Signalite

APPLICATION NEWS

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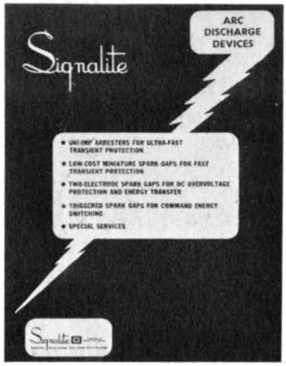


Vol. 11, No. 1

Signalite 1933 Heck Avenue Neptune N J 0775

The first of a two-part series by Mr Bazarian, detailing the most recent information available on Gas Discharge Devices and their application in Transient Voltage Protection, is featured in this issue. In a follow-up two-part series in subsequent issues, the author will discuss Gas Discharge Devices for Electrical Energy Transfer

GAS DISCHARGE DEVICES FOR USE IN TRANSIENT VOLTAGE PROTECTION

By Albert V Bazarian
Manager of Development Engineering
Signalite

As the electronic industry advanced into the age of transistors and integrated circuits, electronic equipment became highly susceptible to damage from electrical transients.

Ordinarily, vacuum tubes have been able to absorb transients and continue to function. Solid state components and integrated circuits, however, are rapidly destroyed by unwanted transients. When the peak value of the transient exceeds the peak inverse voltage rating of the diode or transistor, it will go into the avalanche condition and will instantaneously burn out. The damage caused by unwanted transients extends to all types of components and equipment: meters and motors, relays and resistors, communication equipment and computers—all are susceptible to the effects of transients. The undesirable effects are vast in number and are found in nearly all electronic circuit applications.

Transients may be categorized as appearing from two sources external and internal. Of the externally generated sources, lightning is the most important since it is known to occur often. Other naturally occurring phenomena, such as movement of charged clouds and electrostatic effects, will also cause transient voltages. Direct contact with lines and low frequency induction are other disturbances for which protection may be required (Figure 1).

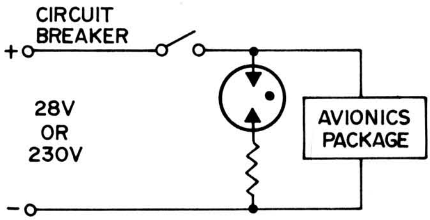


Figure 1
Transient protectors are used in aircraft to protect against lightning or electrostatic charge.

These external sources affect communication lines, such as telephone, telegraph, and CATV, as well as power lines. All antenna installations are prime targets for naturally occurring phenomena. Thus protection must be given to radio, TV, and microwave transmitting and receiving antennas or risk damage from these sources whose voltage pulses normally have very fast rise times, with typical values to 100kV/μs (Figures 2, 3, 4).

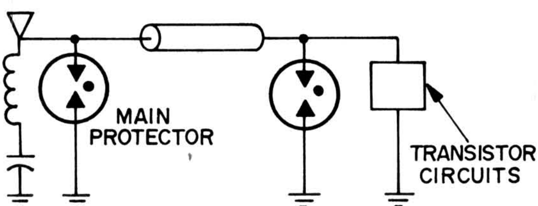


Figure 2
Transient protectors used to protect against lightning or excessive electromagnetic induced voltages.

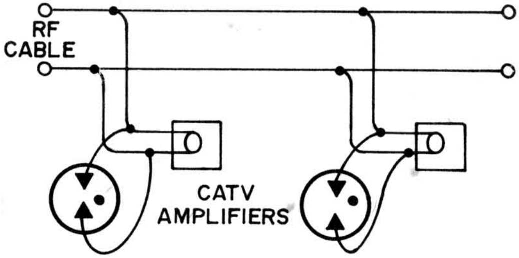


Figure 3
Transient protectors can protect CATV amplifiers against lightning or inductive transients.

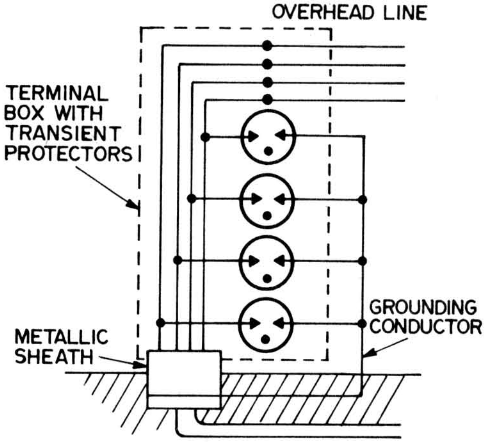


Figure 4
Connection of transient protectors at the transition from overhead communication lines to buried cable.

Internal sources of voltage transients primarily are due to intentional or unintentional switching processes. These may include the normal switching of components in an inductive circuit, or the unintentional failure of a component resulting in a voltage surge in unwanted areas. Examples of these include inductors of any type, motors, generators, relays, solenoids, contactors, electromechanical voltage regulators, spark-over on switch contacts, spark-over on any circuit component, and arcing within TV tubes, vidicons, or power tubes (Figure 5).

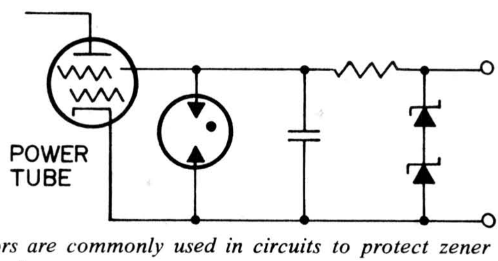


Figure 5
Transient protectors are commonly used in circuits to protect zener diodes against excessive voltage surges

In DC circuits, the source of the transient is due primarily to the characteristics of the load being switched. When switching power to a capacitive load, a current surge may result for the time needed to charge the capacitive component of the load. For an inductive load, if the current is interrupted, a high voltage surge will occur since the inductive component of the load tends to resist any change in current. Voltage and current surges, which are the result of switching of inductive and capacitive loads, are the primary sources of DC current transients. In AC circuits—in which the switching action is not synchronized with the AC potential—varying transients will be generated as the AC potential is applied or removed from across the load (Figure 6, 7).

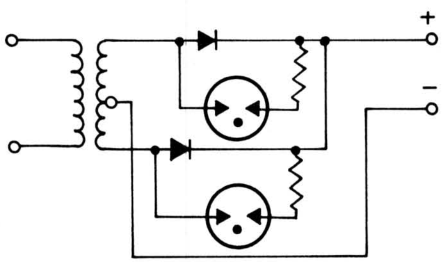


Figure 6
Used across high voltage rectifiers transient protectors guard against high inverse transients.

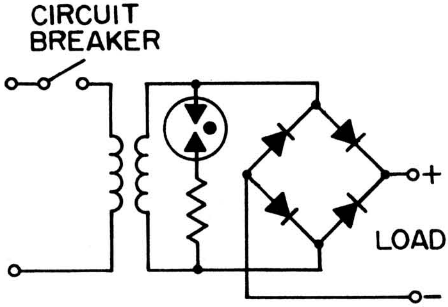


Figure 7
Transient protectors are commonly used across the transformer secondary to prevent line transients from getting in the AC power supply components or load circuits.

Various methods and components have been used to limit these transients to tolerable levels. These include varistors, zeners, and gas discharge devices. Since the most recent advances have been made in gas discharge devices, we will focus on their characteristics as transient voltage protectors, and cite some of their applications. Also we will make some comparisons of the various types of transient suppressors and protectors, indicating suitable applications for each.

VARISTORS AND ZENERS

The application of varistors and zeners as transient protectors has been mostly in the low voltage range not covered by gas discharge devices. Recent developments in varistors have allowed them to be applied as line protectors where the capacitance and leakage currents are not significant. Zeners are used extensively at low voltages (<30 volts) to limit internal transients in transistor circuits. Zeners have been very effective for low voltage and low energy transients which are generated mostly from internal sources.

A varistor is a device which changes in resistance as the applied voltage changes. The voltage-current (v-i) relationship is normally written as $i = KV^{\alpha}$ It is evident from this relation that, as the voltage changes, the resulting current will change more rapidly, depending upon the value of α Typical values of α for varistors made of silicon carbide are 3 5, and for varistors made of metal oxide, values of $\alpha = 25$ have been obtained. For a metal oxide varistor having an alpha of 25, the current will change by 5 orders of magnitude as the voltage changes by 100 volts.

In designing varistors as transient protectors, operation is such that the resistance will change from a high value (under normal voltage conditions) to a very low value for transient voltage conditions. For an alpha of 25, varistor characteristics include a clamping voltage that may be 2 to 4 times the normal operating voltage, effective capacitance of 500 to 1000 pf, and leakage currents in the milliamp region. Since the total energy of the transient must be absorbed by the device, the user must prescribe the maximum transient energy, risking damage from transients having higher-than-rated-values.

A zener utilizes the negative characteristic of a semiconductor diode. When used as a transient protector its usefulness is dependent upon its ability to handle overloads. Higher ratings have been obtained by series parallel arrangements, but at higher cost and high interelectrode capacitance. Since transient magnitudes and durations cannot be predicted accurately, zener protection has been limited mostly to low voltage and energy conditions.

GAS DISCHARGE DEVICES

We can group gas discharge devices into two categories: devices for transient voltage protection, and devices for electrical energy transfer In essence, the technology of materials and gases is similar for both types of devices.

The basic characteristics of gas discharge devices do not allow application in the less than 75-volt region. For voltages above this level, however, gas discharge devices offer nearly ideal characteristics for minimum interference with normal operation and the essential capability for transient protection.

NEW ADVANCES

Several new and significant advances have been made recently by the Signalite Engineering Department in the design of gas discharge transient voltage protectors.

In one family of devices, the Signalite Uni-Imp® Series, protection is offered with unit impulse characteristics. (Figure 8) The unit impulse refers to the ratio of pulse to DC breakdown. It means that the ratio of the pulse breakdown to DC breakdown is unity for ramp speeds even beyond normal measurement capability Some of these devices developed by Signalite have been submitted to government and industrial laboratories for objective testing, and feedback reports indicate that unit impulse characteristics were maintained even for ramp speeds in excess of 100 kV/μs. This design breakthrough has: (1) overcome the statistical and formative time lags that for years had been a barrier to the improvement of gas discharge devices, and (2) re-established the gas discharge device as a widely used type of transient surge protector

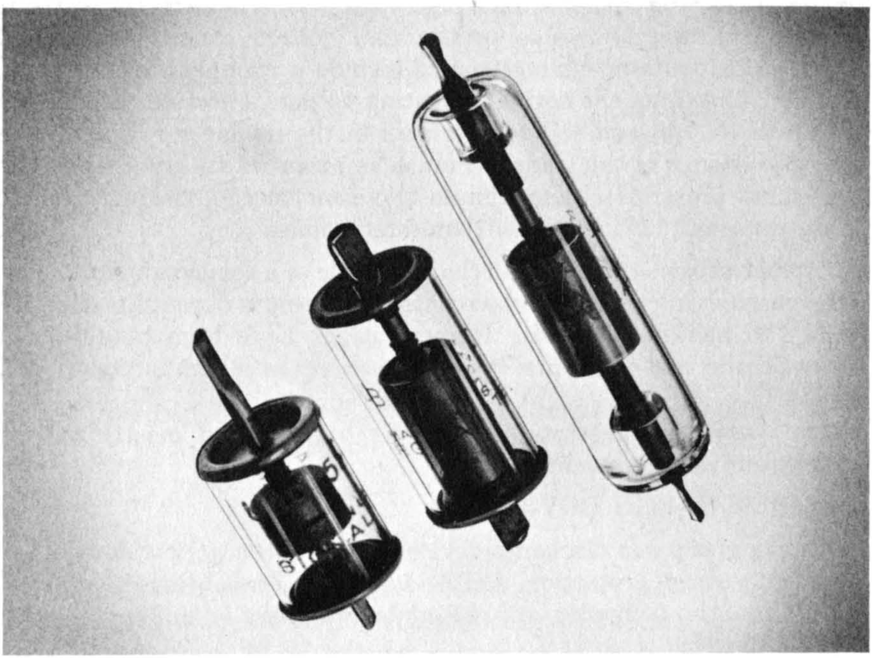


Figure 8
Signalite Uni-Imp® devices.

Another family of devices, the Signalite Comm Gap Series, offers ceramic-to-metal construction at low cost with characteristics that include low interelectrode capacitance (approximately 1 pf) and high hold-off impedance (greater than 10^{10} ohms). (Figure 9). The impulse ratio of this series is approximately 2 to 4, depending upon the rate of rise of the pulse voltage. Thus this Signalite series is particularly suitable for use in RF circuits up to frequencies of several hundred megahertz where capacities of approximately 1.0 pf will not disturb the RF circuit conditions. These devices also are useful in power line circuits for transient protection when used with the proper level of series resistance to prevent follow-on currents.

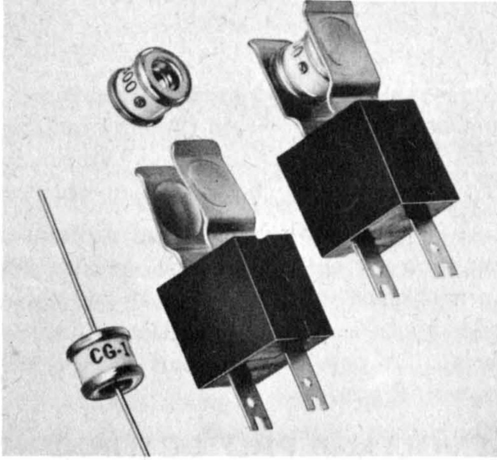


Figure 9
Signalite Comm Gap devices

TRANSIENT PROTECTION DEVICES COMPARED

The V-i characteristic of Figure 10 indicates a very low voltage for arc currents therefore a gas discharge device acts primarily as a voltage switch. In the open condition, the "switch" has these characteristics (1) high voltage hold-off capability, (2) very low leakage, 10^{10} ohms, (3) very low capacitance a few pf, (4) speed of response—a few nanoseconds. After the "switch" closes, we find these characteristics (1) very low arc voltages (20-30 volts), (2) high current capability, and (3) low ratio of device size/transient energy

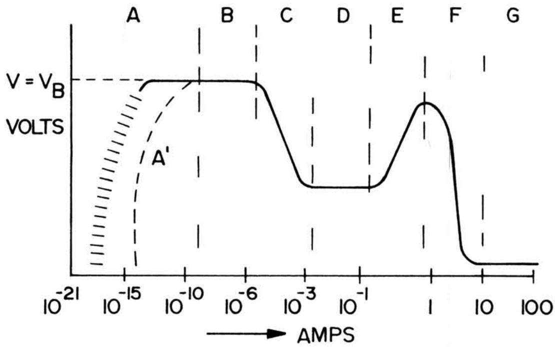


Figure 10
Schematic form of V-i relationship of a gas discharge device.

Because of the switching action of the gas discharge device, the energy dissipated within the device is minimal. The balance of the energy contained in a transient is dissipated in other resistive components of the circuits, including wiring as well as resistive components of inductors and capacitors.

With zener diodes, thyrites, and varistors, however, the energy of the transient must be dissipated within the bulk materials of the surge arrestor The electrical energy is converted to heat and the heating effect is normally destructive to the normal operation of this device.

The very nature of transients is the unpredictable aspect of their magnitude and energy content. The surge arrestor is made with enclosures that can withstand extreme currents and their instantaneous heating without destruction of critical junction or temperature-sensitive crystalline materials. A comparison chart of the various types of protectors is shown in Figure 11.

TRANSIENT VOLTAGE PROTECTOR COMPARISON

Component	Signalite Uni-Imp®	Signalite Comm Gap	Varistors	Zeners
Capacitance (farads)	10^{-11} to 10^{-12}	10^{-12}	10^{-9} to 10^{-10}	10^{-8} to 10^{-9}
Rating	4	4	1	1
Pulse Energy Dissipation (joules)	10^{2} to 10^{3}	10^{2} to 10^{3}	10^{1} to 10^{2}	10^{-2} to 10^{2}
Rating	4	4	3	1
Peak Current Capability (amps)	10^{3} to 10^{4}	10^{3} to 10^{4}	10^{2} to 10^{3}	10^{1} to 10^{2}
Rating	4	4	3	1
Clamping or Impulse Ratio (ratio)	1.0	3.0 to 5.0	2.0 to 4.0	1.0 to 2.0
Rating	4	2	3	4
Standby Drain (amps)	10^{-9} to 10^{-12}	10^{-9} to 10^{-12}	10^{-3} to 10^{-4}	10^{-4} to 10^{-6}
Rating	4	4	1	2
Temperature Range Capability (degrees C.)	-55 to +125	-55 to +125	-40 to +85 50% derating at 100°	-40 to +85 50% derating at 100°
Rating	4	4	2	2
Total Cumulative Rating	24	22	13	11

Rating System — Excellent 4; Good - 3; Fair - 2; Poor - 1.

Clamping Ratio — The ratio of peak suppressed voltage at a given current to the rated steady peak circuit voltage.

Impulse Ratio — The ratio of pulse breakdown voltage for a fast rising wavefront to DC breakdown.

Figure 11
Comparison of various types of transient protectors.

TRANSIENT PROTECTION APPLICATIONS

Gas discharge transient protectors have been designed into a vast number of different types of circuits. The *military* use has been extensive due to the need for enhanced reliability of total system performance. The number of failures of components and circuits has been greatly reduced by eliminating the destructive transients. The *telephone industry* has used gas discharge protectors for protection of terminal equipment and personnel from transient voltages. At one time, carbon blocks, open to air, were the only available type of protective device. Today, the hermetically sealed gas discharge device offers higher reliability to communication equipment and critical control circuits, and this industry relies upon gas discharge transient surge protectors as the most dependable type of protective device available. The *CATV* industry now is using gas discharge devices for transient protection in power lines, as well as for signal line protection.

Any component in an electric circuit having maximum voltage rating may be protected by use of a gas discharge transient surge protector For example: capacitors, inductors, resistors, tubes, and solid state rectifiers may all be protected by connecting a gas discharge surge protector in parallel with the component.

CAN YOU SOLVE THIS ? ?????

ANSWER TO CAN YOU SOLVE THIS: VOL. 10, NO. 1

Gentlemen

I have some comments concerning the problem of power monitoring discussed in page 462 in your Volume 10, No. 1, issue. I would suggest the use of drop out relays for the 3 phase devices, transformers, etc., which would serve several functions. First, upon loss of 3 phase power, they would disconnect 3 phase loads, thus eliminating false power monitor indications due to "autotransformation." Also, they could prevent potential burnouts of 3 phase devices due to partial power delivery Those units with drop out relays would be restored to service by a manual reset button. A delay release relay could be included to decrease the possibility of nuisance dropouts.

Sincerely,

John R. Lincoln
Project Construction Department
University of Vermont

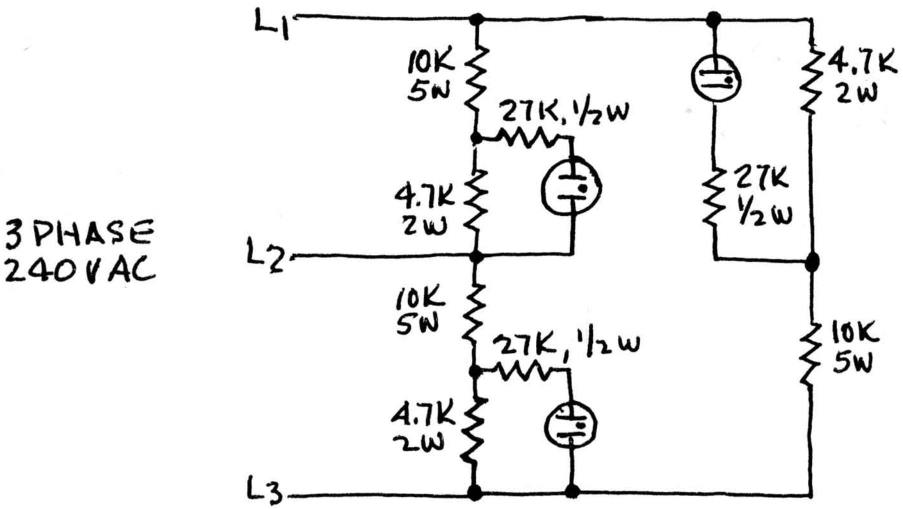
Ed. Note. A reasonable approach to the problem. It would be costly, however, because of the high cost of power controllers.

Gentlemen:

For the 3 phase system supplied on one phase only during emergency operation if line 1 to line 2 is supplied at full voltage then L2-L3 and L1-L2 will be only 50% voltage.

To obtain neon indication of a failure of this nature use a resistance voltage divider so that the neon breakover voltage is close to full voltage. The current in the divider should be high compared to the neon current.

Typical values for a 240 volt system are shown in the diagram.



If lamps do not light, increase value of 4.7K resistors to, say, 6.8K

Note: if 3 phase motors are connected to the system then they will maintain all 3 phases close to full voltage and this system will not work.

G. R. Phillips
Century Electric Co.

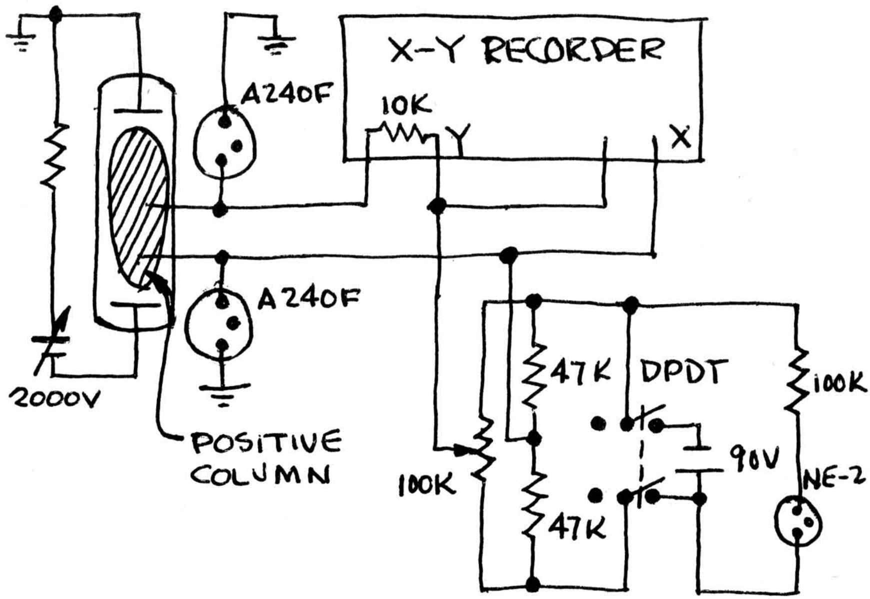
YOUR GLOW LAMP APPLICATION FORUM

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

DOUBLE PROBE CIRCUIT PROTECTION

Dear Sir:

The electron density and the electron temperature in gas discharge is often measured by means of floating double probes. Under certain conditions, when we initiate the discharge, the potential of the probes rises above the normal floating potential (500V) of the X-Y recorder in the measuring circuit. We have used two A240F neon glow lamps to protect the instrument from transient overvoltages and a NE-2 glow lamp as a pilot light to indicate that the 90V battery is in the circuit.



Yours truly,

Raymond Rajotte
Montreal, Canada

CURRENT LIMITING RESISTOR EQUIVALENT

Ed. Note In "A Stabilized Voltage Source Using Neon Glow Lamps for Reference and Protection," Vol. 10, No. 1, a Corning 5K/2W resistor is shown in the circuit on page 461 under the section on current limiting. Mr John Schmidt of TRW, Inc. (IRC) has sent us some IRC resistors for this application which we evaluated and found perform as well as the Corning resistors originally specified.

Drop Us A Line . .

If you have an interesting application of neon glow lamps or spark gaps in your circuitry . or a problem concerning the use of these components, drop us a note telling about it. Interesting letters will be published in a future issue of the *Application News* - and we will send you an Owl Eye Nite Lite for your interest.

Applications which in the opinion of Signalite have significant interest will also be brought to the attention of the editors of leading technical publications for consideration as articles and featurettes. If you would like help in preparing your material for publication, just send us the facts and data; we will put it in the correct form for publication. Your by-line and company credit will be given with your permission.

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

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

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For information about Signalite neon glow lamps, spark gaps, and other gas discharge products for circuit component and/or indicator applications, for specifications on Signalite components, or for general information about Signalite and its products, call us at any of the following telephone numbers:

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