0.5	0.15-4.0	+10
ZD5275	IN5275	185	175	139	0.5	0.3 -1.9	

Notes:

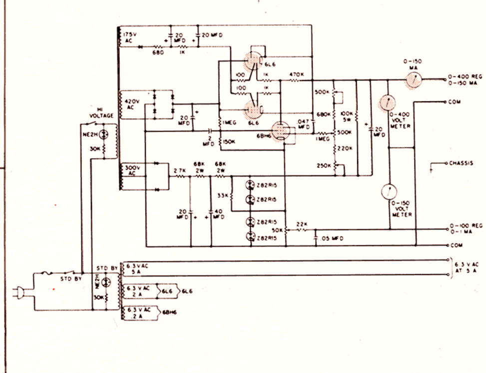
Device numbers shown are indicated by Suffix "A" for units with a tolerance of ±10%; by Suffix "B" for units with a guarantee of ±5% use; by Suffix "C" for units with a tolerance of ±1% use; and ±20% units no suffix is required.

Equilibrium conditions reached within 2 minutes after ignition are common to all voltage regulators and reference tubes.

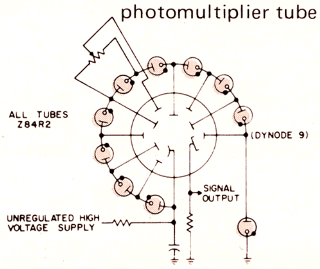
Typical regulation curve for cold cathode voltage regulator



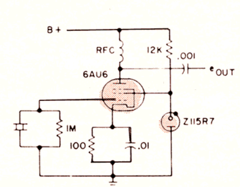
Electronically regulated power supply

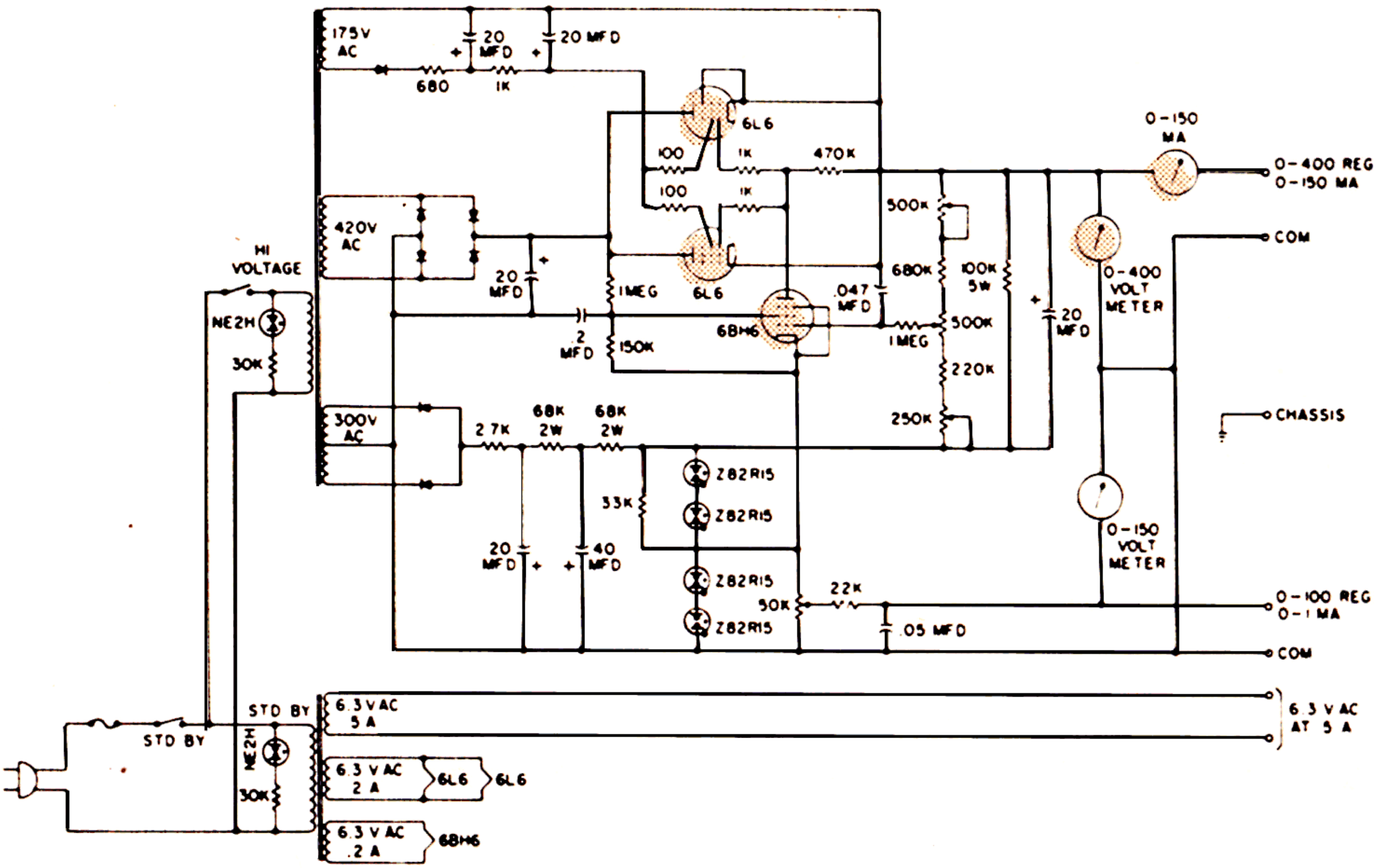


Cold cathode voltage regulators with photomultiplier tube



Voltage regulation for crystal oscillator




175V AC
20 MFD
20 MFD
680
1K
6L6
100
1K
470K
100
1K
0-150 MA
0-400 REG
0-150 MA
420V AC
500K
COM
HI VOLTAGE
20 MFD
6L6
680K
100K 5W
0-400 VOLT METER
1MEG
.047 MFD
NE2H
.2 MFD
6BH6
1MEG
500K
20 MFD
30K
150K
220K
300V AC
68K 2W
68K 2W
2.7K
250K
CHASSIS
Z82R15
33K
Z82R15
0-150 VOLT METER
20 MFD
40 MFD
Z82R15
22K
50K
0-100 REG
0-1 MA
Z82R15
.05 MFD
COM
STD BY
6.3 VAC 5 A
6.3 V AC AT 5 A
STD BY
NE2H
6.3 V AC 2 A
6L6
6L6
30K
6.3 V AC .2 A
6BH6

Glossary of Commonly Used Terms

ABNORMAL GLOW
The region of operation where the current rises exponentially with voltage. This region is an unstable area consisting of a high voltage and low current.

AGING
The process in which any device is subject to current in excess of its operational mode for a period of time to stabilize its electrical characteristics.

ARC VOLTAGE
Voltage across the electrodes of a device during conduction of arc current—also known as tube drop.

BREAKDOWN VOLTAGE
The voltage at which a discharge occurs between the electrodes. This breakdown is dependent upon the gas used and the geometry of the tube. It is the voltage required to make the lamp glow, also known as firing voltage, ignition voltage, striking voltage and trip voltage, and identified by the symbol V_B and ranges from 65-200 volts.

BRIGHTNESS
A subjective photometric quantity of radiant energy.

CIRCUIT COMPONENTS
A neon tube (cold cathode diode) that is designed to perform circuit functions such as switching, voltage regulation, et cetera.

COLD CATHODE DIODE
A gas filled diode that does not require cathode heaters for electronic emission.

CORONA
The illuminated area of a glow lamp that surround the cathode.

DARK EFFECT
The intensity of available light affects the number of photons accessible to free electrons from their valance, the number of photons increasing proportionally with light intensity. For a lamp to be used in ambient atmosphere, a light problem does not exist. However, in applications where there is no light, ions must be generated. This can be accomplished by the addition of radioactive isotopes.

DESIGN CURRENT
That level of electric current at which rated life values are based.

END OF LIFE
That point expressed in hours where specified characteristics of a device do not meet specifications.

EXTINGUISHING VOLTAGE
The level of voltage appearing across the lamp's electrodes at the instant it turns off.

FIRING VOLTAGE
See Breakdown Voltage.

FLICKER
The phenonomen of corona moving from one work area to another and obvious to the naked eye, usually occurs at a frequency of 25 cycles and less.

GLOW LAMP
A high stable, active electronic component, operating off line voltage consisting of a minimum of two electrodes (anode and cathode), sealed in a glass envelope and filled with a gas, usually neon. This device can give illumination and perform circuit functions such as switching, voltage regulation, optical coupling and isolation, and triggering. The color of the glow is governed by the type of gas in the tube.

INDICATOR
A neon tube designed to give indication of a status such as Off/On.

IGNITION VOLTAGE
See Breakdown Voltage.

ION
An atom which has either an excess or deficiency of electrons.

IONIZATION
The process by which an electron is removed from an atom, leaving the atom with a positive charge.

IONIZATION TIME
The time required for the lamp to start conducting after application of breakdown voltage.

MAINTAINING VOLTAGE
The voltage measured across the lamp when it is conducting and controlled by the work function of the cathode and the particular gas used. This voltage ranges from 48-80 volts depending upon lamp design and is almost constant regardless of current flow, symbolized by Vm.

NORMAL GLOW
The illumination that is characterized by a voltage drop that is nearly independent of the discharge current.

PASCHEN CURVE
A graphical representation of the relationships of voltage breakdown, a specific mixture and pressure and electrode spacing.

RATED LIFE
RATED LIFE is the number of hours which produces specified changes in characteristics. In lamps for indicator use, the end of useful life is considered to be when light output reaches 50% of its initial value for standard brightness glow lamps, or when the lamp becomes inoperative at line voltage for high brightness glow lamps.

STABILIZATION
The DC aging process to eliminate oxides used to achieve unifrom work function of the electrodes.

STRIKING VOLTAGE
See Breakdown Voltage.

T2
Terminology used to identify the diameter of the glass envelope.

T2R
Terminology used to identify a lamp with a ballasting resistor attached.

TOWNSEND DISCHARGE
The point where non self-pushing discharge occurs, the threshold point of the tube's operation characterized by no glow and a low degree of current (10 to 100 uA).

TRIGGER TUBE
A gas discharge device with three electrodes (anode, trigger and cathode) which can be fired upon command, usually used for high speed applications.

TRIP VOLTAGE
See Breakdown Voltage.

TURN ON TIME
The time lag before voltage reaches breakdown and directly related to the amount of voltage in excess of the breakdown voltage applied to the device.

WORK FUNCTION
The amount of energy required to free electrons from the surface of materials for conduction.

Glow Lamps

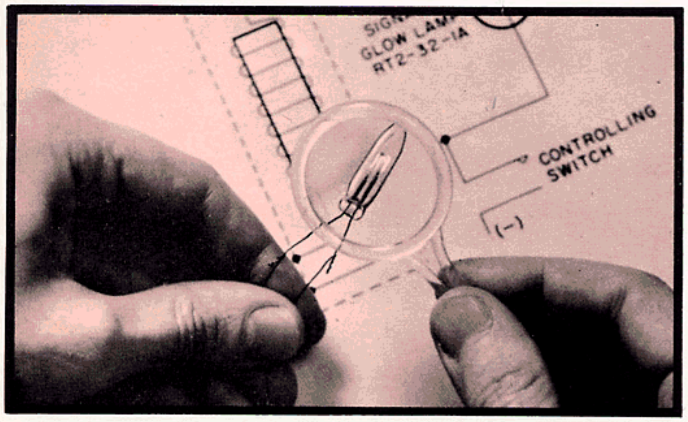
Design
Operation and
Application

Glow Lamps/Design/
Operation/Application

Warranty/Owl

SIGNALITE A Division of General Instrument Corporation

Glow Lamps/ Design Operation and Application



Construction, Operation and Operational Characteristics

Glow lamps, known variously as neon lamps, gas discharge tubes, and diodes, have been produced and used widely for better than two decades. Most commonly they are used as indicators in appliances and other equipment to indicate an "on" status or a "ready" status. In recent years improvements in the design and manufacture of these devices have resulted in increasing use as circuit components in electronic circuitry, measured by the same standards of performance and reliability as any other component in the circuit.

Working closely with customers over the past years, we have found that more intelligent use of the unique characteristics of glow lamps can almost invariably be obtained when these characteristics are known and understood. Unfortunately, the basic information upon which knowledge is built is not easily available. Application information, on the other hand, is readily available. To fill this gap, this series of articles will discuss how the glow lamp works, why it works that way and what can and cannot be done with it.

General Construction

The basic construction of neon lamps is shown in Figure 1. The envelope is made of glass sealed in two areas, the tip and press. In the press area the leads protrude through one end of a hollow cylinder of glass and the glass is heated and pressed about the leads. This holds them in mechanical position and forms a hermetic seal about the leads. The unit is evacuated and gas is introduced through the tip area prior to tipping off. Because the

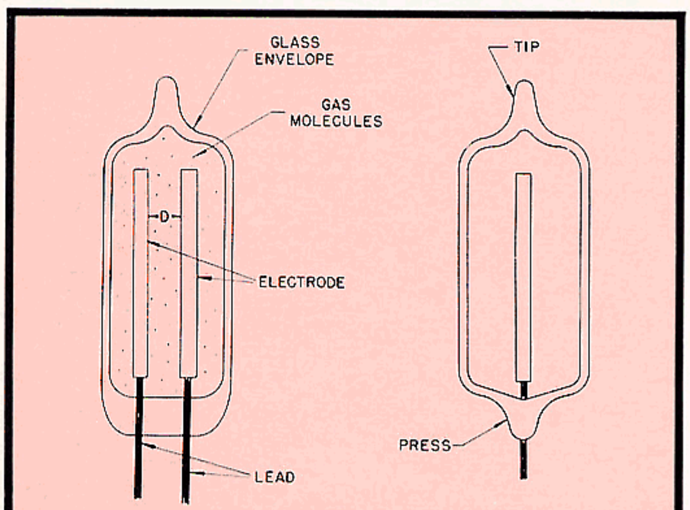


Figure 1 Neon Lamp

leads are mechanically held at sealing, the electrodes are controlled in spacing. This device, because it has only two electrodes, is called a diode.

Diode construction is used for the manrfacture of indicators, circuit components, energy transfer devices, and voltage regulators.

Operation

Figure 2 indicates, generally, the actions that take place within the device during operations. Specifically illustrated are:

1. Electron actions
2. Positive ion actions
3. Sputtering
4. Light emissions

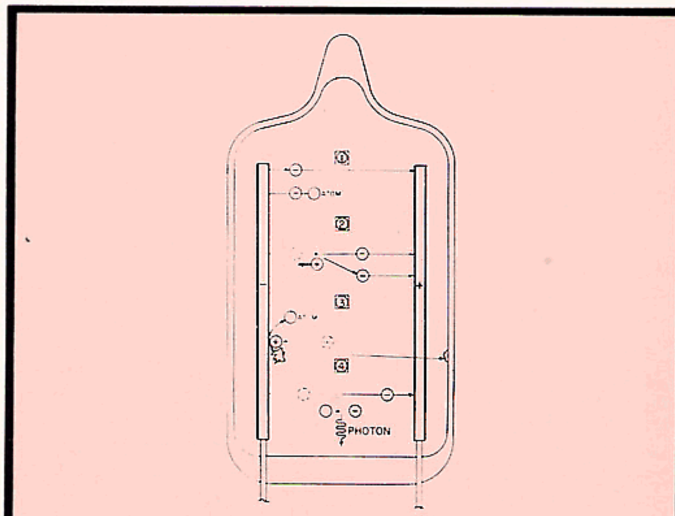


Figure 2 Electron action in a neon lamp

A diode operates in the following manner. A voltage is supplied between the anode and the cathode which, when sufficiently large, will cause electrons to be emitted from the cathode surface. The electrons, accelerated by the electric field, collide with atoms of gas and can do one of two things:

1. The traversing electrons can "strike" an atom of gas and elevate one of its valence electrons to a higher energy state. It is a fundamental rule of nature that all physical systems shall be in their lowest energy state; *i.e.,* Newton's apple. Consequently, at some time after being elevated, the electron will drop to a lower energy state. When this occurs, a photon of light is emitted, the wave length of which is determined by the difference in energy between the two levels the electron occupied. The total light output from a glow lamp is the result of millions of such occurences at a given instant.

2. The atoms can have electrons knocked completely off in which case the atoms become positively charged ions. The electric field between the anode and cathode is in such a direction that the ions are accelerated toward the cathode. They collide with, and knock material off the cathode. This phenomenon is called sputtering. In general, two types of cathode are used in glow lamps; a., a metal base with an emissive coating over the metal; b., a bare metal cathode where the material is of a chosen type and uniform in material distribution throughout its volume.

Sputtering of an emissive coated cathode results in the emissive material being removed. This material has a low work function and is used to lower the firing voltage of the lamp. As the material is knocked off, the bare metal underneath is exposed. The bare metal has a higher work function than the emsisive coating and therefore the breakdown and maintaining voltage of the lamp goes up.

Bare metal cathodes have higher breakdown and maintaining voltages than emissive coated cathodes because of these reasons. Sputtering takes place in these lamps just as in the emissive coated cathode lamps. However, when the surface material is removed by sputtering, the exposed material underneath is exactly the same as the sputtered material and no changes in the electrical parameters occur.

Corona, or the illuminated region of a glow lamp, occurs in the area where the lowest work function exists on the cathode. It is possible to have two or more areas on the cathode with an identical work function. In this case, there is a distinct possibility that the corona will appear between either of these areas and the anode. In fact, the corona will move, in some random fashion, from one area of low work function to another area of low work function. When this occurs at a frequency of less than 25 cycles, it is obvious to the eye. This phenomenon is called flickering. In most cases it is undesirable because it is distracting. We are presently investigating techniques that will define flickerers before they occur so that we can guarantee their absence from our product.

For proper operation glow lamps require some ions to be present in the tube. The ions are created by electron emission (photoelectric effect) which can be generated by light which has an intensity of five foot candles or more. Therefore, if a lamp is to be used in ambient light, few turn-on problems will be encountered. For applications where the lamp is to be used in the dark, radioactive material is added to the lamp. The emission from the radioactive material generates the necessary ions. Atomic Energy Commission regulations are strictly adhered to in the use of any radioactive materials. But in any case, the amount of radioactive material is so low in magnitude that it is not harmful. In addition, the glass envelope is lead glass and contains all emission within the tube.

In the upper right hand corner of Figure 2 is a plot of breakdown voltage vs. the product of pressure and spacing. The resulting curve is the Paschen curve. A given Paschen curve applies only to one gas or gas mixture. The breakdown voltage of a device is designed by choosing a pressure and lead spacing that will give the desired characteristics in conjunction with a given gas. Maintaining voltage is controlled by work function of the cathode as well as the particular gas used. Note that the curve indicated has a relatively sharp bottom shape. This results in a wide variation in a breakdown voltage for small changes in spacing or pressure. Close tolerance devices require curves that are fairly flat in the pressure times distance relationship. This can be obtained with very specific gas mixtures.

Other Types of Construction

There are many electrode configurations for diodes as well as many envelope shapes and sizes, but the operation is still that of a diode. Figure 3 shows a different type of construction. This device is called a trigger tube because it has three elements, one of which "triggers" or causes the tube to fire.

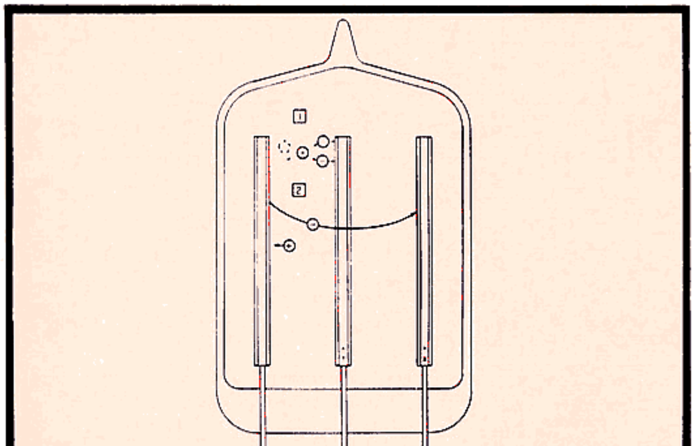


Figure 3 Trigger Tube

Operation Characteristics

Figure 4A shows, diagrammatically, how light is generated by electrons "striking" an atom. An electron is elevated to a higher energy state and desires to return to the ground state. It does so at a later time and emits the energy change as light. The wavelength of the light depends on the energy change that the electron went through. The energy levels are restricted by quantum physics. Figure 4B shows the same results as 4A in different form.

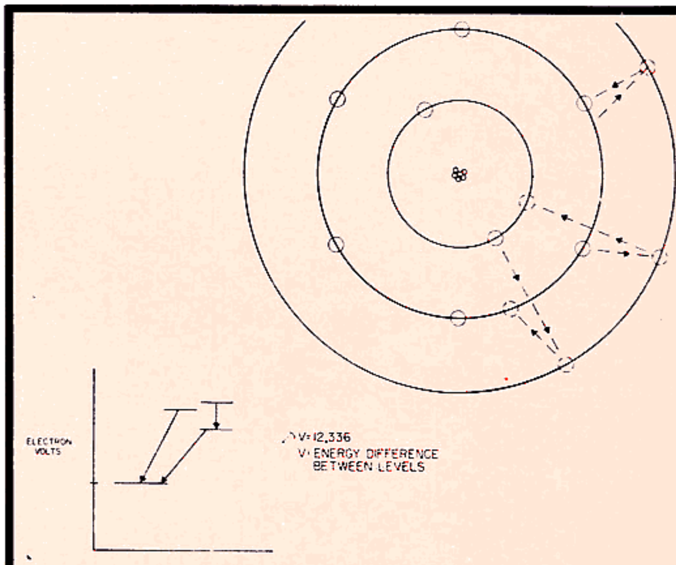


Figure 4 Light Generation

The wavelength of the emission can be calculated from the equation shown:

The spectral outputs of a gas diode are illustrated in Figure 5A and 5B for two different gas mixtures. These are the two most common gases used in glow lamps. Note that for neons (Figure 5A) the light output is in the wavelength of 5700 angstroms and higher. This is the red response area of the human eye, and therefore appears red to the eye. The argon lamp (Figure 5B) has a red content above 5500 angstroms and into the infrared range, and a blue which is less than 4700 angstroms. However, because of the intensity of the blue and the fact that the eye cannot see infrared the red gets washed out and the lamp appears blue to the eye.

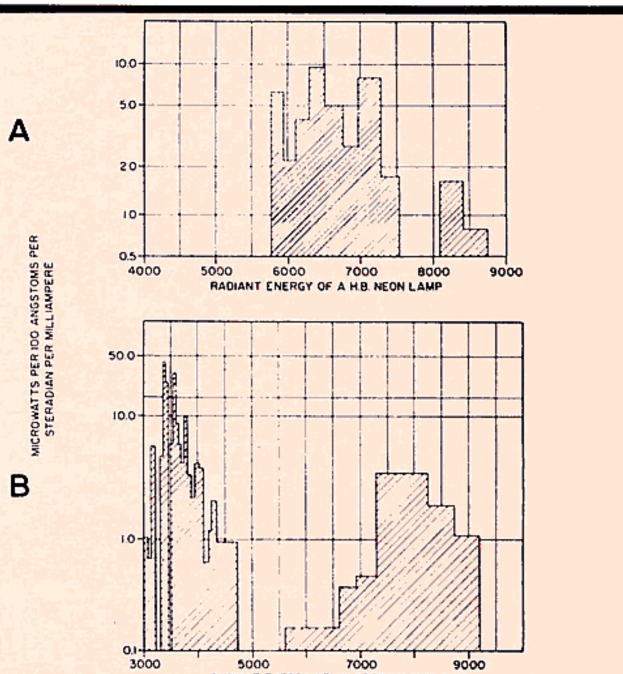


Figure 5 Spectral Distribution

The volt-ampere characteristics of a gas diode are shown in Figure 6. While the curve does not show specific voltages a wide range of breakdown and maintaining voltages is available.

The normal area for operation of a glow lamp is in the negative glow region and published specifications are given for this area. After sufficient current flows through the lamp to create 100% corona coverage, any additional current takes the lamp out of the negative glow area and into the abnormal glow area. This is hard to discern by eye, but the lamp is very bright. The sputtering rate is markedly increased and the tube life considerably shortened.

If the current is raised to a point above the abnormal glow area, the tube will go into an arc mode. For normal devices, this is also highly destructive. However, some devices are specifically designed to operate in the arc mode. These devices are used for pulse energy transfer in such operations as squib firing, drive of optical shutters, and the like.

The shape of the curve in the maintaining region is generally not of interest for light source devices such as indicators. However, for voltage regulators it is necessary that the maintaining curve be fairly flat over some specified current range. In the design of voltage regulators and voltage reference tubes, it is possible to hold this characteristic to within ± 1 volt variation. The current range is specified on our data-sheets. Voltage regulator tubes have a much better temperature coefficient than zeners and also dissipate less power.

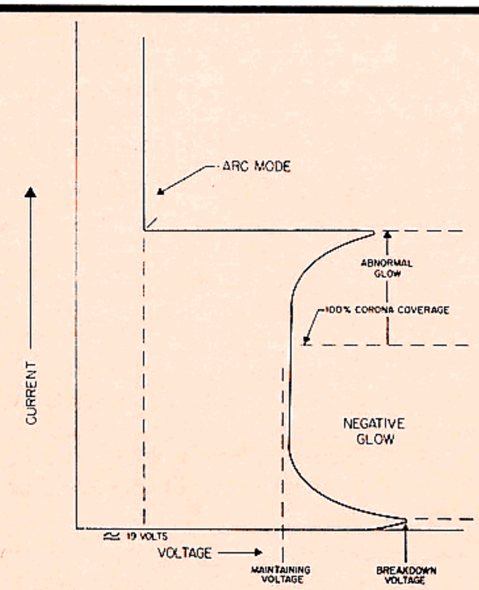


Figure 6 Volt Ampere Characteristics

Ignition Characteristics and Methods

There are a variety of ways which can be employed to turn on and turn off neon lamps. The most appropriate method is the one which best meets the requirements and characteristics of the specific circuit in which the lamp is to be used.

Turn-On Method

In Figures 7 and 8 various ways are illustrated to turn the neon lamp on. However, regardless of the method employed, the breakdown voltage of the device must always be exceeded.

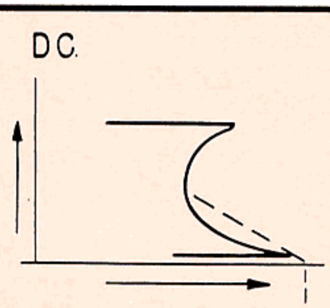


Figure 7A

Figure 7A illustrates the method of turning a lamp on by DC. In this case a suitable resistor is placed in series with a power supply and the power supply voltage is raised to a point where the voltage exceeds the breakdown voltage of the lamp. The voltage across the lamp will suddenly drop to its maintaining voltage and will operate a current determined by the supply and the resistive load line. It will stay at this point until the voltage is reduced to a value below its maintaining voltage.

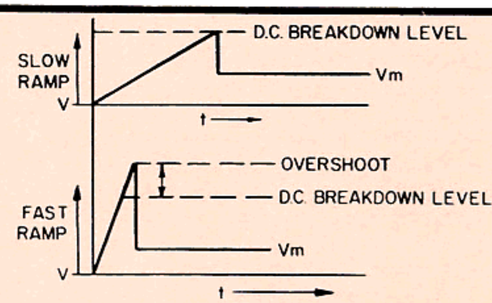


Figure 7B

Figure 7B illustrates the action of the lamp relative to different ramp voltages. A slow ramp, about 10V per second, results in the lamp firing at the same level as that determined by the application of DC. However, a fast ramp, about 10V per millisecond or less, results in an apparently higher breakdown voltage. The voltage in excess of the DC breakdown value is called overshoot. This is caused by the finite ionization time of the lamp and is the result of the inability of sufficient ions to be generated during the early portions of the ramp.

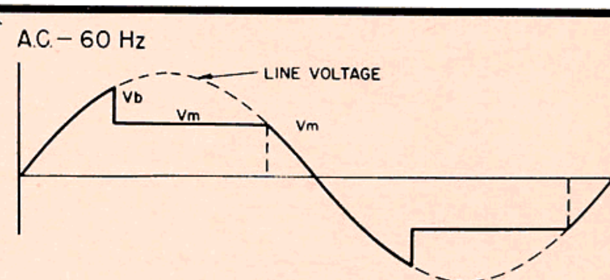


Figure 7C

Figure 7C illustrates the action of a lamp when exposed to an AC voltage. This is typically the action of the devices used in ½ wave and full wave proportional controls if one assumes that the capacitor is charging at the same rate as the line frequency. The voltage will rise to the breakdown voltage of the lamp at which point the lamp will fire delivering a pulse to the gate of the SCR or triac. The lamp will stay at its maintaining voltage until such time that the line voltage drops below the maintaining voltage and the lamp will extinguish. The firing point in the positive and negative direction can vary a few volts because the tubes are not necessarily symmetrical in both directions.

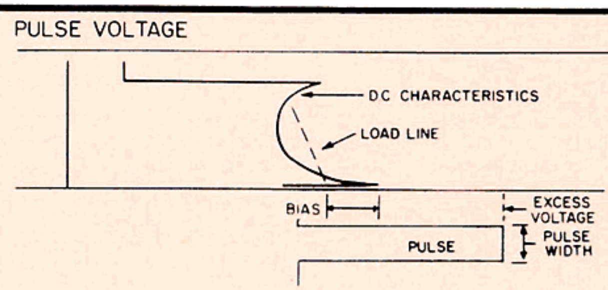


Figure 7D

Pulse voltage turn on is shown in Figure 7D. A lamp is biased at some point below its breakdown voltage but above its maintaining voltage. A pulse of sufficient amplitude which has a width in excess of the ionization time is superimposed on the bias voltage. The lamp will turn on during the existence of the pulse, and after the pulse has been removed it will stay on, sustained by the bias voltage at a point on the curve as determined by the bias voltage and the resistive load line. If the bias voltage is not greater than the maintaining voltage, the lamp will go off when the pulse is removed.

Figure 8A illustrates the action of a laser or flash tube on the characteristics of a glow lamp. It is to be particularly noted that the breakdown voltage (dark) can be modified when sufficient illumination is presented to the lamp. This illumination is not arbitrary in frequency as it must be the exciting wave length for the particular gas molecules involved. Also, the cathode has a photoelectric work function that must be exceeded for the cathode to emit electrons. Therefore, a laser, with its monochromatic output, would have to have the exact exciting frequency of the gas molecules or sufficient energy to exceed the work function of the cathode. A flash tube, on the other hand, puts out a broad spectrum of frequency some of which is bound to be the exciting frequency of the gas, or have sufficient energy to overcome the photoelectric work function. Since, however, the power involved in the exciting frequency (generally U.V.) is very low, the flash tube must almost be in physical contact with the neon lamp in order to turn it on.

The glass used to make lamps is lead glass, G-1 or G-12. These glasses have poor spectral transmission below 3000 angstroms. The frequencies below 3000 angstroms are the very frequencies to which gas excitation or photoelectric work function are most sensitive. Consequently, high intensity is needed to get a small amount of U.V. through the glass.

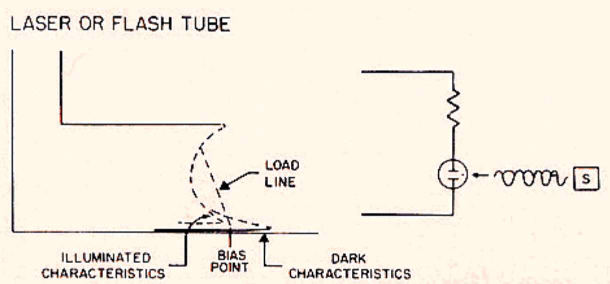


Figure 8A

The exciting of the gas molecules by high voltage is illustrated in Figure 8B. If a voltage source of sufficient magnitude is placed around or on the glass envelope of a lamp, sufficient ions are generated to lower the breakdown voltage. This is very similar to the action of the laser and a flash tube.

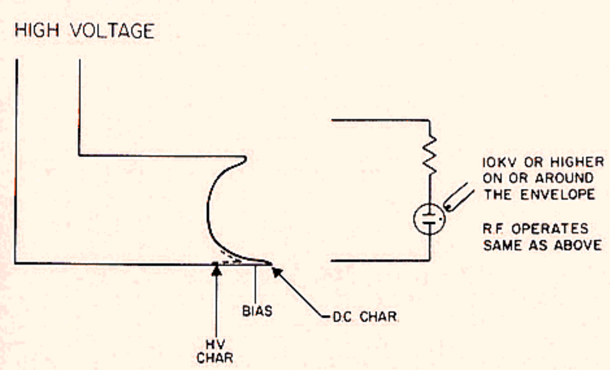


Figure 8B

High Voltage

Application of R.F. near or on the glass envelope will excite the tube in the above manner and will reduce the breakdown voltage (dark) as indicated above.

A general note on DC operation should be made here relative to turn on characteristics. If a device is run for some hours with current flowing in one direction, a lamp becomes "polarized". If such a lamp were tested for its breakdown voltage in the reverse direction before and after the application of DC, it would be noted that its breakdown voltage has gone up. If the lamp now has current passed for some hours in the reverse direction, the breakdown voltage will return to its original reading. This fact is important when designing circuitry where a lamp is occasionally reversed in polarity.

Trigger Tube Turn-on

Trigger tubes are generally used for high-speed applications. The speed is derived from the fact that the tube is ionized by a keep-alive current flowing between the trigger and cathode. Keep-alive currents are generally in the microampere range and, therefore, high values of resistance are used in the circuit. This provides the added advantage of a high impedance.

In the keep-alive technique, the tube is used in the following manner. A low current is caused to flow between the trigger and the cathod to pre-ionize the tube. A voltage in excess of the breakdown voltage is applied across the anode and cathode as a pulse or step function. The tube will respond to this voltage in a period of time as low as 10 microseconds. It should be specifically noted that the trigger current causes only a small variation in the breakdown voltage from anode to cathode, about 5 or 10V.

The device can also be used, as the name implies, as a trigger device. In this configuration, a voltage is applied across the anode and cathode which is slightly less than the breakdown voltage. Trigger current is then supplied via the trigger to cathode circuit and the breakdown voltage from anode to cathode is lowered to a value below the bias voltage; thus the tube will turn on. It should be noted that this mode of operation does not have the speed of response of the keep-alive technique because the ions must be generated by the trigger to cathode pulse.

In Figure 9B it can be seen that the trigger to cathode breakdown voltage is less than the anode to cathode breakdown voltage. This is a direct result of the Paschen's curve. Namely, the pressure of the device is constant, and therefore, the breakdown voltage from the trigger to the cathode and from the anode to the cathode depends on the spacing of these electrodes. Since the trigger is closer to the cathode its breakdown voltage will be lower than that of the anode.

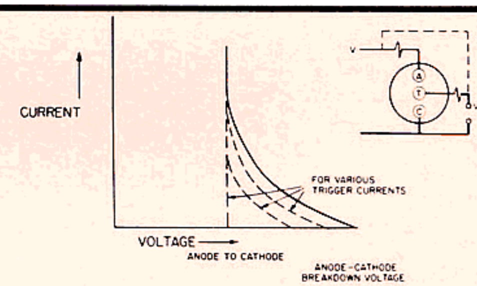


Figure 9A

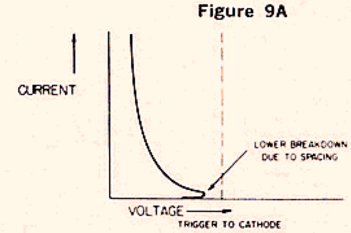


Figure 9B

Given the same set of minimal voltage conditions, a diode will turn on in several milliseconds while a trigger tube, with keep-alive current, will turn on in tens of microseconds. The turn-on time for diodes is given in Figure 10A. The ionization time, or turn-on time, is directly related to how much voltage in excess of the DC breakdown voltage is applied to the device. In addition, the curve is dependent on the intensity of the ambient light while the measurements were being made.

This curve represents the fastest possible ionization time for a given percent of overvoltage.

For less than 20% overvoltage, the curve is going asymptotic to the time scale. Therefore, for a small change in overvoltage a large change in ionization time will occur. When the percentage of overvoltage exceeds 40% any further decrease in ionization time is small.

This curve was obtained using square wave drive (Figure 10B) with variable pulse width. For any wave shape other than square wave, the turn-on time will be longer than indicated in the curve (10A).

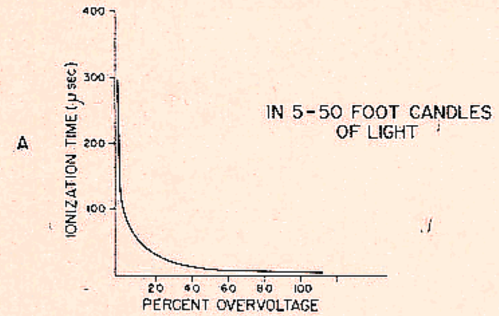


Figure 10A

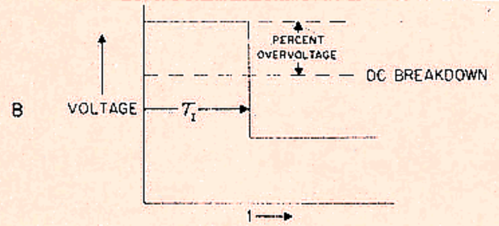


Figure 10B

Turn-Off Time

It is generally desired to know the turn-off time of the light output and the voltage recovery, or deionization time. Figure 11A indicates the turn-off time of the light. DC current was supplied to a lamp for some period of time. At time T = O the circuit was interrupted instantaneously. The light level rose from the DC level to about five times the DC light level and then proceeded in a long tail descent to darkness in a period of 200 microseconds. This light peak was caused by a number of excited electrons that could not return to ground state while current was flowing. When the current was interrupted they spontaneously returned to the ground state generating the increase in light output for a period of a few microseconds.

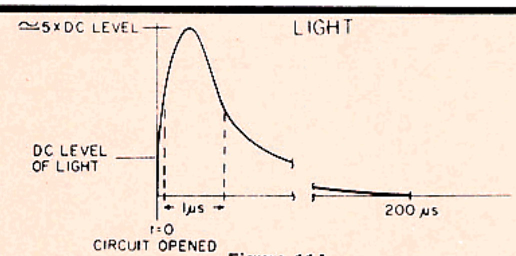


Figure 11A

Figure 11B demonstrates the relationship of the voltage recovery. This particular curve was made from data taken on a lamp with

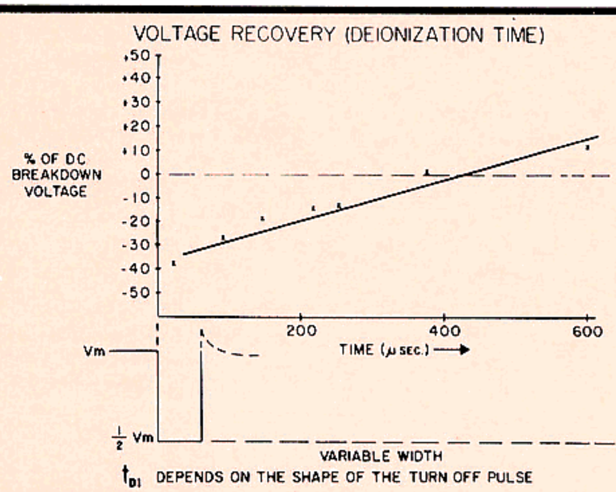


Figure 11B

2 ma flowing. It is to be emphasized that for other currents the slope of the curve will be significantly different. With high currents flowing, the recovery time will be longer, while with lower currents flowing, the recovery time will be faster.

The curve was obtained by operating the above lamp at its maintaining voltage and driving it off to ½ its maintaining voltage with a square wave. The ½ maintaining voltage was chosen because it is the voltage at which the lamp recovers the fastest. The width of the drive pulse was varied and the voltage to which the tube recovered was determined at the positive excursion. For pulses less than 20 microseconds long, the tube did not recover past its maintaining voltage. As the pulse width was increased the percent of voltage recovered was approximately linearly related to the pulse width. A pulse width of about 400 microseconds was necessary before the tube recovered to its DC breakdown voltage.

For shapes other than a square wave and for voltage levels of other than ½ maintaining voltage the results would be slightly different than those indicated in the curve.

The small size, low current requirements, light output, stable voltage operation, and other characteristics of neon lamps make these devices applicable to a wide variety of tasks in electronic and electrical circuitry. Many of these applications have been discussed in previous issues of *Signalite Application News* and in the book, *Applications of Neon Glow Lamps,* by the late Edward Bauman.

While many variations on individual circuits can be constructed depending on the specific requirements or tasks to be performed, there are several basic circuits which can illustrate various applications. In Table I is a list of many of the applications which Signalite has provided neon lamps for — in most cases standard production lamps, in some cases specially designed lamps with unusual characteristics to meet a specific need.

Basically, the neon lamp will perform one, or a combination, of three operations: indicate, switch, and regulate. This, of course, is an oversimplification. Under switching, for example, would be included simple switching, energy transfer, memory switching, frequency dividers, oscillators, timers, proportional control, and so forth. The circuits that will be discussed here are basic circuits and are intended to show the application of the principles rather than to provide a comprehensive review of all circuit possibilities.

Figure 12 shows a straight-forward indicator circuit which tells one that power is supplied to the unit or that the unit is on. Lenses are generally used with the lamp to provide contrast and to diffuse the light. Indicators can be used on either AC or DC. The light-emitting characteristic of neon lamps is characteristic of all lamps with the exception of voltage regulators, and thus many times the lamp can be used to provide both an indicator function as well as another precision-type function in the circuit.

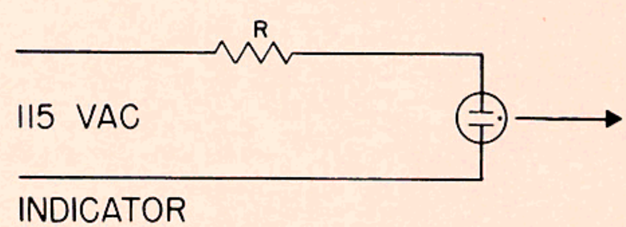


Figure 12

A simple timer circuit is shown in Figure 13. This circuit can provide time delays up to several minutes. The AC is half wave rectified by the diode and this half wave is applied to C and the lamp through R. The resistor can be a variable resistor such as a thermistor, electrodes in a solution, and the like. It limits the rate of charge the capacitor can obtain for each half cycle and, consequently, the voltage builds up slowly on the capacitor. At some time after the power is applied, the voltage across the capacitor will reach the firing voltage of the lamp and the lamp will turn on. The lamp will discharge the capacitor to slightly lower than the maintaining voltage of the lamp and the lamp will go off.

The capacitor now starts charging again and the cycle repeats as long as power is applied. It should be noted that it will take much

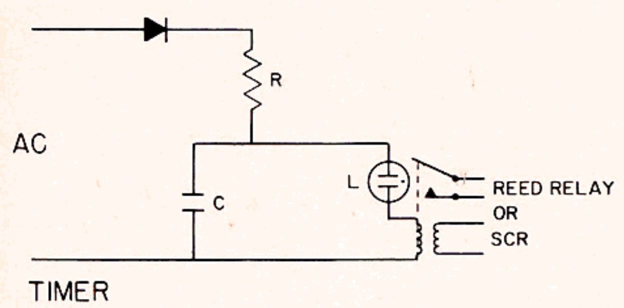


Figure 13

longer for the first pulse to occur than for subsequent pulses. This is because the capacitor is starting to charge from 0 volts initially and charges from slightly lower than the lamp's maintaining voltage thereafter. For very long delays leakage resistance must be as high as 20,000 megohms. Lamps with leakage resistance as high as 1 million megohms are manufactured by Signalite.

The circuit in Figure 14 operates on a similar principle to that in Figure 13 except that DC is supplied and no rectifier is necessary. For the same magnitude of input voltage, the circuit will not give as long a time delay as that of Figure 13 because only a half wave is applied in Figure 13.

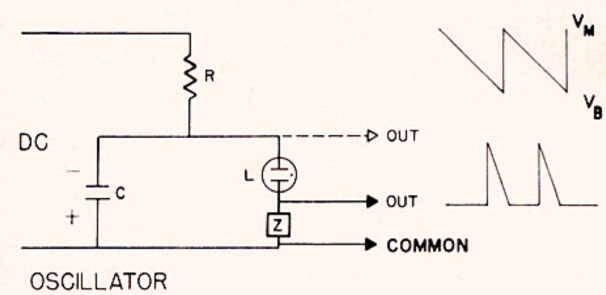


Figure 14

The circuits in Figures 15 and 16 are similar in operation and differ only in the amount of phase angle available to the load. An SCR is only functional when its anode is positive relative to its cathode. Thus, it can only function on ½ of the AC wave or for a 180 phase angle. A triac, on the other hand, will function on both halves of the line providing a gate pulse is supplied during both periods. Both halves of the line correspond to a 360 phase angle.

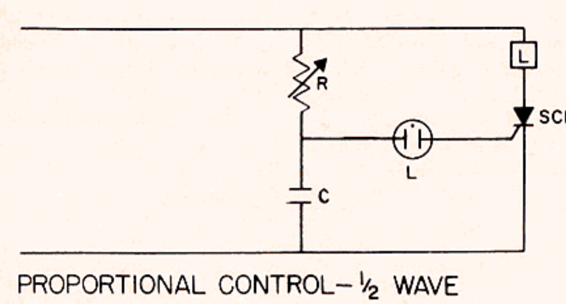


Figure 15

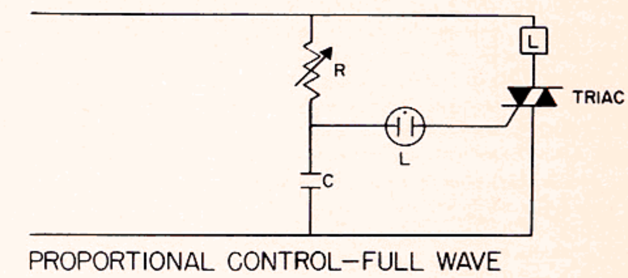


Figure 16

The resistor-capacitor combination determines when the voltage across the lamp will reach the breakdown voltage during each half cycle. When the lamp fires it discharges the capacitor through the gate circuit and the SCR or triac will turn on. (This assumes that the anode of the SCR is positive.) On the negative half cycle the pulsing circuit supplies a negative pulse to the SCR. This is in the reverse bias direction of the gate to cathode junction and the SCR could not turn on even if the anode were the correct polarity.

Triac circuits differ in that triacs can be turned on with either positive or negative pulses regardless of the polarity across the device. Thus, on the first half cycle the positive pulse will turn the triac on, and on the next half cycle the negative pulse will turn it on. Both the SCR and the triac go off when the AC voltage goes through zero.

Varying the resistance value will cause the lamp to reach its firing voltage earlier or later in each half cycle. Therefore, the output will vary in "proportion" to the amount of the AC wave that the circuit allows to be applied. The resistor can be a potentiometer as in the case of a motor speed control, a thermistor as in the case of a heat control, or similar variables.

We recommend low gate current SCR's for most applications. Use of these SCR's results in a longer lamp life since the lamp does not have to deliver such high peak gate current.

The circuit in Figure 17 shows a series-shunt photochopper. The variable resistors shown are in fact photocells whose resistance is low when light is shining on them, and high in the dark. Lamps A and B can be controlled by external circuitry or could be installed in a flip-flop arrangement. Only one lamp should be on at a time. Lamp B is on when no output signal is desired. Photocell B essentially shorts (several K ohms) the input. Light A is off and the impedance of photocell A is many megohms. Thus, the input signal is effectively shunted.

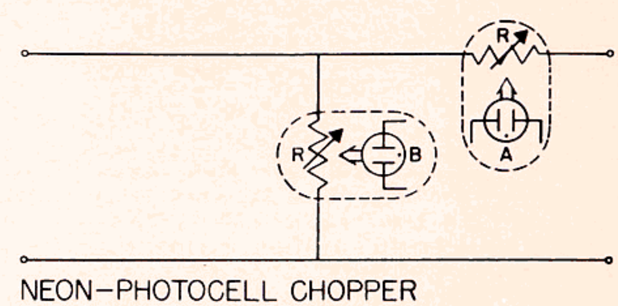


Figure 17

When B is off and A is on the signal is allowed to pass. This occurs because B is many megohms while A is several K ohms. Many other configurations are possible in the neon-photocell type circuitry.

Because of the bistable characteristics of the neon lamp, many different types of memory switch circuits can be constructed. (See Signalite Application News, Vol. 4, No. 3.)

A simple circuit shown in Figure 18 uses a gas device for switching small signals and is used for remote control or in conjunction with a short or long term erasible memory where it might be desired to store a program or other data for three or four days or longer, and then erase them. Low leakage is an important factor in this type of application. The capacitor leakage resistance is in the area of $10^{+18}\Omega$, at low voltages, the neon lamp leakage is $10^{+12}\Omega$, and the FET transistor leakage should be about $10^{+13}\Omega$. With these values, it has been shown that there is a loss of 5% in 1000 hours.

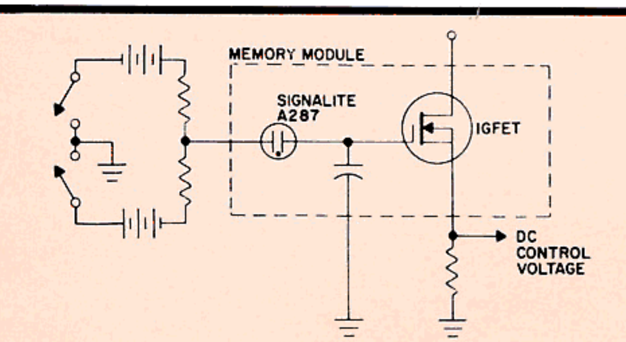


Figure 18

In this circuit when either of the function switches shown are closed, the neon lamp will conduct and allow a charge on the capacitor to be varied up or down in response to the direction of control desired. The FET transistor which is following the capacitor voltage has a function to provide the variable DC control voltage output.

Gas discharge devices can be specifically made to handle energy transfer. The devices used for energy transfer operate between the breakdown voltage and the arc mode voltage. The voltage across the tube when it is in the arc mode is approximately 19v and the device has low dynamic impedance. Depending on the breakdown voltage, various energy transfer efficiencies can be obtained. The maximum energy transfer efficiency appears to be 70% with present technologies. Figure 19 shows a circuit using the energy transfer characteristics of a gas device for developing several KV to trigger a flash tube.

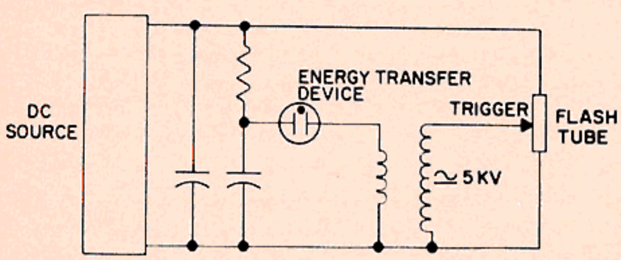


Figure 19

One of the most useful of the basic characteristics of a specially designed gas discharge device is that it maintains a constant operating voltage over a wide operating current range. Because of this these devices are widely used as voltage regulators, voltage references, surge protectors and other regulatory devices. In Figure 20 is shown a simple circuit for protecting other circuit components against the counter electro-motive force created when the current through an inductive load is opened. Under the sudden surge of counter emf, the lamp breaks down and ignites. The stored energy in the coil discharges vary rapidly through the lamp. Voltage on the circuit is held to the maintaining voltage of the lamp until such time as the counter emf falls below this maintaining voltage, at which point the lamp extinguishes. The same principle applies whether the surge is counter emf, as in this case, or an externally induced surge on the power line caused by any of a variety of factors, including lightning.

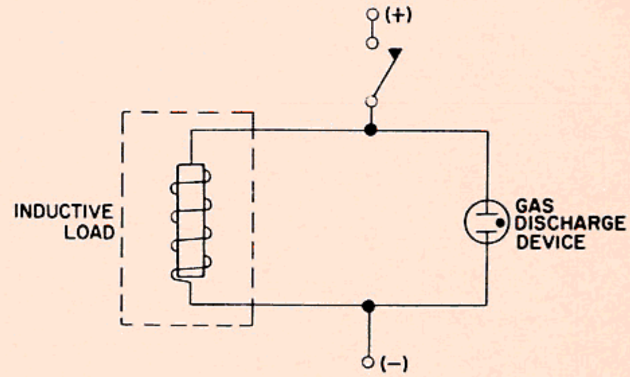


Figure 20

Specifications and Handling

In order to obtain maximum performance from a neon lamp, as with any other component, it is important to specify what is required correctly. Such specifications are a combination of the requirements of the circuitry in which the lamp will be used the environment and performance of the equipment, and the available characteristics of the lamps themselves. In addition to these specifications, there are certain mechanical characteristics which can affect the performance and/or lifetime of a neon lamp.

Life

The rated life for neon lamps is the length of operating time, expressed in hours, that produces certain specified changes in their characteristics when operated at design current. In most applications the lamp is not on all of the time. In these applications only the time during which the lamp has current flowing through it determines the useful life. If this period is of a short duration, as in pulsing operations, the useful life will have to reflect the fact that the lamp's rated life is not being consumed while it is inoperative. Actual life would be equal to the lamp's rated life divided by the operating duty cycle. In many applications the actual useful life, i.e., calculated operation time of the lamp, will exceed by many times the estimated lifetime of the equipment or circuit in which the lamp is installed.

Lifetime depends in part on the construction techniques used, and in part on the operating conditions of the lamp. Shown in Figure 21 are life test results for two different construction techniques: 1) standard brightness lamps, and 2) high brightness lamps. Figure 21A shows the average lifetime in percentage for the standard brightness lamp operating under specified design conditions. The end of life for this type of lamp is specified as that period of time which has passed (on the average) until the light output is reduced to 50% of its initial light output. Standard brightness lamps are designed so that this period is 25,000 hours or more. Note that the breakdown voltage of the lamp goes up with increased usage, but that at 25,000 hours, it is still below 115 vac.

The life of a high-brightness lamp is defined as that period of time which has passed (on the average) until the unit will not fire on a standard line voltage of 115 vac. The life curve for this type of lamp is illustrated in Figure 21B. The high-brightness lamp differs from the standard brightness lamp in that its breakdown voltage is fairly constant to about 80% of its rated life and then the breakdown voltage rises very rapidly. The light intensity also follows this pattern in that it is constant until the breakdown voltage starts changing and then decreases.

The light output of both lamps changes for one or both of the following reasons:

1. Sputtering takes place continually in the lamps and the sputtered material deposits on the glass wall of the envelope. As the period of usage increases more and more material is deposited on the wall building up an increasingly opaque coating. This restricts the amount of light that can be emitted from the tube.

2. As the breakdown voltage of the lamp increases, its maintaining voltage also increases. The current being passed through the lamp is determined by the voltage drop across the series resistor, and as the maintaining voltage increases, the drop across R decreases with a resulting decrease in current. Since the light output is directly proportional to the current flowing through the lamp, the light output is linearly reduced also.

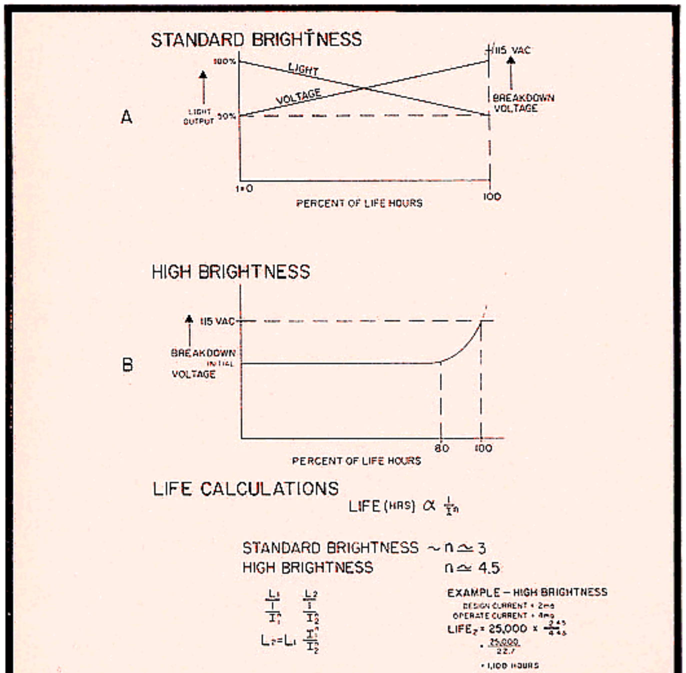


Figure 21

Also indicated in Figure 21 are calculations that must be made if a lamp is used at other than its design current. It is to be particularly noted that life of a neon lamp is proportional to $1/I^n$ where for standard brightness lamps "n" is approximately 3 and for high-brightness lamps "n" is approximately 4.5. The example indicates that for a high-brightness lamp operated at twice its design current its life is shortened to approximately 4.4% of its rated life at the design current.

For lamps used as components in electronic circuitry light output is not usually a matter of prime importance except where they are being used with photocells. In circuit component applications the critical characteristics are usually the breakdown and maintaining voltage ratings. Because these change gradually the end of life occurs when the lamp no longer meets specifications, rather than a catastrophic failure. Life testing of neon lamps must be conducted at design current and cannot be accelerated. Running a lamp at currents above its design current causes spot heating of the cathode emissive material. This, in turn, will increase the sputtering of the emissive material, changing the lamp's aging characteristics at a rate that is not reproducible or easily related to its life at normal usage. Consequently, any attempts to accelerate aging at higher currents will not be applicable to actual service.

In addition to construction life expectancy depends on the operating conditions of the lamp with life increasing as operating currents are decreased. If the lamp is installed in a circuit where it will be subjected to pulsing, the peak current pulse wave shape and pulse duration all will have their effect on lamp lifetimes. Operation on direct current rather than alternating current will shorten lifetime figures perhaps up to 50% in some installations, because of the fact that only one electrode is being used instead of both. As a rule of thumb, average circuit component neon lamps will have rated lifetimes in the area of 7,500 hours of continuous operation.

Electrical Specifications

The electrical specifications shown in Table 2 are self-explanatory. However, it should be pointed out that circuit components have more specifications than indicators. Because of this fact, they are generally higher priced. The only specification that requires some additional definition is light output. It is indicated that standard brightness lamps have an output of .06 lumens per milliampere while high-brightness lamps have an output of .15 lumens per milliampere. It would appear on the basis of this data that a high-brightness lamp is only a factor of three higher in light output than a standard brightness lamp. However, because additional current can be passed through the high-brightness lamp without reducing life characteristics these lamps can put out about 8 times as much light as the standard brightness lamp.

TABLE 2

ELECTRICAL CHARACTERISTICS TO BE SPECIFIED

	INDICATORS	CIRCUIT COMPONENTS
Breakdown Voltage (AC or DC)	______V. Max	____V. ± ____
Maintaining Voltage	Not Spec.	____V. ± ____
Design Current	Res. Spec.	________Ma.
Life (at Design Current)	________Avg.	________Avg.
Definition (Stand. B)	50% of Light	________ (Volts)
(High B.)	Will not fire on line voltage	
Leakage Resistance	Not Spec.	______Meg OHM
Extinguishing Voltage	Not Spec.	________Volts
Turn on Time (Dark)	90% 1 Sec. 99% 3 Sec.	______Milli-Sec.
Light Output (Per Milliamp-Ref.)	S.B. .06Lum/Ma. H.B. .15 Lum/Ma.	Not Spec.
Corona Coverage H.B.	1/3 Min.	Not Spec.
S.B.	3/4 Min.	Not Spec.

Mechanical Specifications

A general rule of thumb is to keep the number of specifications to a minimum so as to keep the cost to a minimum.

In general, only a few mechanical specifications are required and are included in our standard catalog. Table 3 gives the more common mechanical specifications plus some additional specifications that are normally not published. The information indicated can be considered to be standard purchasing specifications, or manufacturing dimensions and tolerances. Any specifications outside of these particular dimensions would require an unusually high order volume, and in general the lamp would be more expensive than standard types. Standard shock and vibration specifications are indicated; however, devices can be made to withstand much higher values. To indicate this capability Signalite is presently producing a device that withstands a 20,000 G shock.

TABLE 3

MECHANICAL CHARACTERISTICS TO BE SPECIFIED

ENVELOPE	
Length (in.) Max	1/2, 3/4, 27/32, 1, 1-1/16
Diameter (in.)	.222 — .244
LEADS	
Diameter (in.)	.016 ± .001
Length (in.)	Per Customer Drawing (1" and 2" are standard)
Center to Center Dist. (in.)	.061 Nom (at Electrodes)
Resistor	Per Customer Drawing
Solder Dip	Per Customer Drawing
BULB	
Clear, Frosted, etc.	Per Customer Drawing
SHOCK	
Ten Shocks of 30 G's of A Duration of 11 ± 1 Millisecond	
VIBRATION	
Sinusoidal Drive, 5-55Hz, Half Amplitude .03 Inches	

Potting

In many circuit applications it may be desirable to pot the lamp as indicated in Figure 22. Because the envelope is constructed of glass, it is desirable to pot the lamp in a soft material. Materials such as silastic are acceptable. After curing of the soft material, the lamp can then be potted in such materials as epoxy, glass-filled epoxy, quartz filled epoxy and the like. Strain relief should be provided prior to potting in the soft material so that any external mechanical forces cannot be transmitted to the seal area of the lamp.

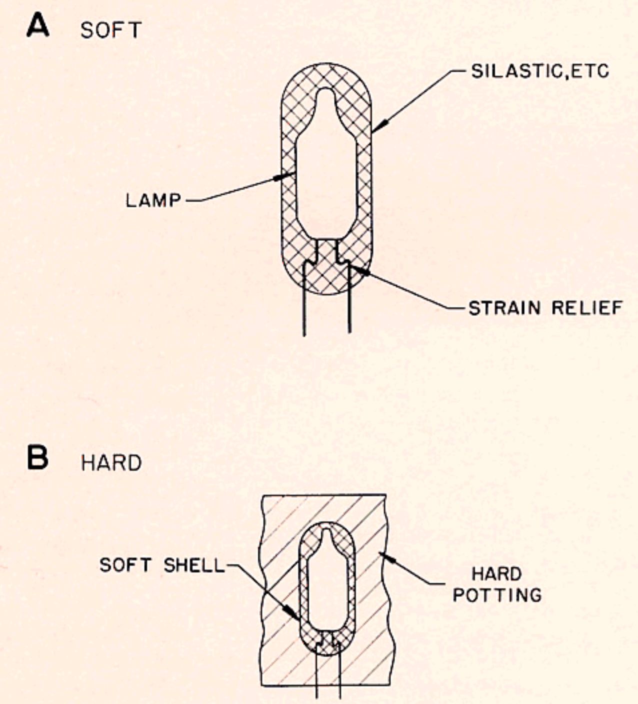


Figure 22

Resistor Assemblies

Lamps can be purchased with one or more resistors attached to one or both leads as shown in Figure 23. The resistor is attached by butt welding a lead of the lamp to a lead of the resistor. In equipment that is to be used at high ambient temperature we recommend ½ w or ¼ w insulated resistors. These resistors have derating curves that start at 70 degrees centigrade and are linearly derated to zero at 150 degrees centigrade.

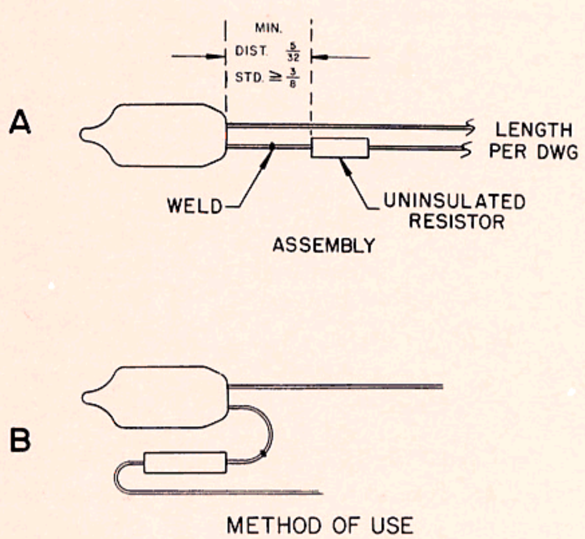


Figure 23

Lead Bending

If it is necessary to fit a lamp or lamp and resistor in an assembly, it is very important to bend the leads properly. Improper bending of the leads can result in a fracture of the glass where the lead enters the press area of the lamp. Figure 24B indicates the proper method of bending the leads. The bending fixture firmly grasps the lead for a distance of at least 1/8" from the glass. The lead then is bent around a curved surface of the fixture. This results in the lead coming straight out of the glass for some minimum distance and reduces the probability of the glass being fractured.

In this series of discussions we have tried to anticipate and answer most of the commonly asked questions about the characteristics and applications of neon lamps. Because the applications vary over so wide a spectrum, we may not have answered all of the questions pertinent to a specific application. If such be the case and you would like detailed information concerning an individual use and/or characteristic, please contact Signalite's Application Engineering Department. There is no obligation for this service.

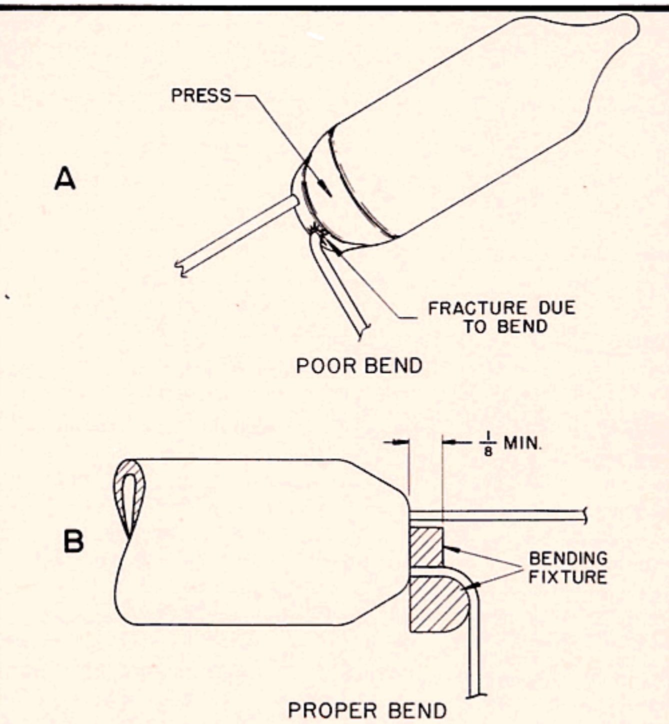


Figure 24

ACKNOWLEDGEMENT

Some information contained in these notes was obtained during numerous discussions with J. Cawley, Manager of Design Engineering, Signalite, Inc.

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WARRANTY

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All devices claimed to be defective will be subject to inspection by SIGNALITE. Normally, SIGNALITE will request return of devices for inspection; however, SIGNALITE reserves the right to make inspection on customer's premises. Returns are not to be made until authorized by SIGNALITE, and in such event, charges for transportation involved from point of return within the Continental United States, will be reimbursed by SIGNALITE, provided a bona fide warranty obligation is found to exist.

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The foregoing warranty, and conditions under which same is applicable, is in lieu of any other warranty or liability whether expressed, implied or statutory. In no case will SIGNALITE be liable for collateral or consequential damage or an amount in excess of the actual purchase price paid under any other subject to this warranty.

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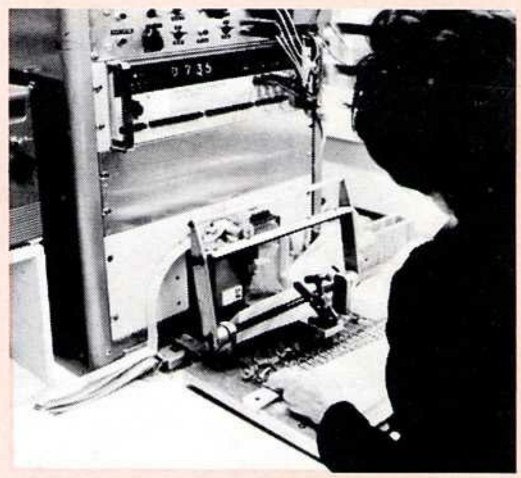
4/79-5M

a brief history of Signalite

Signalite Incorporated was founded in 1951 and for several years manufactured a series of miniature neon glow lamps and other specialty items. With the development of highly automatic production equipment, Signalite soon became the leading supplier of a full range of neon indicator lamps primarily for the appliance industry. In 1961 a new plant and administrative offices were constructed on a ten acre tract in Neptune, New Jersey. Since then there have been three major plant expansions.

During the period from 1961 to 1967, a number of new products were introduced. Circuit component lamps (close tolerance gas discharge tubes) found rapid acceptance as voltage regulators, oscillators, proportional controls and in a large number of other applications.



Today Signalite supplies neon indicator lamps, circuit components, and other components to a vast number of industries including appliances, aircraft and aerospace, communications, entertainment and industrial and defense electronics.

Modern Signalite laboratory test facilities include environmental test equipment for shock, low and high frequency vibration, and temperature and humidity cycling. Computer capabilities include high-speed measurement and analysis of component parameters such as voltage, energy, impedance and firing time.

In 1967, Signalite Incorporated was acquired by the General Instrument Corporation and became the nucleus of the Electro-Optical Products Group. The growth of the Signalite Division continues at a rapid pace.

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