Superior Protection of Power Supplies with MOV + Spark Gap Combination

Introduction

Current and Voltage Surges on AC Power Lines are responsible for most failures of electronic appliances and equipment. The Power Supply section of the equipment faces the brunt of these power line disturbances.

High Voltage Spikes are often too quick (short duration, high frequency) for protection devices to act and cause breakdowns in Bridge Rectifiers and/or STRs. Higher Energy Surges (longer duration or with heavier current component) progressively damage other (generally robust) components as the Mains Filter Capacitor.

Power Supply Designers pay special attention to controlling the menace of Power Line Disturbances by using components as Metal Oxide Varistors, Line Inductors, In-rush Current Limiters etc. Each component serves a different purpose. This Application Note will limit the discussion to the advantages vs disadvantages of using Metal Oxide Varistors (MOV) and suggest a possible solution to the Life Vs Protection Level trade-off faced by MOV users.

Metal Oxide Varistors (MOV)

Varistors, as the name suggest are Variable Resistors and the internal impedance depends on the potential applied across them. A suitably chosen Varistor, under normal operation should exhibit a very high impedance and thus permit negligible Leakage Current. As the potential across the Varistor rises beyond the Varistor Voltage the impedance should fall rapidly and should ideally become independent of the current flowing through it and by inference clamp the potential across itself to ONE CONSTANT specified value. Once the externally applied potential across the Varistor recedes to less than the Varistor voltage the impedance should rise again towards the original high level and once again prevent flow of current through the Varistor. In this manner the Varistor acts like a conditional shunt and is applied in a parallel configuration to the Power Supply.

However, as all components, Varistors do not exhibit ideal behavior and are prone to the following problems.

a) High Clamping Voltage
b) Thermal Runaway
c) High Capacitance
d) Finite Impedance in SHUNT (conducting) mode
e) Significant Leakage current in OPEN mode.

Due to the above mentioned problems designers using Varistors face a trade-off in choosing the protection level (measured in terms of the manufacturer specified Clamping Voltage Level) and the protection life (usually determined empirically according to nature of the equipment being protected and the surge environment where the equipment is likely to be used).

In India, for 240 Vrms, 50 Hz supply, experts recommend the use of atleast a 14mm dia Varistor with an AC rating of 470 Vrms. However, this is rarely used as such a rating implies an unacceptably high Clamping Voltage level. In other words, the above suggested rating offers a low protection level. On the other hand if a lower AC rms rating is chosen the protection life is compromised. Power Supply designers in India frequently use an AC rms rating of 300Vrms which gives a Manufacturer specified Clamping Voltage level of about 800V at a surge current of 50A (8x20µs pulse). Whether this level is adequate or not is for the designer to determine.

Design Imperative

LG electronics has chosen to use a Varistor with an AC rating of 395 Vrms (Varistor Voltage is 620 V). The Manufacturer specifies a Clamping Voltage level of 1020V at a surge current of 50A (8x20µs). It is desirable to reduce this Clamping voltage Level to as LOW a value as possible. A safer level of about 800V at the same Surge Current Specification is likely to improve protection levels but care must also be taken to not compromise on the Protection Life offered by the lower rated Varistor.

Series combinations of Fast acting Spark Gaps and MOVs have proved to be useful in resolving this trade-off between Protection Level and Protection Life. Such a solution has so far been hampered by the quality of Spark gaps available (till now) – Spark gap technologies have so far not been able to offer the required Fast Response Time and the Surge Current Capacity needed for the above mentioned application at a reasonable cost.

Designers have tried to use AIR GAPS which are cheap but they suffer from poor Response Time and are hence not effective. Other Ceramic Tube based Spark Gaps cannot offer the SURGE CURRENT CAPACITY required in this application. GD Tubes can offer a high Surge Current Capacity but have a poor response time and are also very expensive.

Punsumi's own PTB series can respond to Surges quickly but cannot offer the Surge Current Capacity required for this application. The engineers at Punsumi have now developed the new PTC series – which can shunt heavy levels of Surge Current and can do so repeatedly.

When used in series with Varistors the PTC can be used as a Voltage Dependent Switch which allows conduction of current through itself and the Varistor only if a surge energizes it. In the process the Clamping Voltage Level of the PTC itself is less than 30V which is negligible in the context of this application. As a corollary, in the INACTIVE (open) state, when the Insulation Resistance of the PTC is very high only very miniscule current is allowed through (in Pico Amperes) thus preventing flow of current through the Varistor and prolonging its protection life. In other words, when used in series with the PTC the Varistor Voltage can be reduced to improve the Protection Level without compromising the Protection Life.

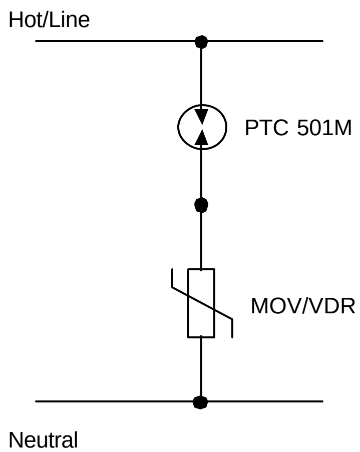

Figure 1: Series Combination of Spark Gap + VDR

Features of the Varistor + Spark Gap Series Combination

- **Lower Clamping Voltage**
- **No Thermal Runaway**
- **No Leakage Current at steady state operating conditions**
- **Longer Life**
- **Extremely Low Capacitance**
- **High Insulation Resistance**
- **Stability Against Repeated Surges**
- **Low Cost Solution**

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Typical Application

Protection of Equipment

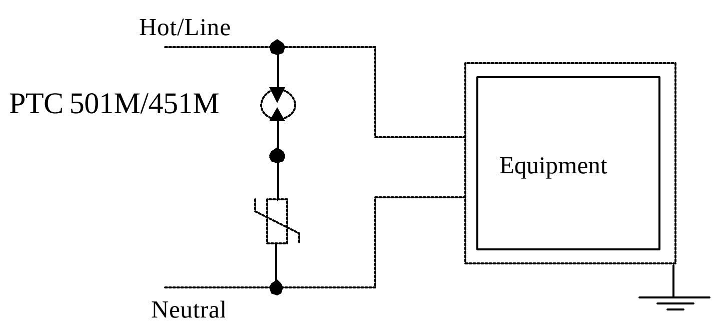


Figure 2: Application of Spark Gap + VDR combination

Product Guide

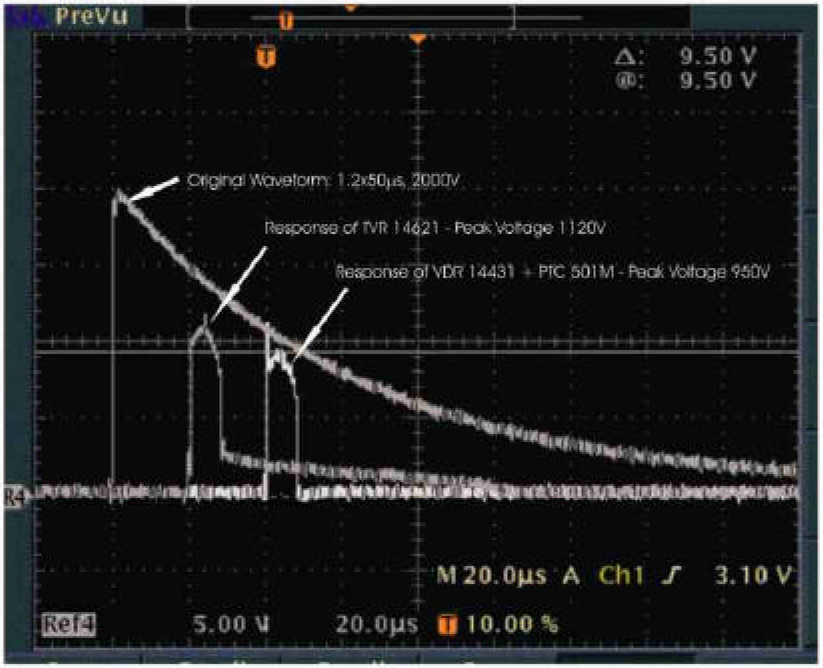
Model		DC Spark-over Voltage Vs (in Volts)	Insulation Resistance	Clamping Voltage @ 50A	Surge Life test	Surge Current Capacity	AC withstand voltage	Capacitance
PTC	451M	360-540	> 100M Ohms	30 V	8x20µs, 100A, 500 times, 30 sec interval	8x20µs, 2500 A	275 V	< 2 pF
	501M	400-600	> 100M Ohms	30 V			300 V	

AC Withstand Voltage: Maximum RMS Voltage that can be safely applied between the leads of the PTC

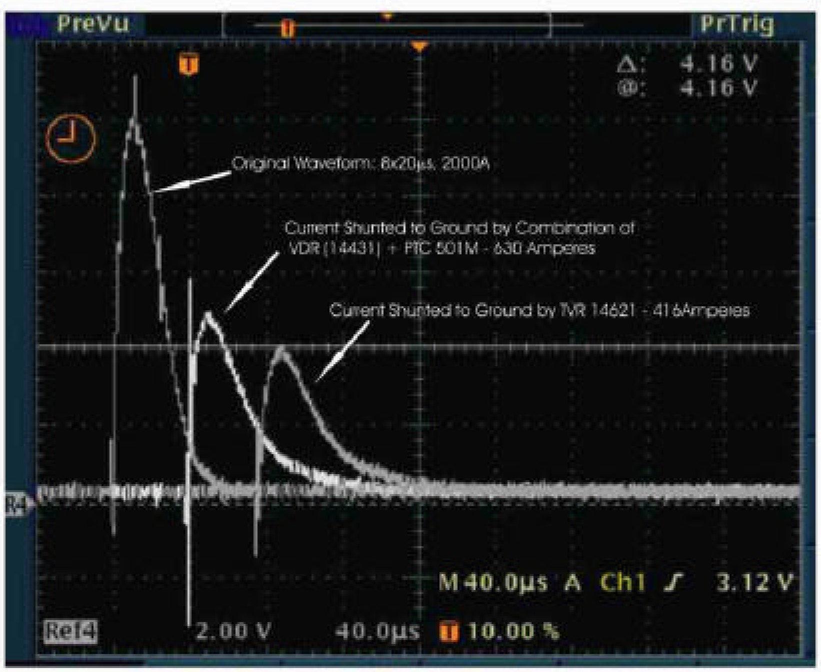
Performance

The following Oscilloscope Screen Captures illustrate the performance of the MOV – Spark Gap Combination when compared with the MOV used by LG Electronics.

Performance: TVR 14621 Vs Combination of VDR + PTC 501M



Surge Response of TVR 14621 and Combination VDR+PTC 501M
on
1.2x50µs, 2000V Voltage Waveform



Surge Response of TVR 14621 and Combination VDR + PTC 501M
on
8x20 ms, 2000A Current Waveform