Overvoltage Protection for Modems Using Gas Discharge Tubes

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GDTs offer a viable alternative to thyristors for overvoltage protection.

In telecommunication systems, voltage surges caused by lightning or ac power faults can affect sensitive electronics from the main distribution frames to subscriber terminals. Manufacturers are increasingly using overvoltage protection components in telecom equipment such as telephones, fax machines, and modems. These components protect the susceptible devices by shunting the surge currents to ground and by limiting the transient voltages to a safe level.

In modem applications (ADSL, cable boxes, fax machines, etc.), semiconductor thyristors are widely used. Thyristors are marketed under trade names such as SIDACtor (Teccor), Surgector (Littelfuse), TISP (Bourns), Trisil (STMicroelectronics) and SiBar (Raychem). The SIDACtor, which is the most well known of all thyristors in the U.S. market, will be referenced throughout this article. An alternative—but relatively unused—solution for modem overvoltage protection is the gas discharge tube (GDT). This article introduces a GDT and describes the benefits of this new technology for modem applications. Also included is a parametric comparison of common SIDACtors versus comparable specially developed GDTs for modem applications.

Thyristors

A thyristor performs overvoltage protection by acting as a switch, shunting the surge currents to ground from the circuit it protects, while clamping the induced transient voltages. While the voltage across the thyristor is below its Off-state voltage, V_{DRM}, it remains in a high-impedance state. As the voltage approaches V_{DRM}, it exhibits characteristics similar to an avalanche diode.

When the current reaches a value, I_S, the thyristor switches to the On state and conducts current at a voltage of V_T. If the maximum surge current of the thyristor is greatly exceeded, it enters a state of permanent conduction and will not return to its high-impedance Off state. Figure 1 shows the typical current-voltage (I-V) characteristics of the thyristor.

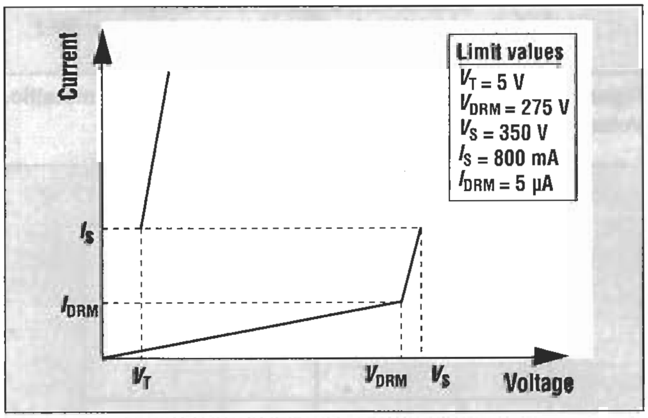

Figure 1. Typical I-V characteristics of the thyristor.

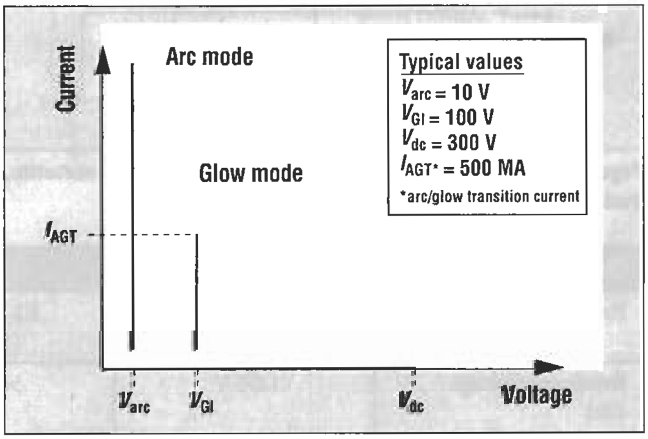

Figure 2. I-V curve of a gas discharge tube.

GDT Solution

The operation of a GDT is very similar to that of a thyristor. GDTs can be compared with symmetrical low-capacitance switches, in which resistance can switch from several gigaohms during normal operation to less than 1 Ω after sparkover caused by a surge voltage. GDTs use the principle of limiting surge voltages by generating an arc of conductive gas in the tube. Transient current flows through the tube and away from the susceptible electronics it protects. The voltage across the sensitive electronics is also limited.

The following provides a synopsis of GDT operation. When the surge voltage exceeds the GDT sparkover voltage, switching occurs either into glow or into arc mode, according to the I-V curve in Figure 2.

If the surge current is above about 500 mA, the GDT will definitely enter into arc mode. Below 500 mA, the arrester can be in either glow or arc mode. In arc mode, the GDT clamps the surge to a constant arc voltage of approximately 10–20 V.

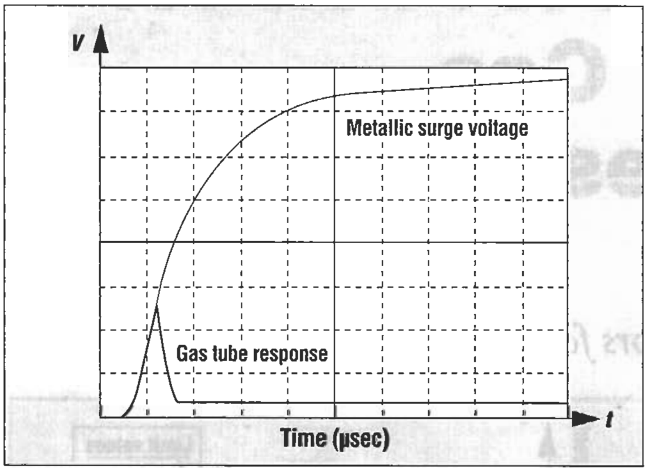

Figure 3. FCC Part 68 Figure 68.302, 1500 V peak, metallic. Voltage-limiting ES300XP: 430 V.

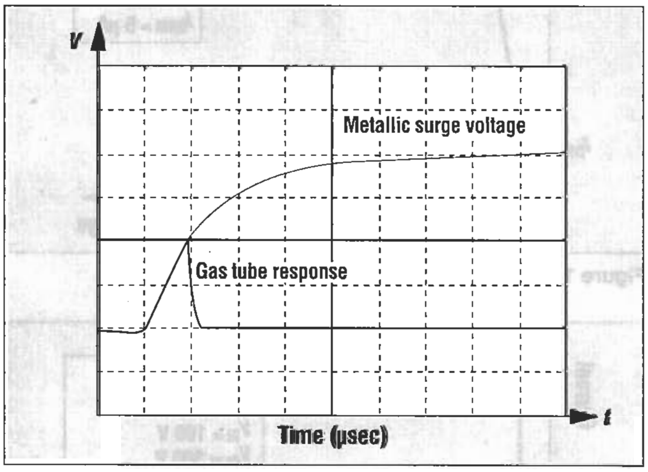

Figure 4. FCC Part 68 Figure 68.302, 800 V peak, metallic. Voltage-limiting ES300XP: 380 V.

In glow mode, the voltage across the GDT is between 50 and 200 V. A GDT can switch from Off state to arc state within a few microseconds. After the voltage across the GDT returns to a steady-state condition, the device returns to its normal high-impedance state.

GDTs for modem protection incorporate optimized activation compound, gas mixture, gas pressure, and ignition aids to minimize rise-time dependency and ensure the lowest sparkover voltage. Typically, modems must meet the surge requirements of TIA/EIA-IS-968 (formerly FCC Part 68) without damage. Figures 3 and 4 show the response of one GDT as a function of two critical TIA/EIA-IS-968 surge type A requirements.

GDT Advantages

There are four key advantages to selecting a GDT solution for modem protection: capacitance, current-handling ability, environmental effects, and susceptibility to high rates of current rise.

Capacitance. With its high insulation resistance (>10 GΩ) and ultralow capacitance (<1 pF), a GDT has virtually no loading effects on the network it protects, so it is the ideal component for high-speed applications. With these typical characteristics, a GDT can support modem data rates up to 2 GHz.

Current-Handling Capability. GDTs also offer increased protection levels with higher surge-current ratings. For example, some GDTs can withstand 2.5 kA, 8/20 microseconds and can provide higher design margins than semiconductor solu-tions. Such robustness is useful in high-voltage-transient applications.

Environmental Effects. GDTs are hermetically sealed devices, and the GDT discharge regions are shielded against any environmental influences. Some GDTs, for example, can operate from –40° to 100°C without any parametric deratings. Semiconductor solutions, such as thyristors, could be derated over temperature changes. As the ambient temperature of the thyristor device changes, parameters such as the switching voltage, holding current, and current handling also change.

Susceptibility to High Rates of Current Rise. Thyristors can be destroyed by unusually high rates of current rise (*di/dt*). GDTs are insensitive in this aspect.

Overvoltage Protection	GDT		SIDACtor	
Parameter	ES-300XP (leaded)	ES-300XN (SMD)	P3100EA (leaded)	P3100SA (SMD)
Breakover Voltage (dc)	>275 V	>275 V	>275 V	>275 V
Maximum Breakdown Voltage (dc)	<350 V	<350 V	<350 V	<350 V
Peak Current (I_{pp})	2500 A (8/20 μsecond)	2500 A (8/20 μsecond)	150 A (8/20 μsecond)	150 A (8/20 μsecond)
Dimensions (nom)	4.6 × 4.7 mm (see drawing)	4.0 × 4.7 mm (see drawing)	4.6 × 4.73 mm (TO-92)	5.59 × 3.94 mm (DO-214AA)
Operating Temperature	–40° to 100°C (no derating)	–40° to 100°C (no derating)	–40° to 85°C (no derating)	–40° to 85°C (no derating)
Capacitance	<1 pF	<1 pF	30 pF	30 pF

Table I. Two common SIDACtors compared with gas discharge tubes.

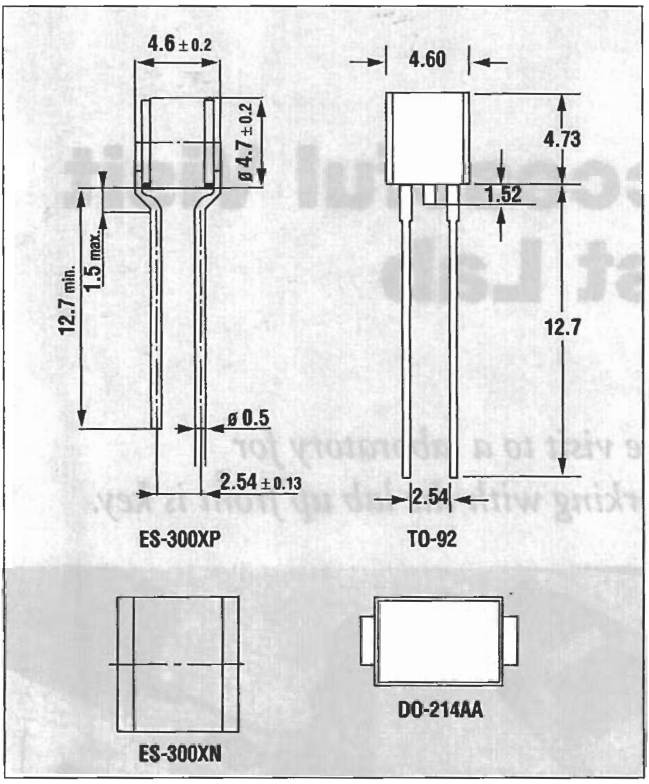

Figure 5. A comparison of the soldering-pad dimensions of leaded and surface-mount gas discharge tubes to the TO-92 and TO-220 SIDACtors. Although taller, the ES-series XN GDT fits exactly into the TO-220 pad dimensions. Measurements are shown in millimeters (mm).

Myths and Misconceptions

This article has highlighted some advantages of GDTs for modem protection. However, some myths and misconceptions impede their widespread use in industry. Some designers are concerned that the reliability of GDTs may be inferior to that of semiconductors. It is important to note that billions of GDTs have been used reliably, over more than three decades. Epcos Inc. (Iselin, NJ) field reliability data show that the failure rate for GDTs are less than 10 parts per million. Extensive service life data prove that GDTs are reliable overvoltage protectors. GDT characteristic parameters do not show major changes in service life tests at 500 surges with a 30-A, 50-microsecond duration or at 10 operations with a 2.5-kA, 8/20-microsecond duration.

Some designers also assume that in telecommunication applications GDTs are primarily used for subscriber or station protection. However, GDTs offer primary protection in main distribution frames (MDFs) and can replace semiconductor solutions in many modem and telecom platforms worldwide.

Yet another misconception is that GDTs are more expensive and large in comparison with semiconductors. However, a wide range of GDTs—including miniature types—are specifically designed to match the sizes and compete with the price points of SIDACtors. For example, some GDTs with the XP version (leaded) and XN version (surface mount) fit the solder pads of the SIDACtors TO-92 and DO-214AA (SMB) precisely—without any modification and also shows the relative sizes of these comparisons. Figure 5 also compares the soldering-pad dimensions of leaded and surface-mount GDTs to the TO-92 and TO-220 SIDACtors. Although taller, the ES-series XN GDT fits exactly into the TO-220 pad dimensions. Table I compares key parameters of two common SIDACtors and two GDTs.

Conclusion

Like the more commonly used thyristors, GDTs protect against voltage surges caused by lightning or ac power faults that can affect sensitive electronics, from main distribution frames to subscriber terminals. GDTs are ideal for high-speed applications. They provide high insulation resistance and ultralow capacitance, so they have virtually no loading effects on the network being protected. They are also robust enough for high-voltage-transient applications. As hermetically sealed devices, GDT discharge regions are shielded against environmental influences and can operate from –40° to 100°C without any parametric deratings. Moreover, GDTs are not susceptible to unusually high rates of current rise.

GDTs have many misconceptions to overcome, but they offer a viable alternative solution for modem overvoltage protection in telecommunication systems.

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