MOV CONNECTOR TECHNOLOGY: EMP AND OTHER TRANSIENT PROTECTION

Newly developed transient protective connectors that utilize metal oxide varistors (MOVs) are useful in protecting sensitive components from the high-energy transients resulting from ESD, EMP, and lightning.

Takayuki Okada, Amphenol Canada, Amphenol Products, Scarborough, Ontario, Canada

INTRODUCTION

In recent years, protection against electrical disturbances such as electrostatic discharge (ESD), electromagnetic pulse (EMP), and lightning has become a very important issue.

Metal oxide varistors (MOVs) have been used as a means of protection in this area for over 15 years. Their advantages include compactness, cost-effectiveness, fast response time, and high energy handling capability.

Recently, a technological breakthrough in manufacturing processes enabled the development of a new family of connectors that utilize MOVs (Figure 1). These connectors are used to protect a wide variety of systems from harmful electrical transients.

This article describes transient protective connectors that use metal oxide varistors (MOVs). It will clarify their basic characteristics and reliability, will explain terminologies used, and, finally, will provide a connector selection guide.

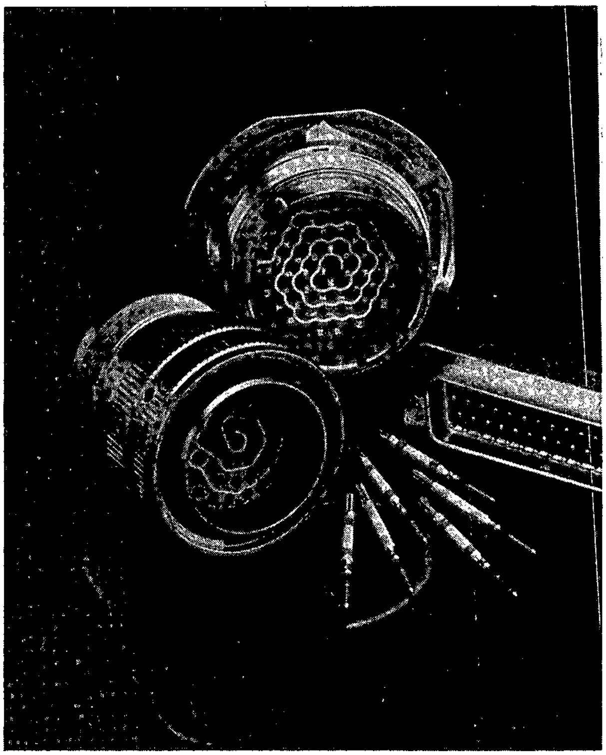

Figure 1. High Reliability Military/Aerospace EMP (MOV) Filter Connectors.

TRANSIENTS

A transient (sometimes called a surge) is a condition when voltage, current, or frequency deviates from the steady state. There are many types of transients with a wide variety of causes. However, ESD, EMP, and lightning are the main causes.

EMP is caused by high-altitude or ground-nuclear detonation. Gamma rays from a nuclear burst collide with molecules in the atmosphere and create a strong magnetic field which causes severe electromagnetic interference. A transient can also be caused by something as simple as switching power to the inductive element in a circuit, such as a motor or transformer. This type of transient is very common to many electrical and electronic systems.

The intensity of the transient depends on various factors. In typical ESD pulses, for example, the open-circuit voltage could reach 10 to 20 kV with pulse risetime of 10 to 100 nanoseconds. Energy levels of such pulses could exceed 100 millijoules.

In the case of high-altitude nuclear detonation, the magnetic field strength could reach as high as 50,000 volts/meter on the ground, and the entire North American continent could be affected by a single nuclear burst.

THE NEED FOR TRANSIENT PROTECTION

Ordinary electrical outlets frequently see spikes with voltages as high as 6 kV and short circuit current of 200 amperes. Without proper protection, sensitive components such as integrated circuits, transistors, diodes, and even resistors and capacitors, could be damaged by such high energy transients.

There are basically three types of system degradations caused by the transients. One type of degradation is a system upset. Relatively less severe transients can cause a temporary malfunction of the system. Once the transient has been dissipated, the system will restore its normal operation. A second type of degradation is a permanent damage. Component parts can be permanently damaged by the transient. The system will not function even after the transient condition has been dissipated. In the third type of degradation, the system may not fail because of a particular transient condition; however, the component parts will deteriorate because of repeated transient strikes. This will result in an unexpected short operating life of the system.

A transient protective device itself can also be damaged by the transients if the device does not have proper rating, thus leaving the system vulnerable.

Capacitors are sometimes used for transient suppressing purposes. However, for fast rise pulses, the effectiveness of the capacitor diminishes due to the presence of parasitic inductance. In addition, dielectric breakdown can take place at relatively low pulse levels.

ELECTRICAL CHARACTERISTICS

A metal oxide varistor (MOV) is a voltage-dependent, non-linear, resistive semiconductor device which acts like a high-speed switch with nanosecond response time. At rated operating voltage, the varistor has a high resistance. If the line voltage exceeds a certain value, the resistance of the varistor drops to a very low value, thus shunting the pulse safely to ground. Once the voltage drops to the normal operating voltage, the varistor recovers its high-resistance condition.

The density of this new MOV compound can be controlled to obtain a high energy absorbing capability in a relatively small volume. For example, a varistor for size 20 contact can safely dissipate peak pulse current of up to 500 amperes and 3 joules of energy.

THE NEW FAMILY OF CONNECTORS THAT COMBATS TRANSIENTS

By packaging the varistor transient protective devices into standard EMI filter connectors, no additional circuit is required for system hardening. Since the tubular varistor is radially mounted over the connector pin without leads, very low impedance grounding is obtained. For varistors with leads, the high frequency element of the fast rise pulse will generate high lead impedance which, in turn, masks the fast response time of the varistor.

One concept of mounting the MOV device onto the contact utilizes a patented conductive elastomeric membrane, which provides the required low impedance connection as well as superior physical stress isolation (Figure 2). For EMP applications, MOV devices are particularly suitable because they are virtually immune to extremely high doses of electron and neutron irradiations.

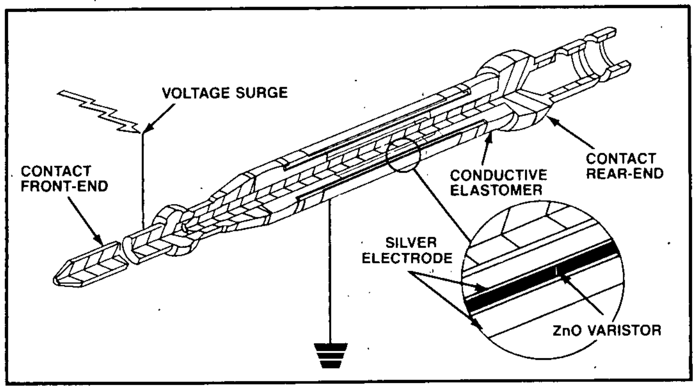

Figure 2. Flexible Varistor Filter Pin.

Transient protective connectors are available, or under development, for configurations interchangeable and intermateable with various existing connectors specified in MIL-C-5015, MIL-C-24308, MIL-C-26482, MIL-C-26500, MIL-C-27599, MIL-C-28804, MIL-C-38999, and MIL-C-83723, as well as customized connectors to meet special requirements for new and retrofit applications.

The various transient protective devices can also be supplied with EMI/RFI filters in one package to suppress a variety of harmful electromagnetic interferences. Connectors are available with removable/programmable crimp termination contacts for easy maintenance, as well as with non-removable solder termination contacts.

VARISTOR TERMINOLOGIES

The following are some of the common terminologies applicable to varistor transient protective devices as defined in the IEEE C62.33-1982 specification:

Rated dc Voltage, Vm(dc):
: Maximum continuous dc voltage which may be applied to the varistor.

Rated rms Voltage, Vm(ac):
: Maximum continuous sinusoidal rms voltage which may be applied to the varistor.

Nominal Varistor Voltage, V_N (dc):
: Voltage across the varistor measured at a specified pulsed dc current, I_N(dc), of specific duration. I_N(dc) is usually 1mA dc. Note that this value is different from Rated dc Voltage (Vm(dc)).

Clamping Voltage, (Vc):
: Peak voltage across the varistor measured under conditions of a specified peak pulse current and specified waveform.

Rated Peak, Single Pulse Transient Current, (I t m):
: Maximum peak current which may be applied for a single 8/20 microseconds impulse, with rated line voltage also applied, without causing device failure.

Rated Single Pulse:
: Energy which may be dissipated for a single impulse of maximum rated current at a specified wave-

shape, with rated rms voltage or rated dc voltage also applied, without causing device failure.

DC Standby Current, (I_D):
Varistor current measured at rated voltage, Vm(dc).

AC Standby Power, (Pd):
Varistor dc power dissipation measured at rated rms voltage Vm(ac).

Lifetime Rated Pulse Current:
Derated value of rated peak single pulse transient current (Itm) for impulse duration exceeding that of an 8/20 microseconds waveshape, and for multiple pulses which may be applied over device rated lifetime.

Rated Transient Average Power Dissipation, (Pt(Av)m):
Maximum average power which may be dissipated due to a group of pulses occurring within a specified isolated time period, without causing device failure.

RELIABILITY

An extensive test has been conducted as an MOV connector qualification test under the direction of the United States Air Force Weapon Laboratory (A.F.W.L.). This test program was based on the requirements of MIL-C-26482 (Electrical Connector, Circular, Miniature, Quick Disconnect) and IEEE C62.33-1982 (Test Specification for Varistor Surge-Protective Devices).[1]

Two types of varistor samples have been subjected to various tests such as thermal shock (−55°C to +125°C for 5 cycles), random vibration (MIL-STD-202, Method 214, condition 2, letter J), physical shock (300G), contact retention and operating life test (at +125°C) for 1000 hours under continuous operating voltage).

All of the tests were successfully completed. Varistor samples showed very stable characteristics after an operating life test of 1000 hours at 125°C with rated dc and ac voltages applied. For example, average ac standby power (Pd) of V220 samples at 175 V ac was 3.8 milliwatts after the life test compared with 3.4 milliwatts before the test.

The MOV transient protective connectors are based on the field-proven hardware as the standard EMI/RFI filter connectors that have been in use for many years.

EMP (MOV) FILTER CONNECTOR SELECTION GUIDE

The following is the MOV transient protective connector selection guide used to specify a properly rated MOV for the system:

Operating Temperature:
Operating temperature range is from -55°C to +125°C.

Operating Voltage:
Continuous operating dc or ac voltage of the line must be identified, and it must be equal to or lower than the varistor rated dc or ac operating voltage (Vm(dc) or Vm(ac)).

Peak Pulse Current:
Expected highest peak pulse current should be defined for the system, and it must be equal to or lower than the varistor rated peak single pulse transient current (Itm). In most cases, the system will see repeated pulses during its operating life. For the repeated pulse applications, the pulse current level must be derated.

Energy Level of the Pulse:
Energy of the pulse is calculated from the following formula:

$$E = \int V\,I\,dt$$

where

V = Voltage across the varistor,
I = Current flowing through the varistor,
T = Duration of the pulse.

Expected energy level of the pulse must be equal to or less than the rated single pulse transient energy (Wtm). However, in some cases, a group of pulses occur during a short time period. In this case, the expected energy level of these repeated pulses must be less than the varistor rated transient average power dissipation (Pt(Av)m).

System Susceptibility:
It is important to define the system susceptibility, for it depends on the design and type of the components used in the system. Integrated circuits, for example, can be damaged by the transient with energy as low as 10 millijoules. A vacuum tube, on the other hand, could survive up to many joules.

Line Frequency:
Capacitance associated with the varistor should be taken into consideration, especially for high-speed data transmission lines, and for applications where both EMI/RFI filtering and transient protection are required.

COMBINING PROVEN TECHNOLOGIES

EMP (MOV) filter technology combines the voltage clamping shunting capacity of metal oxide varistors with standard EMI filter contact/connector technology. Design engineers can, therefore, rely on an integrated, shock and vibration resistant, compact, hybrid connector system for fast response protection against EMP, ESD, lightning, and other transients. ■

REFERENCES

1. IEEE C62.1982, Test Specification for Varistor Surge-Protective Devices, IEEE, 1982.