A new approach to surge suppression

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A new type of surge suppression technology, recently introduced by RCA Solid State, has been developed to protect sophisticated electronic circuits from rapid, high-voltage power surges that conventional surge suppressors cannot handle.

This new surge protector, called a Surgoctor, is really a two-in-one device combining two proven components—a zener diode and a thyristor—in a single unit.

Because it combines the continuous voltage protection of the zener with the thyristor's ability to handle high current, the Surgoctor provides instantaneous protection against fast-rising, high voltage pulses—pulses that are too rapid or too powerful for conventional devices such as gas tubes, MOVs, air gap carbon blocks, or stand-alone zener diodes.

As a result, the Surgoctor provides much-needed secondary surge protection for telecommunication circuits, data links, and other sensitive electronic circuits that are especially vulnerable to damage from transient voltage.

A Look at the Problem

The need for a new type of surge suppressor stems from the increasing sophistication of today's electronics. In the telecommunication industry, for example, the trend is toward increasing use of medium scale integrated (MSI) and very large scale integrated (VLSI) circuits. These circuits, used in equipment that transmits, processes, codes, switches, and stores data, have a multifunction capability but are intolerant of voltage overloads.

The most common device used to protect these circuits is the gas discharge tube: air gap carbon blocks are also frequently employed for surge suppression. While these devices can handle extremely high currents, they do not switch rapidly enough to catch the fast-peeking pulses characteristic of lighting, electromagnetic discharges, load changes, commutation spikes, and switching transients. Hence, a secondary surge suppressor—one that reacts quickly enough to catch the fastest pulses—is needed to provide complete continuous protection. And that is where the Surgoctor comes in.

How It Works

The Surgoctor is a Woodward device. It consists of an SCR-type thyristor whose gate region contains a special diffused section that acts as a zener diode. The zener portion of the Surgoctor provides continuous protection of the circuit, just as a stand-alone zener would.

Here's how it works:

The Surgoctor allows normal operation of the circuit as long as the voltage does not exceed a certain maximum value (Voo). RCA currently manufactures Surgoctors rated at 30, 50, 100, and 230 volts.

When a transient pulse hits the line, voltage begins to rise—often at an extremely rapid rate—lighting the SCR, for example, can cause a voltage rise in excess of 1000 volts per microsecond.

A gas tube or carbon block cannot react rapidly enough to block such a pulse, but the Surgoctor can.

As soon as the voltage reaches the avalanche breakdown value, the zener instantly "clamps" the voltage. The voltage can rise above its normal value for the circuit, but only by a small amount, the Surgoctor ensures that the protected circuit never sees a voltage greater than 100 percent of the zener avalanche operating voltage.

This is where the thyristor portion of the Surgoctor comes into play. A normal stand-alone zener diode maintains a constant voltage for the duration of the pulse and can quickly burn out from this energy overload. But in the Surgoctor, current flows from the zener region into the thyristor gate, switching on the thyristor in nanoseconds. The thyristor drops to low voltage, creating a low impedance in the circuit, and shuts the excess energy from the zener region to the ground.

In effect, the thyristor draws energy away from the zener, allowing it to turn on the transient. Because of this, the Surgoctor can handle about ten times more current than a stand-alone zener.

While the transient is on the line, the Surgoctor remains in the ON state, and the voltage across the circuit is low. Its precise value depends on the type of pulse and the type of Surgoctor being used.

Eventually, the pulse passes, and the circuit begins to work. When it reaches a certain minimum value, known as the "holding current," the Surgoctor

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automatically shuts off, and normal circuit operation returns, with the lesser section of the Surgeor again providing continuous protection.

Performance Characteristics

The Surgeor has been thoroughly tested, using a Key-Tek (Huntington, N.Y.) surge tester, for a number of industry-standard pulses. These pulses are usually described by two time intervals: the time it takes for the current to decay to 50% of its peak value, and it takes the pulse to reach peak current. The second number is the time in microseconds that it takes for the current to decay to 10% of its peak value. For example, a 1 x 2 pulse reaches peak current in 1 microsecond, and the current decays to 50% of its peak value in 2 microseconds.

Three of the standard pulses used to rate surge suppression devices today are: 1 x 2, 10 x 200, and 10 x 100. The 1 x 2 pulse is used to simulate fast arcing lightning impulses. A standard value for voltage rise is 15 kV/μs. The 10 x 200 pulse is often specified by the FCC for communications equipment. A 10 x 100 pulse is specified by IEEE and the Rural Electrification Administration for characterization of telephone protection.

Presently, Surgeors offer surge protection against transient surge current of 300 amperes for a 1 x 2 pulse and appropriately scaled currents at 10 x 200 and 10 x 100. These rated surge current can be applied to the Surgeor's repeated, without degradation.

The overvoltage ratio of the Surgeor is the ratio of the highest voltage encountered by the protected circuit (during a 100-μs microsecond pulse) over the rated voltage of the Surgeor. The Surgeor's overvoltage ratio is 1:1. The Surgeor has the lowest overvoltage ratio of any surge suppression technology on the market today, which means it suppresses transient voltage more effectively than gas tubes, MOV's, or each other.

Many surge-suppression devices are characterized by the speed at which they switch on. A gas discharge tube, which gas must diffuse before the device can function, takes microseconds to become operational.

But this specification is meaningless for the Surgeor, because the Surgeor provides instantaneous and continuous protection. The lesser section of the Surgeor always clamps voltage when the voltage reaches a certain minimum voltage for which the device is rated. It is simply impossible for the voltage to exceed a value equal to the breakdown voltage multiplied by the 1.1 microsecond constant unless the device is operated beyond its specification.

Figure 1 illustrates this point. The Surgeor type STG-12, which is rated at 240 volts, clamps the transient voltage as soon as the excess is applied to the load. After the 1.1 microsecond constant, the Surgeor switches on and drops the voltage to just a few volts. The voltage will remain at this low value until the surge gases and the current drops below the holding current.

The gas discharge tube, on the other hand, is designed to operate. By the time it becomes operational, a circuit hit with the 1 kV microsecond pulse sees anywhere from 400 to 1000 volts. Such a voltage is enough to cause damage or destroy the circuit.

As stated, the Surgeor can handle peak currents up to 300 amperes, depending on the type of pulse. Unlike electronic devices, the Surgeor will eventually fail if pushed beyond its specifications. However, the Surgeor is designed not to fail open at a 1 x 2 pulse below 53 kV.

This is an important feature, especially in telecommunications applications. If a device fails open, the circuit remains unprotected until the device is replaced. And open fuses on the line are not easily detected. A short, on the other hand, provides continuous protection against surges, although it prevents operations of the circuits and is easy to locate for repair or replacement.

Aside from failure due to overrating beyond the device's specifications, the Surgeor has no inherent failure modes. Performance is consistent and does not degrade with repeated pulse or time. And there is no inherent limit on the Surgeor's operating life. We predict the Surgeor will have a lifetime comparable to RCA transistors, which last for 20 years or more. In comparison, MOV's and carbon blocks have rated mechanisms.

Surgeors are usually used in conjunction with primary protection devices, and therefore should never see currents exceeding their rated capacities. When operated within their specifications, Surgeors automatically switch to these ODF state once the pulse passes and the current drops below the holding current. The holding current of the Surgeor must be greater than the normally available current in the circuit to ensure that the Surgeor will remain in the ODF state when the transient has passed and allow normal circuit operation.

Design considerations

Here are some factors to consider when designing surge protection into a circuit.

Line voltage

Select a device that will remain in the ODF state under the normal operating voltage of the circuit. Surgeor model STG-12, for example, should not be used with a line voltage above 50 V.

Maximum voltage

Determine the maximum voltage your electronics and devices can handle, then choose surge protection to ensure that the circuit never sees a voltage exceeding this upper limit.

The STG-12 is guaranteed not to exceed 65 volts with a 1000 μs transient. This value is safe up to the full current capability of the Surgeor. All Surgeors are rated for this important characteristic.

Polarity

A line that requires protection from a single polarity can be sufficiently protected with a unidirectional Surgeor. Lines that require protection in both polarities will need a bidirectional Surgeor or a uni- and bidirectional Surgeor in combination with diodes.

Location

The Surgeor should be located near the electronics it is intended to protect. An ideal place is at the front of the circuit board where the input lines enter. By incorporating the Surgeor into the board itself, you take advantage of the ease of repair and replacement inherent in today's modular electronic system design. Also, the inductance at any interconnection limits the current supplied to the Surgeor.

When designing, keep in mind that the impedance through the Surgeor to the ground must be lower than the impedance from the circuit to the ground.

Otherwise, some transient energy may flow through the circuit during a transient impulse.

A major application of the Surgeor is in telecommunications. Surgeors can protect a wide variety of equipment, including telephone handsets, headsets, "intelligent" telephones, FENs, and central office equipment. Here, the Surgeor protects the expensive electronics from damage while ensuring that services are not interrupted by transient voltage.

In a typical telephone application, the Surgeor would be placed between the tip and ring lines. Several different configurations are possible. In the bridge circuit, six diodes and one unidirectional Surgeor are placed between the two lines, right after they enter the telephone. The diodes "steer" the current in the right direction, enabling the single unidirectional Surgeor to handle both positive and negative pulses.

An alternative approach is to replace the bridge circuit with a diode circuit that eliminates the need for diodes. Eliminating the diodes reduces the inductance and lowers the cost of the circuit.

Surgeors can also be used in computer equipment, especially in data communications links. Surgeors both directly into the modem protected with computer memory and the equipment itself. Another use of the Surgeor in a trigger is in the trigger circuit and unidirectional Surgeor with a triac. The unidirectional Surgeor replaces the sum of the triac circuit normally required to trigger a larger SCR.

In addition, the Surgeor's protection, small size, and low cost make them suitable for alarm systems, automobiles, televisions, motion lighting, CATV, and aircraft electronics.
Choosing a technology

The Surgeactor represents a new standard in secondary surge protection. It is the choice of which type of device to use is largely dependent on the requirements of your specific application.

Here are some of the other popular surge protection technologies and how they compare and contrast with the Surgeactor.

Gas discharge tubes

These small, inert gas-filled glass tubes are usually located inside transformers or inside the building. While they are effective on a high voltage, they are vulnerable to damage from high energy surges.

Carbon blocks

Carbon blocks are very popular in outdoor applications, but they are not suitable for use in high-energy environments due to their low thermal conductivity.

Diamonds

Diamonds are used in high-voltage environments, but they are not very effective in lower-voltage applications.

Types Available

RCA manufactures six types of Surgeactors: unidirectional, bidirectional, and SCR.

The unidirectional Surgeactor is designed for use in applications where only one polarity is required. It is available in a range of sizes, from 600 volts to 250,000 volts. The bidirectional Surgeactor is designed for use in applications where both polarities are required. It is available in a range of sizes, from 600 volts to 250,000 volts. The SCR Surgeactor is designed for use in applications where both polarities are required and the voltage can be controlled. It is available in a range of sizes, from 600 volts to 250,000 volts.

Suggested applications include electrical power systems, computers, and telecommunications equipment.

Proven technology

Although the Surgeactor is new, it is based on proven technologies, and it has been manufactured for more than 20 years.

RCA has been manufacturing Surgeactors for more than 20 years. The Surgeactors are manufactured on the same production lines used for the production of transistors. They are available in a variety of types and are compatible with all standard electronic components.

For further information on the Surgeactor, contact John D. Smith, RCA Solid State, Route 202, Somerset, NJ 08873.