Security And Communication Applications of Thyristor Surge Suppressors

Thyristor Surge Suppressors (TSS) can provide reliable protection for communication equipment and security equipment, which are widely used in modern society. This paper introduces the principles, characteristics and type selection of TSS. Besides, the paper also summarizes the typical applications of TSS in the security and communication industry. Finally, the paper verifies the surge protection performance of TSS through the test data of actual cases.

1. Working Principle of TSS

TSS (Thyristor Surge Suppressors), also known as the semiconductor discharge tube, is a PNPN junction four-layer structure device made by ion implantation technology and glass passivation process. The structure is shown in Figure 1. The volt-ampere characteristics of TSS have typical switching characteristics as shown in Figure 2. It has characteristics such as accurate conduction, fast response, strong surge absorption, high reliability and strong stability. TSS can be applied in parallel in circuits. Under normal working conditions, TSS is in the reverse cut-off state. When the transient over-voltage in the circuit exceeds the break-over voltage Vs, TSS can quickly turn on the discharge current so as to protect the back-end equipment from damages caused by abnormal over-voltage. After the abnormal over-voltage disappears, TSS will return to the off state when the current flowing through TSS is less than the holding current I_H.

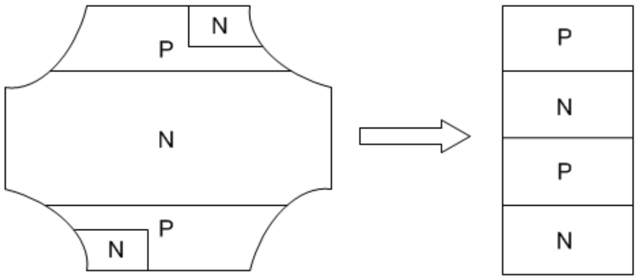

Figure 1. TSS Structure Diagram

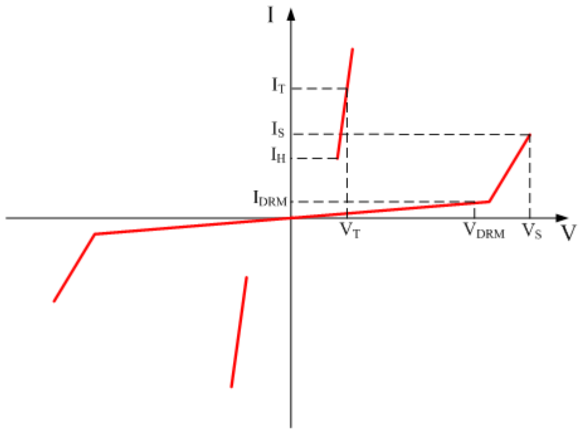

Figure 2.TSS Volt-Ampere Characteristic Curve

2. Switching Characteristics of TSS

TSS is a switching surge protection device. The switching characteristic curve including its positive and negative breakdown slopes is shown in Figure. 3. The switching characteristic curve can be divided into four regions, including an off-state region, a breakdown region, a negative resistance region and an on-state region.

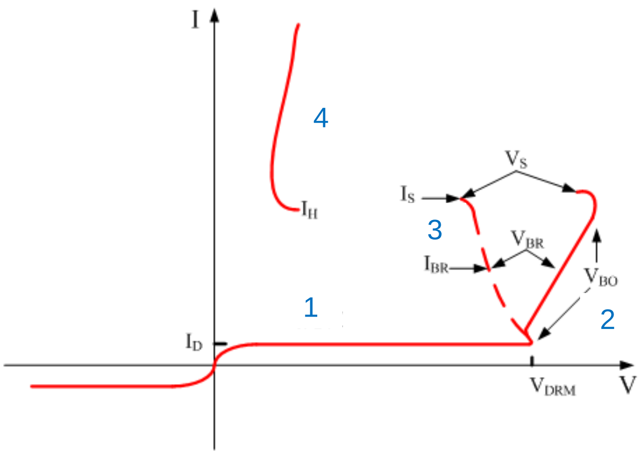

Figure 3. TSS Switching Characteristics Curve

1. off-state region
2. breakdown region
3. negative resistance region
4. on-state region

2.1 Off-State Region

The off-state region is a region with voltage-current characteristics of high resistance and low current. This region extends from the origin to the breakdown starting point. The off-state current is the sum of the junction reverse current and all surface leakage currents. The reverse cut-off voltage V_{DRM} can be added in this region to measure the leakage current I_D of TSS.

2.2 Breakdown Region

The breakdown region is a region with voltage-current characteristics of high resistance and low current. For a TSS with a positive breakdown slope, its characteristics fall in this region. This region covers from the low current part of the high dynamic resistance of the voltage-current characteristics to the significant low dynamic resistance region and the region with a sharp increase in current. Finally, the region terminates when the positive feedback of TSS is sufficient to activate the on-state. Because of the avalanche breakdown activated along with TSS, this region is low resistant. The highest voltage V_S presented in the breakdown region is defined as the break over voltage.

2.3 Negative Resistance Region

The negative resistance region represents the trajectory from the switching point of the breakdown region to the on-state region. For a TSS with a negative breakdown slope, its characteristics fall in this region. In this region, the positive feedback of TSS increases with time, which increases the current, resulting in the voltage drop of both ends of TSS to until it reaches the on-state.

2.4 On-State Region

The on-state region is a region with voltage-current characteristics of low resistance and high current. In the on-state, the current passing through the thyristor with completely positive feedback will produce the lowest voltage drop. The minimum current that just maintains the on-state is defined as the holding current $I_{H.}$ Currents below the holding current will result in the shutdown of TSS.

3. Considerations for TSS Type Selection

3.1 Reverse Cut-off Voltage V_{RWM}

The reverse cut-off voltage of TSS should be greater than the maximum operating voltage or the signal level voltage in the circuit at least.

3.2 Pulse Peak Current I_{PP}

The pulse peak current of TSS should be greater than the maximum surge current that may occur in the circuit or satisfy the specified peak current I_P of the test level.

3.3 Holding Current I_H

The holding current I_H of TSS should be greater than the maximum current of the normal operation in the circuit to prevent TSS from being damaged by follow current.

3.4 Junction Capacitance C_O

The junction capacitance C_O of TSS should meet the rate requirement of the communication circuit to avoid signal distortion caused by excessive junction capacitance.

4.Typical Applications of TSS in Security And Communication

4.1 Application of TSS in CVBS Coaxial Cables

CVBS is a SD analog interface that uses coaxial cables as its composite video signal transmission medium. It is widely used to monitor the video transmission because of its low cost and high reliability. If this interface uses the TVS protection, the signal will be distorted due to excessive junction capacitance. Although GDT’s junction capacitance is low, its residual voltage is much higher than that of TSS. The protection circuit using TSS is shown in Figure 4. TSS selects P0060CA in SMA encapsulation, which can limit the surge voltage of 10/700us +4kV to 78V. The residual voltage waveform is shown in Figure 5. It can also adopt P0080SB-LV1 in SMB encapsulation, which has a lower residual voltage. Its protection level can be up to 6kV.

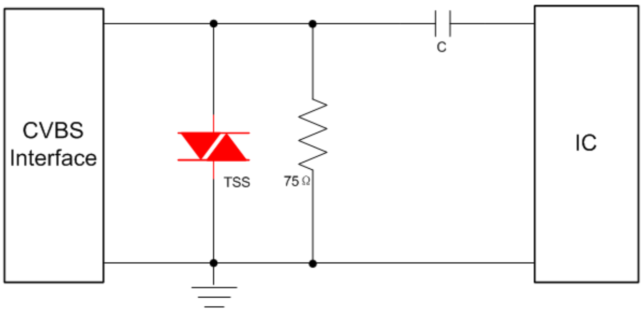

Figure 4. CVBS Protection Circuit

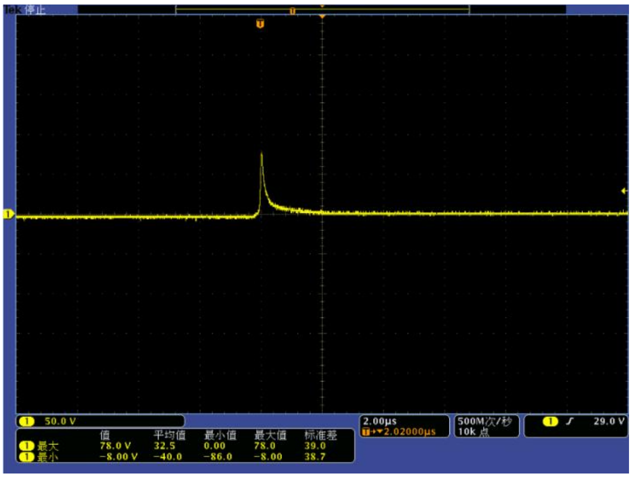

Figure 5. P0060CA +4kv Residual Voltage

4.2 Application of TSS in RS485 Circuits

The RS485 circuits solve the shortcoming of only point-to-point communication in the RS232 circuit. There can be up to 32 nodes connected on the same bus to realize the network communication of one master and multiple slaves. The RS485 circuit is simple and transmits signals in a differential mode. The system only needs to detect the potential difference between two lines. However, it is easy to ignore that the transceiver has a certain common mode voltage range. Only when the common mode voltage requirement of the chip is met can the entire network work properly; when the common mode voltage in the network circuit exceeds the specification, it will affect the stability of the communication and even damage the interface. Therefore, the RS485 interface will generally add differential and common mode protection circuits. As RS485 belongs to the low speed signal, it can adopt the TVS protection or the TSS protection. The residual voltage of the TVS protection is low while the cost is high and the protection level is low. So products above 10V are recommended to reduce the packet loss r caused by leakage; the residual voltage of the TSS protection is relatively high but its cost is low.

The protection level can reach 8kV. The protection circuit using TSS is shown in Figure 6. The TSS protection selects P0060CA so that it can protect against the surge of 10/700us 4kV, while P0080SB-LV1 can protect against the surge of 10/700us 6kV and limit the surge voltage to 30.4V. The residual voltage waveform is shown in Figure 7.

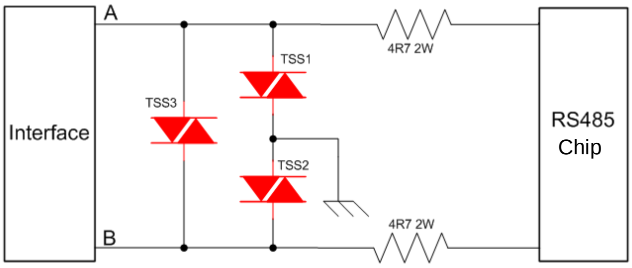

Figure 6. RS485 Protection Circuit

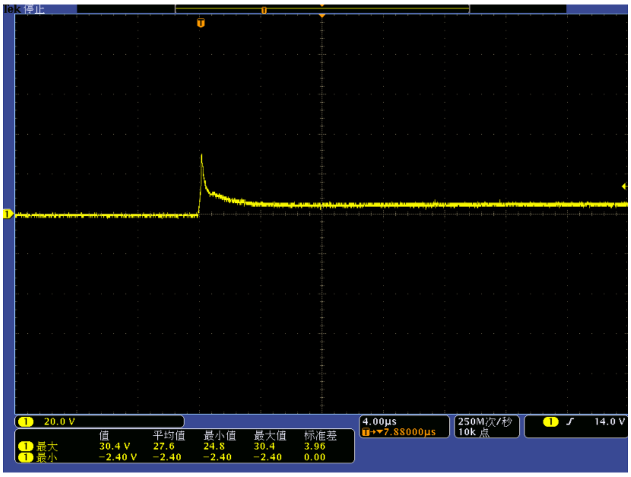

Figure 7. P0080SB-LV1 +6kv Residual Voltage

4.3 Application of TSS in ADSL Circuits

ADSL is a kind of asymmetric digital subscriber lines. It divides the path into low frequency (that is, the original telephone path), uplink (that is, the path from the user end to the local office. The rate can reach 144 kb/s or 384 kb/s) and downlink (that is, the path from the local office to the user end. The rate can reach 2 Mb/s, 4Mb/s, 6 Mb/s. The latest results can reach 8 Mb/s or even 10 Mb/s) through the frequency division multiplexing method. The transmission distance can be up to 5 .5 km. Long-distance communication can sense the surge voltage easily. Therefore, the protection design generally considers the power line connection. If the GDT protection is used, the residual voltage and the cost are high. It is necessary to add a secondary protection circuit. If the TSS protection is used, its residual voltage is lower than that of the GDT protection, the encapsulation is small and the cost is low. The protection circuit is shown in Figure 8. P3500SB using 350V can limit the surge voltage of 10/700us 4kV to 372V. The residual voltage waveform is shown in Figure 9.

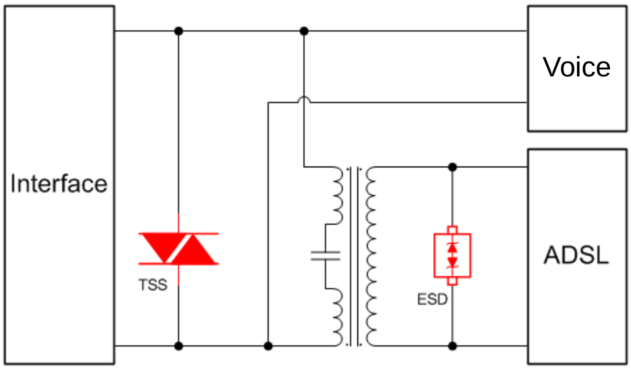

Figure 8. ADSL Protection Circuit

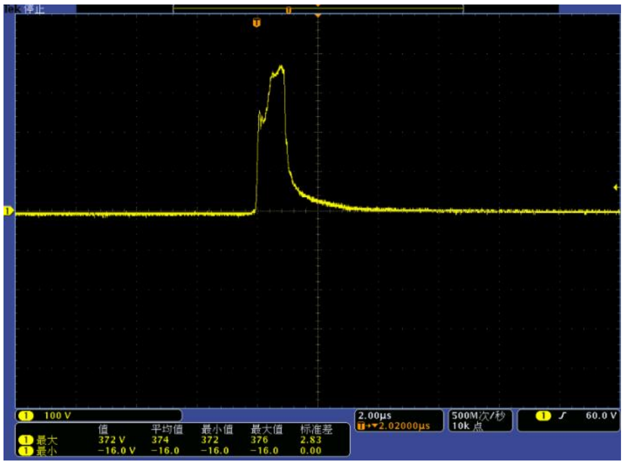

Figure 9. P3500SB +4kv Residual Voltage

4.4 Application of TSS in SLIC Circuits

SLIC two-line analog telephone interface has the function to send power and audio signals to the telephone connected through two lines. It can receive audio signals from the telephone as well. Generally, the programmable TSS device P61089B is used for the protection design, which can meet the surge impact of 10/700us 1.5kV. If users need a higher protection level, it is necessary to add GDT to the front-end of TSS as the first big surge discharge. The protection circuit only using P61089B is shown in Figure 10. The measured residual voltage of 10/700us 1.5kV is about 274.9V, as shown in Figure 11.

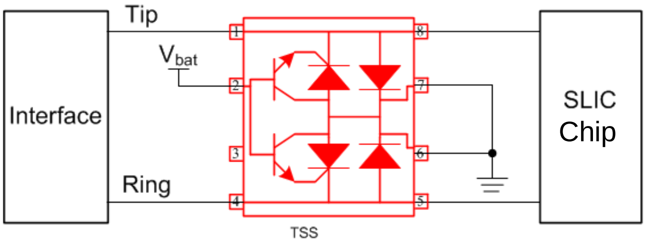

Figure 10. SLIC Protection Circuit

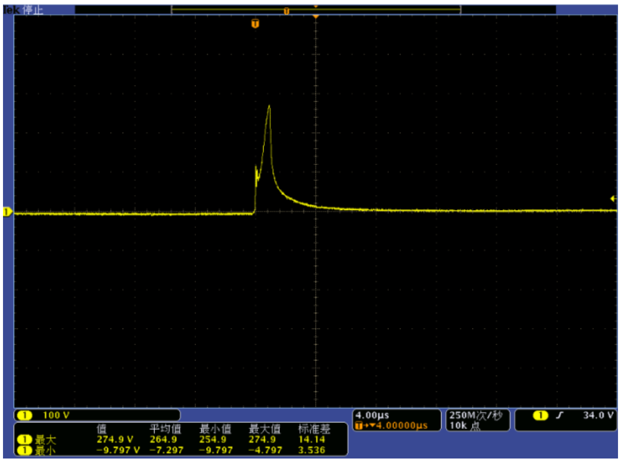

Figure 11. P61089B +1.5kv Residual Voltage

5. Conclusion

TSS is widely used for the protection of security and communication interfaces because of its accurate conduction, fast response, strong surge absorption capability, high reliability, high stability and low junction capacitance. From the protection cases above, it can be seen that TSS has excellent characteristics in restricting voltage, which truly realizes great use with a small size at low cost. It is the best protection means for security and communication interfaces.