Solid State Relay metallic On-State Surge Performance (Appnote 69)

Introduction

Whether designing telephones, modems, PBX or central office equipment, protecting telecom equipment from lightning surges is a prime consideration. Vishay designs their solid state relays (SSRs) to survive repeated lightning surges by building current-limit circuitry into most of their Form A SSRs.

A current-limited SSR restricts surge current flow thereby preserving SSR integrity even after repetitive exposure to lightning fault conditions. Current limiting in Form A SSRs is ideal for protection against surge conditions; however, many Form B or Form C configurations are used in telecom applications as well. This technical note presents a comprehensive evaluation of the metallic on-state surge capability of the entire LH1500 family of SSR devices.

Surge Capability

Surge capability is a function of the SSR's switch silicon area, current-limit value, and turn-on speed. SSRs with larger DMOS switches and lower current-limit values will surge the best. Turn-on speed is also important because the current-limit circuit shuts the SSR off during the first part of the lightning wave where the impulse power is the greatest. Vishay designs slow turn-on times into their SSRs so that the SSRs remain off during the worst part of the impulse wave. Turn-on speed is dependent upon the LED forward current value. A large LED drive current will turn the SSR on faster than desired for lightning surge conditions. We recommend no more than 4 mA to 5 mA of LED forward drive current for large applications.

Surge Waveforms

Two surge waveforms were evaluated.

An 800 V, 10 x 560 μs waveform is specified in the United States by the FCC.

A 10 x 560 µs pulse refers to a double-exponential unipolar impulse wave that rises to full-rated voltage in 10 µs and decays to half of the rated voltage in 560 µs.

A 1000 V, 10 x 1000 µs waveform is called out by the REA and Bellcore for central office equipment in the United States and by the CSA for telecom equipment in Canada. The surge results from the 10 x 1000 waveform could also be applied to the European 1000 V, 10 x 700 μs CCITT standard.

Surge Configurations

Eleven surge configurations were evaluated. For subscriber telephone equipment, four wiring configurations were explored. The first uses a solid-state crowbar type protector directly across tip and ring to protect the equipment from voltage transients. This provides the best protection because the crowbar action shunts metallic surge currents between tip and ring sparing the station equipment.

The second configuration places an MOV directly across the SSR contacts. In this configuration, a properly selected MOV ensures that the transient voltage across the SSR never exceeds its breakdown voltage. This is an important consideration when using an inductive load. An inductor can generate a voltage spike under surge conditions that could potentially damage the SSR. The third configuration uses a resistive load. Here an MOV placed between tip and ring would be adequate.

The last configuration places the MOV between the tip and ring and uses an inductive load. This configuration is not recommended, but unfortunately is prevalent in many designs. It is evaluated here for informational purposes only.

For central office and PBX equipment, three wiring configurations were explored. First, a solid-state protector placed tip to ring was evaluated. This is perhaps the most common configuration for central office design. The other two configurations use MOV overvoltage protection and an in-line current-limiting resistor. This resistor is often placed in the tip and ring leads in central office designs. For this study, only one in-line resistor was used. This assumes worst case, wherein the metallic surge will terminate to ground. Two values were used: 80 Ω, which is common in the United States and 20 Ω, which is common in Europe. Note that for both of these conditions, no load impedance is used in order to illustrate worst-case surge conditions. Any load impedance contributed by the line card electronics could greatly assist the SSR by absorbing some of the power dissipation from the surge.

Surge Tests

Figures 1 and 2 portray the test setup conditions. All of the tests simulate metallic (differential) surge stresses with the SSRs in their on-state. With regards

to an SSR in these telecom applications, a longitudinal (common mode) stress only exercises the input-to-output isolation of the SSR and is of little interest.

The SSRs were subjected to the most severe surge conditions. Little or no series resistance and very low load impedance values were used for these evaluations. For instance, FCC and Canadian test were all performed with absolutely zero series resistance. This would simulate a lightning induction directly at the station equipment.
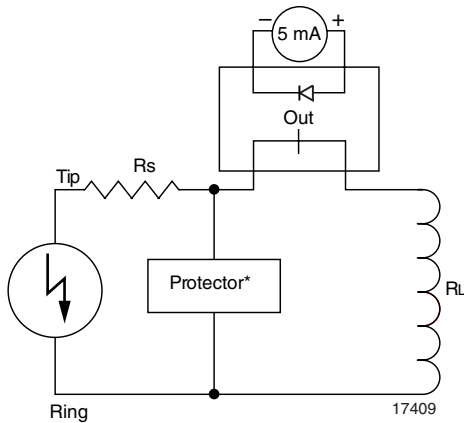

Figure 1. Test setup with protector across tip to ring

Furthermore, the dc load used for these tests was only 50 W to 60 W. In many applications, this load impedance will be much higher. By far, most lightning surges are not as severe as those listed in the various surge test standards. Furthermore, these tests were performed with the SSRs biased on. SSRs in their normally off-state will survive all of the harsh stresses evaluated in this study.
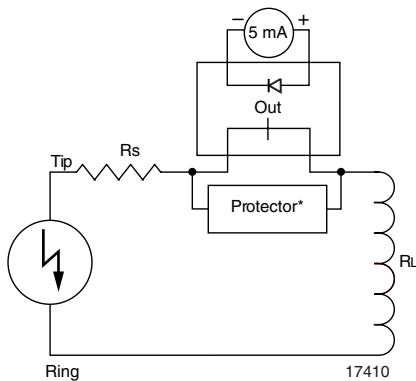

Figure 2. Test setup with protector across SSR contacts

*Protectors

	MOV: Vishay and Matsushita	MOV: Harris	Solid State: SGS Thompson
	or equivalent		
for 150 V SSR	SIOV-S14K50	V82ZA12	-
for 200 V SSR	SIOV-S14K75	V120ZA6	TPB150A
for 250 V SSR	SIOV-S14K95	V150ZA8	TPB200B
for 350 V SSR	SIOV-S14K150	V150LA20	TPB270A
for 400 V SSR	SIOV-S14K150	V150LA20	TPB270A

Conclusion

The results of the surge stress applications are shown in Table 1 which shows which SSR to use for a given application. For best performance under surge conditions, using a solid-state crowbar protector or an MOV directly across the SSR contacts is highly recommended. For applications using a solid state crowbar protector, any Form A or Form B SSR can be used. For applications using an MOV directly across the SSR contacts, use a Form A SSR like the 250 V LH1505, LH1518. The most popular SSR for FCC 68.302 applications is the 350 V LH1500 or the more robust LH1540 Form A SSR.

Form A, I_F =5 µA Form B, I_F = 0	800 V, 10 x 560 µs, 100 A, Subscriber Telephone Equipment FCC 68.302				1000 V, 10 x 1000 µs, 50 A Subscriber Telephone Equipment CSA CS-03 2.1.2 (also applicable) 1000 V 10 x 700 µs, 40 A CCITT K.20				1000 V, 10 x 1000 µs, 100 A, Central Office and PBX Equipment Bellcore LSSGR 15.2 REA		
On-State Metallic Surge	Solid State Protector T-R	MOV Across Contacts	MOV T-R Resistive Load	MOV T-R Inductive Load	Solid State Protector T-R	MOV Across Contacts	MOV T-R Resistive Load	MOV T-R Inductive Load	Solid State Protector T-R	MOV T-R	MOV T-R
R_S (Ω)	0	0	0	0	0	0	0	0	0	≥ 80	≥ 20
R_L (Ω)	0	—	≥ 50	—	0	—	≥ 50	—	0	0	0
R_L*(Ω)	≥ 58	≥ 58	—	≥ 58	≥ 58	≥ 58	—	≥ 58	0	0	0
See Figure	1	2	1	1	1	2	1	1	1	1	1
LH1500	√	√	√	S	√	S,O	S,O	S	√	S,O	S,O
LH1501	√	S	S	S	√	S	S	S	√	S	O
LH1502 A/B	√	√/S	√/S	S	√	S	√/S	S	3√	√/S	√/O
LH1503	√	√	√	S	√	S,O	√	S	√	√	NR
LH1505	√	√	√	S,O	√	√	√	S,O	√	√	√
LH1510	√	√	√	S,O	√	NR	√	S	√	√	S
LH1511	√	S	S	S	√	S	S	S	√	S	S
LH1512 A/B	√	√/S	√/S	S, O/S	√	NR/S	√/S	S	√	√/S	S/S
LH1513	√	√	√	S	√	S,O	√	S	√	NR	S,O
LH1518	√	√	√	S,O	√	√	√	S,O	√	√	√
LH1520	√	√	√	S	√	S,O	NR	S	√	S,O	S,O
LH1521	√	S	S	S	√	S	S,O	S	√	S	O
LH1522	√	√	√	S,O	√	NR	√	S	√	√	S
LH1523	√	S	S	S	√	S	S	S	√	S	S
LH1532	√	√	√	NR	√	NR	√	S,O	√	√	S
LH1540	√	√	√	NR	√	NR	√	S,O	√	√	S

Legend:

√ = relay survives repetitive surges

S = relay shorts or always on

O = relay opens

NR = not recommended, most relays will operate but possibility for SSR damage exists.

* Inductive load. AT&T 2746B transformer primary.