AND8022/D

TSPD (Thyristor Surge Protection Devices)

Telecom Circuit Protection Using ON Semiconductor Protection Devices

ON Semiconductor®

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APPLICATION NOTE

Overview

Today's increasingly complex telecommunication systems, many using high density ASIC's are allowing telecommunications equipment manufacturers to continually improve services and support more lines in tighter spaces with smaller packages.

However, these systems are more susceptible than ever to overvoltage and overcurrent transients. Solid state Subscriber Line Interface Circuit (SLIC) devices, and high speed Digital Subscriber Line (DSL) IC's are located on the telecom "linecard" and require secondary protection to provide reliable operation, prevent costly service interruptions, allow safe operation, and achieve regulatory compliance.

The ON Semiconductor NP series of circuit protectors are used in the secondary overvoltage protection block. Circuits are first protected by primary protection which is usually located at or near the building entrance, known as the Main Distribution Frame (MDF). Primary protectors are generally Gas Discharge Tube (GDT) or Carbon Blocks. The primary protectors limit the very high energy transients, and the secondary protectors limit the voltage and current to acceptable levels and are incorporated on the telecom linecard itself. While there are other types of overvoltage protectors, such as Metal Oxide Varistor (MOV) and Gas Discharge Tube, the TSPD offers unique advantages, making them the preferred choice for Telecom Circuit protection applications.

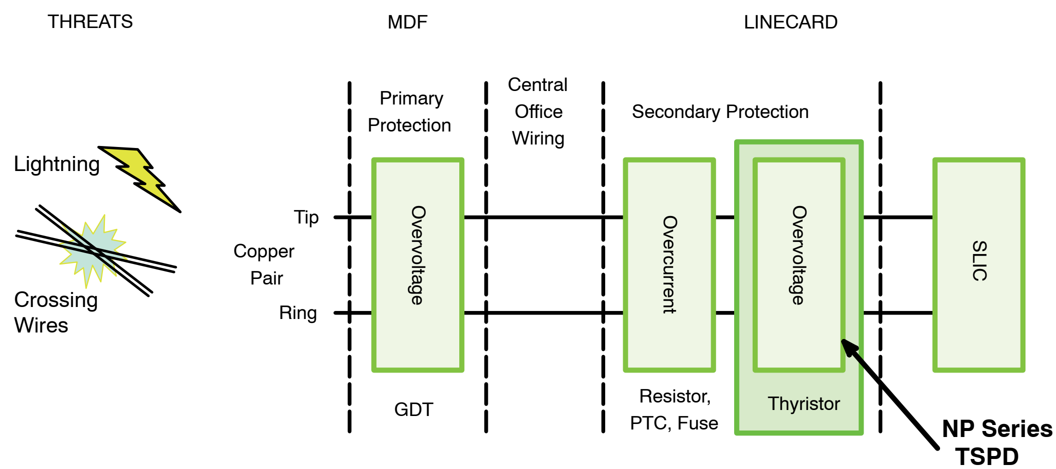

Figure 1. Typical Protection Design

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THREATS

Transients are short−lived events in which an overvoltage or overcurrent condition occurs. In telecommunication equipment, these transients include lightning and AC Power Fault or induction.

Lightning

Lightning is the most common cause of transients in telecommunications systems. Equivalent circuits have been developed to simulate a lightning strike event. There are two types of tests performed to evaluate a telecommunication system's ability to withstand lightning strikes. These are Transverse (between Tip or Ring to ground individually) and Longitudinal (Tip and Ring to ground simultaneously). These Surge tests are defined by an peak open circuit voltage and peak short circuit current, along with maximum rise and minimum decay times.

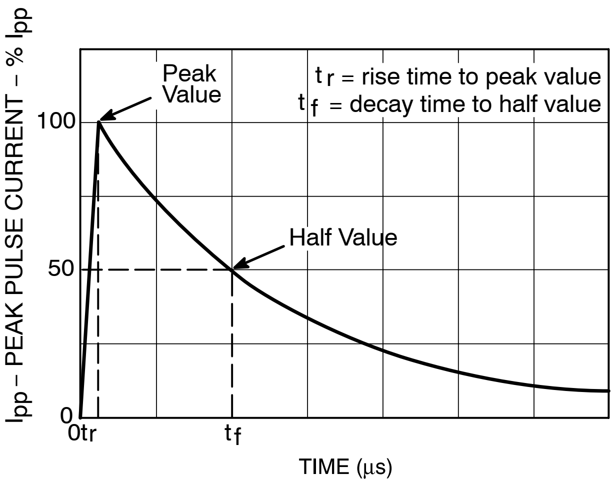

Figure 2. Exponential Decay Pulse Waveform

Power Fault, Power Induction

Power Fault or Power Cross occurs when AC power lines come in close proximity of, or even contact the telecom lines. Power cross events occur when a power line falls on a telephone line on a utility pole, or with maintenance errors or cabling faults. The resulting transient can result in moderate currents of less than 25 A flowing for a long period of time, up to 15 minutes as an example. They are usually at mains power supply voltage levels of 100−240 Vrms.

Power induction is caused by faults which couple into the system. These are typically short duration, high voltage AC transients. These are a few cycles of AC to several seconds in duration and at voltages up to 600 Vrms.

STANDARDS

Telecommunication standards and recommendations have been developed to help engineers design circuits and protection schemes to provide greater reliability, safe operation, and cost effective systems. These tests are used to verify a system's ability to safely withstand and protect a circuit from the transients caused by lightning and power cross threats. The most common test standards are highlighted below.

Standard	Application	Primary Region
GR−1089−CORE	Central Office/Access	USA
K.20	Central Office	International
K.21	Customer Premises	International
K.45	Trunk Networks	International
TIA−968/UL60950	Customer Premises	USA

The following tables (tables 1−4) are grouped by lightning surge and powercross. They are also separated by first and second level test definitions. Under first level conditions the device must be undamaged and continue to operate after the stress is removed. Under second level conditions the device can fail, but must fail in a safe manner.

Lightning Surge Tests

Table 1. First Level − Parts Must Continue to Function

Test	Surge Voltage (V)	Surge Current (A)	Waveform	Repetitions Each Polarity
Telecordia GR−1089−CORE				
Test 1	600	100	10x1000 μs	25
Test 2	1000	100	10x360 μs	25
Test 3	1000	100	10x1000 μs	25
Test 4	2500	500	2x10 μs	10
ITU−T K.2/K.21/K.45				
Basic Level Test 1	1500	37.5A	10x700 μs	5
Test 2*	4000	100A	10x700 μs	5
Enhanced Level Test 1	1500	37.5	10x700 μs	5
Test 2*	6000	150	10x700 μs	5
TIA−968−A				
Test 1	1500	37.5	9x720 μs	2
Test 2	1000	25	9x720 μs	2

*Primary Protector Included in Test Circuit

Table 2. Second Level − Parts Can Fail Safe

Test	Surge Voltage (V)	Surge Current (A)	Waveform	Repetitions Each Polarity
Telecordia GR−1089−CORE				
Test 1	5000	500	2x10 μs	1
TIA−968−A				
Test 1	1500	200	10x160 μs	2
Test 2*	4000	100	10x700 μs	5

*Primary Protector Included in Test Circuit

Power Cross Tests

Table 3. First Level – Parts Must Continue to Function

Test	Open Circuit Voltage (V)	Short Circuit Current (A)	Duration(s)
Telecordia GR−1089−CORE			
Test 1	50	0.33	900
Test 2	100	0.17	900
Test 3	600	1	1
Test 4	1000*	1	1
Test 6	600	0.5	30
Test 7	440	2.2	2
Test 8	600	3	1.1
Test 9	1000*	5	0.4
ITU−T K.2/K.21/K.45			
Basic Level Test 1	600	1	0.2
Test 2	600*	1	1
Enhanced Level Test 1	600	1	0.2
Test 2	1500*	2.24 – 7.5	0.18 – 2
Test 3	230	1.44, 0.77, 0.38	900

*Primary Protector Included in Test Circuit

Table 4. Second Level – Parts Can Fail Safe

Test	Open Circuit Voltage (V)	Short Circuit Current (A)	Duration(s)
Telecordia GR−1089−CORE			
Test 1	277	25	900
Test 2	600	60	5
Test 3	600	7	5
Test 4	600	2.2	900
ITU−T K.2/K.21/K.45			
Basic Level Test 1	230	0.23 – 23	900
Enhanced Level Test 1	230	2.9 – 23	900

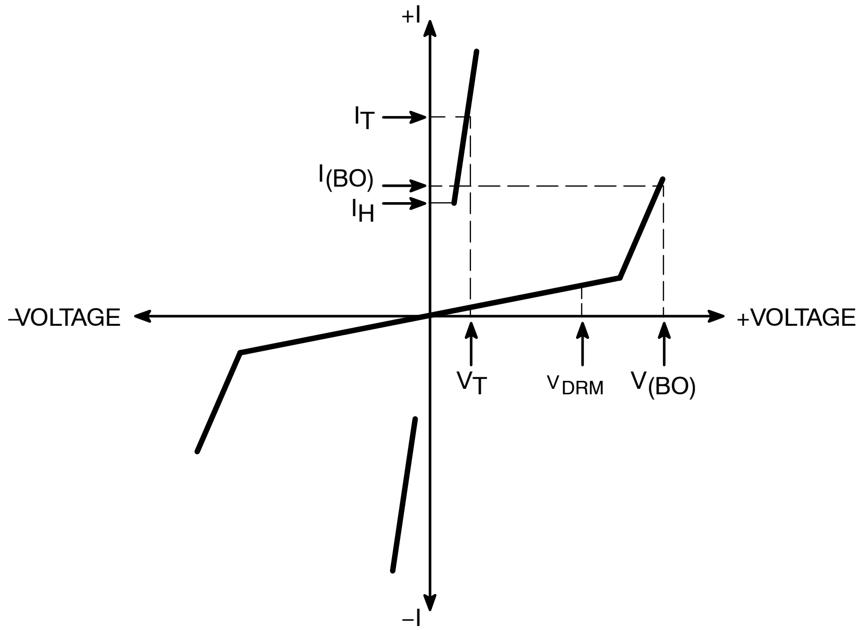

Figure 3. TSPD Operation

Table 5. Voltage Current Characteristics and Definitions

Symbol	Title	Description
$V_{(BO)}$	Max Breakover Voltage	The maximum voltage across the device in or at breakdown measured under a specified voltage and current rate of rise.
$I_{(BO)}$	Breakover Current	The instantaneous current flowing at the breakover voltage (V_{BO}).
I_H	Holding Current	The minimum current required to maintain the device in the on−state.
I_T	On−State Current	The current through the device in the on−state condition.
V_T	On−State Voltage	The voltage across the device in the on−state condition at a specified current (I_T).
V_{DRM}	Rated Repetitive Peak Off−State Voltage	Rated maximum (peak) continuous voltage that may be applied in the off−state condition.
I_{DRM}	Repetitive Peak Off−State Current	The maximum (peak) value of the current that results from the application of (V_{DRM}).

FUNCTIONALLY

The TSPD has two modes of operation:

Open Circuit − Transparent:

It must remain transparent during normal circuit operation. This is achieved by the very small leakage current (<5 μA) when the device is in its' off state. The device looks like an open across the two wire line.

Short Circuit − Protection:

When a transient exceeds the device V_{DRM} , the device switches on, and shorts the transient current to ground, safely protecting the circuit. Once the fault is removed the device must switch back to it's original open circuit condition allowing normal operation to resume.

DEVICE SELECTION

When selecting a TSPD use the following key selection parameters.

Off−State Voltage V_{DRM}

Choose a TSPD that has an Off−State Voltage greater than the normal system operating voltage. The protector should not operate under these conditions:

Example:

Vbat = 48 Vmax

Vring = 150 Vrms = 150*1.414 = 212 V peak

V_{DRM} should be greater than the peak value of these two components:

V_{DRM} > 212 + 48 = 260 V_{DRM}

Breakover Voltage $V_{(BO)}$

Verify that the TSPD Breakover Voltage is a value less than the peak voltage rating of the circuit it is protecting.

Example: Relay breakdown voltage, SLIC maximum voltage, or coupling capacitor maximum rated voltage.

Peak Pulse Current Ipps

Choose a Peak Pulse current value which will exceed the anticipated surge currents in testing. In some cases the 100 A "C" series device may be needed when little or no series resistance is used. When a series current limiter is used in the circuit a lower current level of "A" or "B" may be used. To determine the peak current divide the maximum surge current by the series resistance.

Hold Current (I_H)

The Hold Current must be greater than the maximum system generated current. If it is not then the TSPD will remain in a shorted condition, even after a transient event has passed.

TSPD Compared to Other Overvoltage Protection Devices GDT's and MOV's

Gas Discharge Tube (GDT)

The GDT has a sealed construction with two terminals and inside two electrodes with a small gap between. In this small volume, is trapped a gas with a specific ionization level, therefore, when a voltage transient occurs the ionized gas serves as a current path. The following plot shows the typical operation behavior of a GDT (V−I characteristics):

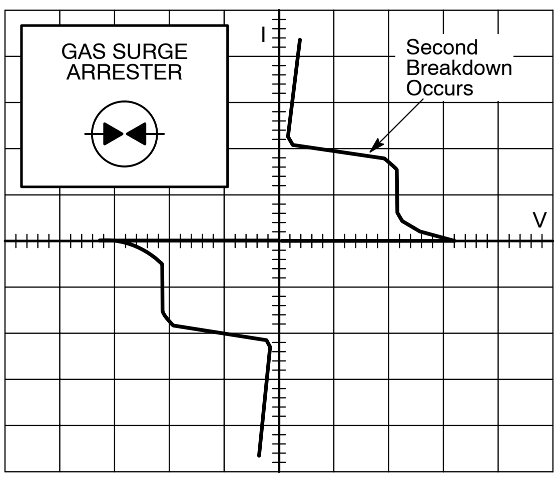

Figure 4.

In this plot, it is possible to observe that the GDT's response is relatively slow, and sometimes this factor could be very critical for telecom applications in which fast response is needed. In addition, as a result of this slow response, some gas tubes' electrodes burn out after a few hundred hits.

Metal Oxide Varistor (MOV)

These solid state devices are in essence two Zener Diodes with the cathodes tied together and the voltage limitation is dependent of the Zener voltage of each Zener diode. In these devices the power dissipation is very high. The following plot shows the typical operation behavior of a MOV (V−I characteristics):

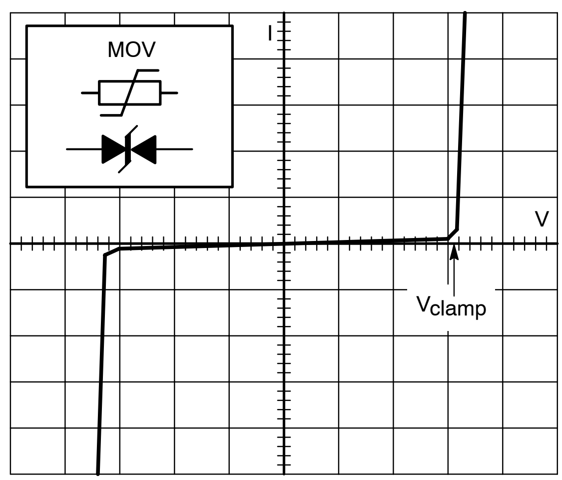

Figure 5.

When an MOV reaches its Zener voltage, it starts to dissipate power, so this is why, if a high transient voltage occurs, the MOV may be damaged because of the high power dissipation that this transient may cause. At the same time, it is very common that the MOV becomes degraded each time it is activated.

Thyristor TSPD Applications

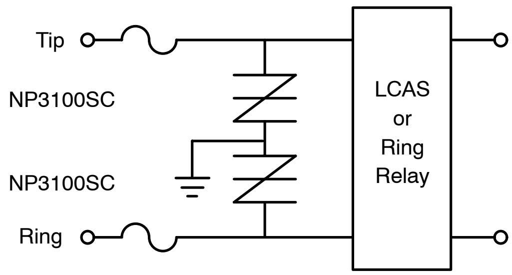

Figure 6. Central Office POTS Card

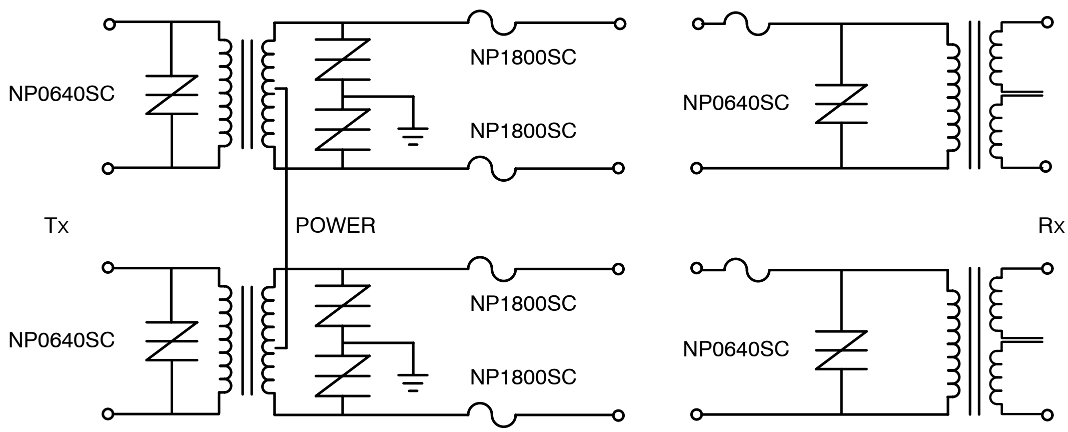

Figure 7. T1/E1

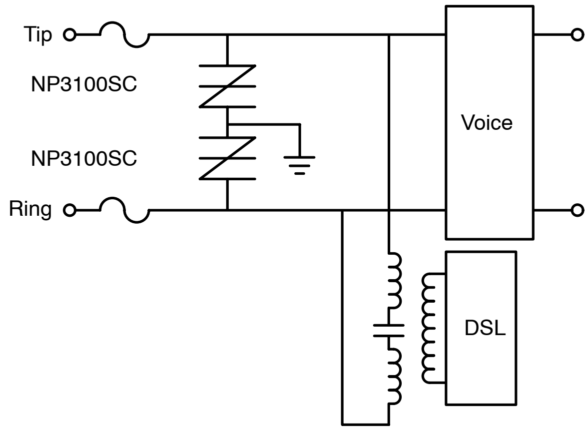

Figure 8. ADSL

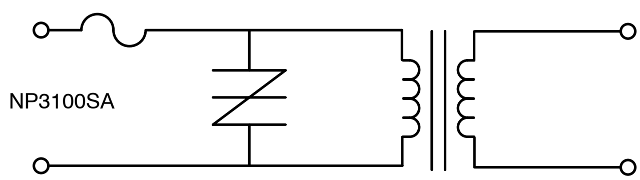

Figure 9. Customer Premise Equipment – Fax, Modem, PBX

PUBLICATION ORDERING INFORMATION

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