Electronic Design & Research, Inc.

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Protection of a Solid-State Device

Nowadays more frequently a Solid-State Relay (SSR) is replacing a commonly used an electromechanically relays (EMR). A much longer, trouble-free SSS operation is a common cited advantage over an EMR device. That is true if a protection is in place and especially for a powerful relay/switch. Switching inductive loads such as a coil of EMR, solenoids, transformers, inductance (like a choke) and motors can be challenging. During a turn-off cycle a large transient voltage is generated. Than larger inductor than more energy it accumulates during the on-cycle. At the turn-off, transient cycle (opening the switch) the stored energy converts into a voltage and will arc across the contact of the switch. A powerful spike will search for a weak path and could cause damage on any linked components.

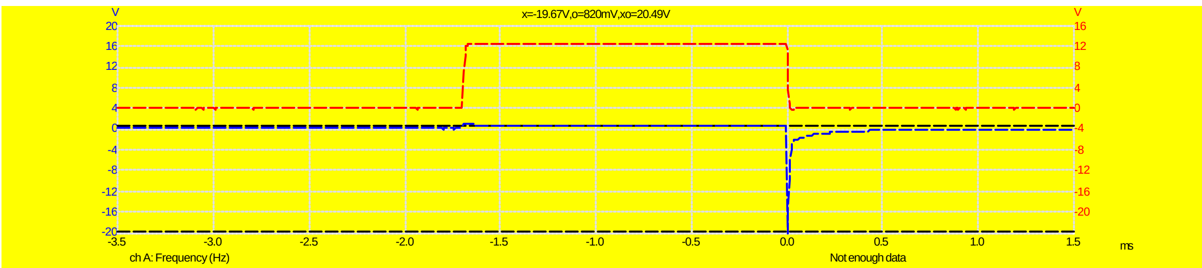

Fig. 1

Figure 1, shows waveforms taken from a generator (top line), and from a solenoid (bottom lines).

The control signal via a powerful switch (p/n EDR84114) applied 8V into the solenoid (resistance 0.35 Ohm). At the end of control pulse (a turn-off moment), the energy saved in the solenoid's coil created a large negative spike and for that reason a probe set at 10x attenuation for preventing possible damage.

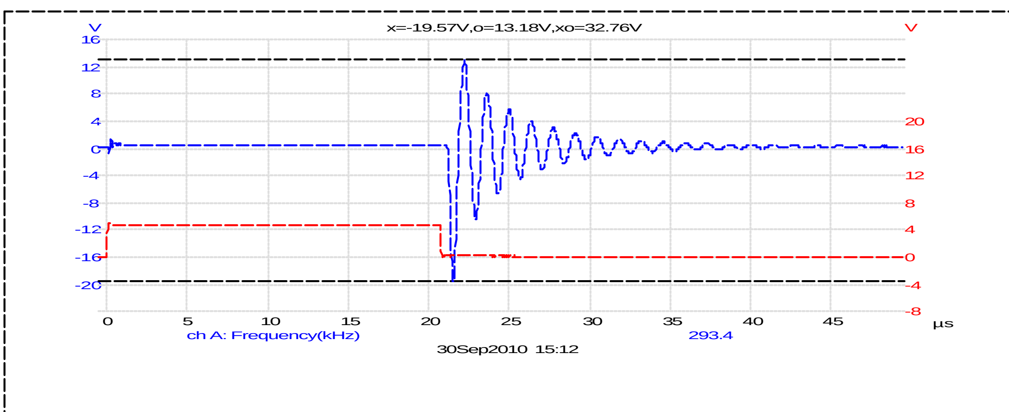

Fig. 2

Recording of a transient spick when no a protection installed. At 3.4V applied voltage the spike is 327V (the probe was set at 10:1). It is more than 90 times higher than applied voltage.

Worse case, these transients spikes will destroy your controller including the switch. At a minimum, transient spikes discharge thru a diode inside of the MOSFET and contributed to its excessive heating up. In milder cases, spikes can cause program failures and flash memory corruption. Devices damaged from inductive spikes are considered to be abused and are not eligible for warranty repair.

Major effort must be undertaking for preventing uncontrollable and destructive actions cause by transient spikes. A low voltage, low power and low frequency mostly require no protection but a high voltage, high frequency, and high power switching can be hazardous to a solid-state switch. There are four options for a controllable discharge existed.

1. For DC power, use a diode connected in series with a small resistor (for limiting a maximum current through the diode) placed in parallel with the inductive load.
2. For an AC power, use a varistor or a bi-directional transient voltage (TVS) and it should be about 1.5 of the applied voltage,
3. Install a snubbing network across the switch (that will create a discharging pass for a transient energy).
4. Use a more intelligent approach and recycle the energy by forwarding it back into the power source.

Protective diode, in some literature called a freewheeling diode, placed across inductive loads provides a path for releasing the energy stored in an inductive load. Two factors should be considered during selecting that diode: (a) voltage, and (b) maximum current or dissipated power. In general, if no other means of protection is implemented such as a snubbing network, the voltage rating for a diode should be about 5-10 times of the power supply (or a steady-state voltage on the load). Selecting the diode's proper current rating is more involved because an inductance and a switching frequency should be considered jointly. A general purpose power diode is sufficient for applications, such as driving a low voltage and low power solenoid, a coil of EMR, and similar devices.

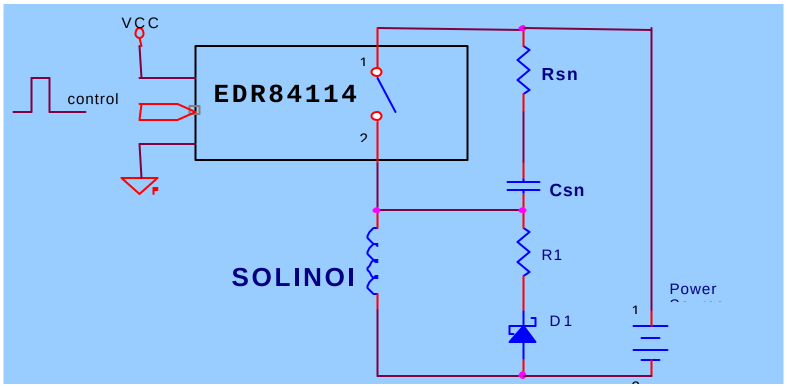

Fig. 3
A hook-up diagram shows p/n EDR84114 provides a power onto the solenoid once the control signal applied on its input.

A more powerful diode is required when a DC motor (no PWM involved) or a large solenoid must be controlled. There is no simple, practical equation existing to calculate the proper current rating of the diode because too many factors are contributing to it outcomes. As a common scene, the diode should be able to withstand a current surge that is equal to a steady-state voltage multiply by factor ten and divided on the impedance of the current path. A pulse (surge) is very short and lasted a fraction of a millisecond. In a high frequency switching applications (for example a PWM power control applications), the diode has to be able to dissipate a lot of power. A powerful, low value resistor in series could alleviate that problem and also installing a more powerful diode on a heat sink could be a good design solution.

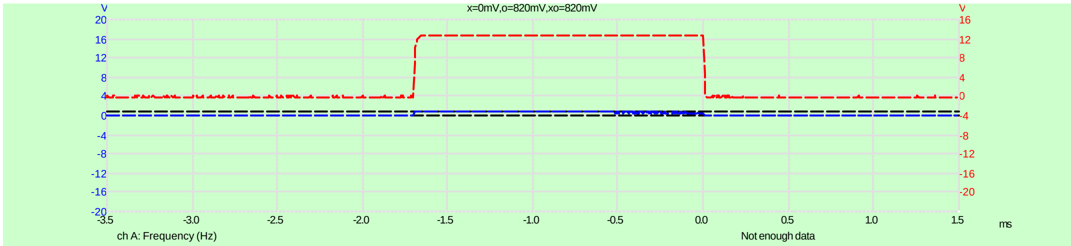

Fig. 4

Recording was taken from the same solenoid (please refer to the Fig. 1) with the diode D1 connected across as shown on the Fig 5. As it's seen, the diode helped to decrease the amplitude of the spike drastically.

Changing the sensitivity scale and record at a high speed reviled presence of a high-frequency remaining of the spike, this is shown on the Fig. 5 below. Those spikes alone will not be able to damage any components (about 16 V p-p) but a very high frequency spectrum of them might interfere with the communication equipment and other sensitive devices.

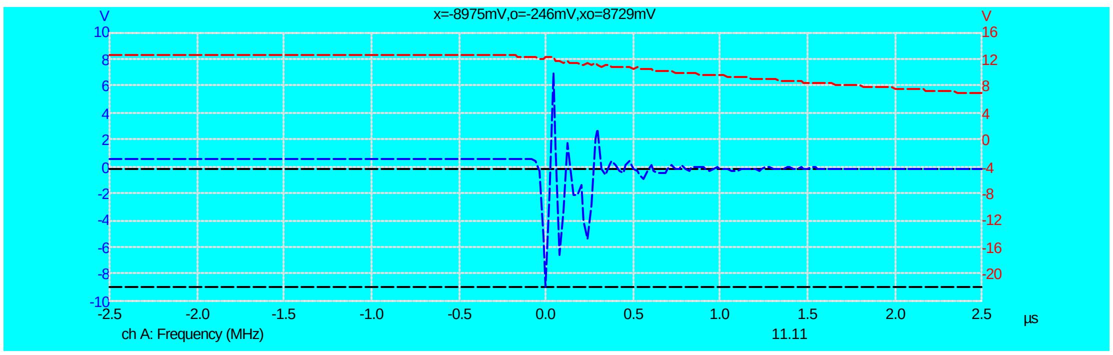

Fig. 5

There are various snubbing networks are available on the market to cure that problem. When DC power switched a single capacitor would dump a super-fast, high-voltage transient spike. For AC applications, a small resistor about 15-100 Ohm is connected in series with the capacitor will do the job. It is good practice to use snubbing network along or addition to other protective means. We manufacture a family of subbing networks (p/n EDR87000/x/v) especially designed for Solid-State Switches. Depending on a model a vary values of capacitor and resistors have being use. The EDR87000 also included an especially design inductor (one or two turns around a powerful ferrite) intend to be connected in series with applied power into the switch/relay. It designed to decrease in-rush current. The EDR87000 provides the best protection among any industrial snubbing networks.

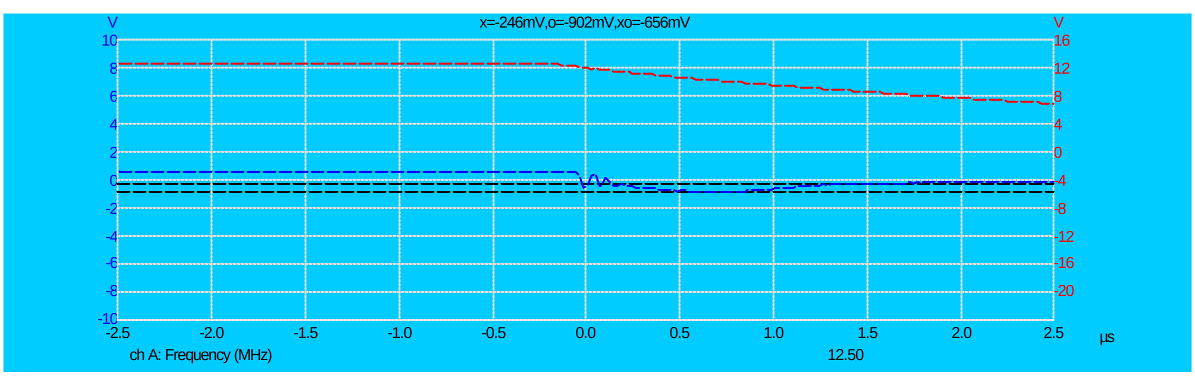

Fig. 6

The recording is showing the resulting of the diode and snubbing network on 200V-high transient spike. It was reduce to insignificant level and present no harm anymore.

General comments and cautions please call for technical support if any additional information is required

Solid State Relays (SSRs) cannot always be applied in exactly the same way as Electromechanical (EMRs) and when such is the case, caution should be taken.

Inductive Loads

While most SSR loads, even lamps, include some inductance, its effect with resistive loads is usually negligible. Only those loads that utilize magnetic to perform their function, such as transformers and chokes (windings) are likely to have significant influence on SSR operation. These loads can create large current surges and the SSR should be derated accordingly.

<u>Transformer Switching</u>

Extremely high current surges are commonly associated with transformers, especially those with a penchant for saturation. The zero voltage turn on feature of standard SSRs (with a TRAIC) can increase this possibility and might require that special precautions be taken. The zero current turn off characteristic of SSRs, while minimizing the problem, will not prevent it. From the practical and economic standpoint, the best choice may still be a standard SSR, overrated to withstand huge surges.

<u>Motor Switching</u>

Dynamic loads such as motors and solenoids, etc., can create special problems for SSRs. High initial surge current is drawn because their stationary impedance is usually very low. As a motor rotates, it develops a back EMF that reduces the flow of current. This same back EMF can also add to the applied line voltage and create 'overvoltage' conditions during turn off. Most of the surge reducing techniques discussed earlier can also be applied to motors. It should be noted that overvoltage caused by capacitive voltage doubling or back EMF from the motor cannot be effectively dealt with by adding voltage-transient suppressors. Suppressors such as Metal Oxide Varistor (MOVs) are typically designed for brief high voltage spikes and may be destroyed by sustained high energy conduction. It is therefore important that SSRs are chosen to withstand the highest expected sustained voltage excursion.

<u>Lamp Switching</u>

The inrush current characteristic of incandescent (tungsten filament) lamps is somewhat similar to the surge characteristic of the thyristors used in AC SSR outputs, making them a good match. The typical ten times steady state ratings which apply to both from a cold start allow many SSRs to switch lamps with current ratings close to their own steady state ratings. CAUTION: Using SSRs for driving mercury, fluorescent, or HID lamps should be avoided. If they must be used, the SSR must be severely de-rated and thoroughly tested in the specific application.

Do not hesitate to call for a technical support or purchasing our product.

Sincerely,

Vladimir A Shvartsman, Ph.D.
President

Transient Voltage Surge Protectors (TVSP & TVSP/S)

http://www.vsholding.com

Technology for people's ideas

The EDR7xxx Series is designed specifically to protect sensitive electronic equipment and devices from high-voltage transient spikes.

Features:

- Small Footprint 1.75”L x .8”W x 1.15”H (size “3”)
- up to 35kW/70V peak pulses capability at 10x1000µS waveform, repetition rate (duty cycle): 0.01%
- up to 550A Peak Forward Surge Current, 8mS
- up to 40W Steady State Power Dissipations
- From 7V to 2900 Volts
- Unidirectional and Bi-directional
- Fast response time: typically less than 1.0pS from 0 Volt to Bv min
- Excellent clamping capability
- Low incremental surge resistance
- Typical current leakage less than 2µA
- Plastic package has Underwriters Laboratory Flammability classification 94V-0, Agency File Number E128662
- Temperature Range -55 °C to 175 °C
- A package provided with either screw-type terminals or 6” wires [suffix /W]
- Devices are available with a built-in snubbing network.

Applications:

EDR made TVSP devices are ideal for protection of high-power Solid-State Relays and Switches, I/O interfaces, Vcc bus and other vulnerable circuits used in telecommunication, computer, industrial, military and consumer applications.

What is Transient Voltage Surge?

In general, there are two sources of Transient Voltage Surges; it is the result of transient voltage and current surges induced on power, telecommunications or RF transmission lines by strong electromagnetic fields created a lightning strike, and during the fast removing discharging path from a charged inductor. Transient Voltage can be greater than 20,000V and current ranges are greater than 100 ampere. Typical rise time is in the 0.1 to 10 microsecond range. **Transient** Voltage is the most common power problems and it’s caused significant damages such as electrical or electronic equipments failure, frequent downtime, lost data, lost time and business downtime, etc.

What are the Transient Voltage Surge Protector (TVSP) and a snubbing network?

Transient Voltage Surge Protector also known as Transient Voltage Surge Suppressor (TVSS), Surge Protection Devices (SPD) or Surge Suppression Equipment (SSE) is an equipment (device) designed to protect electrical and electronic equipments from power surges and voltage spikes. Surge protector clamps an excess voltage thus prevents its destruction.

Ordering information:

S __ __ __ __ __ /__ /__

- Package size; 3, 4, or 7
- Suppression Diodes P / Suppression Diodes + Snubbing N
- Breakdown Voltage
- Uni-Directional A / Bi-Directional C
- Pick Pulse Power
- Steady Power
- A screw type terminal (nothing), 6” wires “W”

Transient Voltage Surge Protectors (TVSP & TVSP/S)

Electronic Design & Research Inc/ VS Holding LLC

High power surge suppressors for protecting Solid-State Relays/Switches in high-frequency applications

Electrical Characteristics, test current = 5mA

P/N	Part (Bi-)	Part (Uni-)	Vbm	Vcm	Ipm	Pppm	Pspm	Imr	S
EDR87009	S3P33C10/3	S3P33A10/3	33	54	250	10000	3	2	-
EDR87010	S3P44C12/4	S3P44A12/4	44	72	250	12000	4	2	-
EDR87011	S3P55C13/5	S3P55A13/5	55	90	250	13750	5	2	-
EDR87012	S3P66C16/6	S3P66A16/6	66	108	250	16500	6	2	-
EDR87019	S3P74C25/6	S3P74A25/6	74	92	450	2500	6	2	-
EDR87013	S3P77C20/7	S3P77A20/7	77	127	250	20000	7	2	-
EDR87014	S3P78C23/6	S3P78A23/6	95	130	230	23000	6	2	-
EDR87015	S3S78C23/100	S3S78A23/100	95	130	230	29000	100	2	yes
EDR87016	S4P110C27/10	S4P110A27/10	110	180	250	27500	10	5	-
EDR87017	S3P126C22/7	S3P126A22/7	154	203	170	26500	7	2	-
EDR87018	S3P150C25/7	S3P150A25/7	150	204	170	25000	7	2	-
EDR87023	S3P220C26/7	S3P220A26/7	220	290	120	26000	7	2	-
EDR87024	S4S220C27/40	S4S220A27/40	220	290	124	27000	40	5	yes
EDR87025	S4P340C35/10	S4S340A35/10	340	450	110	35000	10	5	-
EDR87020	S4S420C3/42	S4S420A3/42	420	540	400	3000	42	5	yes
EDR87026	S4P360C34/10	S4P360A34/10	440	580	79	34700	10	5	-
EDR87027	S4P450C38/10	S4P450A38/10	550	720	70	38500	10	5	-
EDR87028	S7S450C56/100	S7S450A56/100	550	720	83	56400	100	5	yes
EDR87029	S4P510C36/10	S4S510A36/10	627	824	58	36500	10	5	-
EDR87030	S7P560C70/20	S7P560A70/20	640	900	110	70000	20	5	-
EDR87031	S4P640C38/10	S4P640A38/10	786	1030	49	38700	10	5	-
EDR87032	S4P750C38/10	S4P750A38/10	920	1260	42	38600	10	5	-
EDR87033	S4P900C37/10	S4P900A37/10	1110	1460	34	37700	10	5	-
EDR87034	S4P122C38/10	S4P122A38/10	1470	1930	26	38800	10	5	-
EDR87035	S4P162C37/10	S4P162A37/10	1970	2590	19	37400	10	5	-
EDR87036	S4P222C35/10	S4P222A35/10	2700	3700	13	35000	10	5	-
EDR87037	S7N376C105/160		200	376	266	10000	160	0	yes

"/A"	type	Unidirectional
Vb	(volt)	Maximum Breakdown Voltage
Vcm	(volt)	Maximum Clamping Voltage
Ipm	(ampere)	Maximum Peak Pulse Current
Pppm	(watt)	Maximum Peak Pulse Power
Psm	(watt)	Maximum Steady (average) Power Dissipation
Imr	(µA)	Maximum Reverse Current Leakage at Vb
S		Snubbing Network [.68µF + 75 Ohm]
"3"	box	1.75"L x .8"W x 1.15"H
"4"	box	1.975"L x .775"W x 1.15"H
"7"	box	various (custom)

The above is a few devices that are readily available from our stock and a short production cycle. We can manufacture a TVSP or TVSP/S virtually for any required voltage, current and dissipating power. There is no price difference what is listed above and devices for other voltages/powers close to them.

Please fax/email your inquiry to 1-502-933-3422 / info@vsholding.com