SOME STRAIGHT TALK ABOUT MOSORBS
TRANSIENT VOLTAGE SUPPRESSORS

INTRODUCTION

Distinction is sometimes made between devices trademarked Mosorb (by Motorola Inc.), and standard zener/avalanche diodes used for reference, low-level regulation and low-level protection purposes. It must be emphasized from the beginning that Mosorb devices are, in fact, zener diodes. The basic semiconductor technology and processing are identical. The primary difference is in the applications for which they are designed. Mosorb devices are intended specifically for transient protection purposes and are designed, therefore, with a large effective junction area that provides high pulse power capability while minimizing the total silicon use. Thus, Mosorb pulse power ratings begin at 500 watts — well in excess of low power conventional zener diodes which in many cases do not even include pulse power ratings among their specifications.

MOVs, like Mosorbs, do have the pulse power capabilities for transient suppression. They are metal oxide varistors (not semiconductors) that exhibit bidirectional avalanche characteristics, similar to those of back-to-back connected zeners. The main attributes of such devices are low manufacturing cost, the ability to absorb high energy surges (up to 600 joules) and symmetrical bidirectional “breakdown” characteristics. Major disadvantages are: high clamping factor, an internal wear-out mechanism and an absence of low-end voltage capability. These limitations restrict the use of MOVs primarily to the protection of insensitive electronic components against high energy transients in application above 20 volts, whereas, Mosors are best suited for precise protection of sensitive equipment even in the low voltage range — the same range covered by conventional zener diodes. The relative features of the two device types are covered in Table 1.

RELATIVE FEATURES OF MOVs and MOSORBS

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<th>MOV</th>
<th>Mosorb/Zener Transient Suppressor</th>
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<tr>
<td>• High clamping factor.</td>
<td>• Very good clamping close to the operating voltage.</td>
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<td>• Symmetrically bidirectional.</td>
<td>• Standard parts perform like standard zeners. Symmetrical bidirectional devices available for many voltages.</td>
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<td>• Energy capability per dollar usually higher than a silicon device.</td>
<td>• Good clamping characteristic could reduce overall system cost.</td>
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<td>• However, if good clamping is required the energy capability would have to be grossly overspecified resulting in higher cost.</td>
<td>• No inherent wear out mechanism.</td>
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<td>• Inherent wear out mechanism clamp voltage degrades after every pulse, even when pulsed below rated value.</td>
<td>• Ideally suited for precise DC protection.</td>
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<td>• Ideally suited for crude ac line protection.</td>
<td>• Medium multiple-pulse current capability.</td>
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<tr>
<td>• High single-pulse current capability.</td>
<td>• Fails short with overstress.</td>
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<td>• Degrades with overstress.</td>
<td>• Limited high voltage capability unless series devices are used.</td>
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<tr>
<td>• Good high voltage capability.</td>
<td>• Good low voltage capability.</td>
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<td>• Limited low voltage capability.</td>
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In practice, the Mosorb is selected so that its $V_{RWM}$ is equal to or somewhat higher than the highest operating voltage required by the load (the circuits or components to be protected). Under normal conditions, the Mosorb is inoperative and dissipates very little power. When a transient occurs, the Mosorb converts to a very low dynamic impedance and the voltage across the Mosorb becomes the clamping voltage at some level above $V_{(BR)}$. The actual clamping level will depend on the surge current through the Mosorb. The maximum reverse surge current ($I_{RSM}$) is specified on the Mosorb data sheets at 1 ms and for a logarithmically decaying pulse waveform. The data sheet also contains curves to determine the maximum surge current rating at other time intervals.

Typically, Mosorb devices have a built-in safety margin at the maximum rated surge current because the clamp voltage, $V_{RSM}$, is itself, guardbanded. Thus, the parts will be operating below their maximum pulse-power ($P_{pk}$) rating even when operated at maximum reverse surge current.

If the transients are random in nature (and in many cases they are), determining the surge-current level can be a problem. The circuit designer must make a reasonable estimate of the proper device to be used, based on his knowledge of the system and the possible transients to be encountered. (e.g., transient voltage, source impedance and time, or transient energy and time are some characteristics that must be estimated). Because of the very low dynamic impedance of Mosorb devices in the region between $V_{(BR)}$ and $V_{RSM}$, the maximum surge current is dependent on, and limited by the external circuitry.

In cases where this surge current is relatively low, a conventional zener diode could be used in place of a Mosorb or other dedicated protective device with some possible savings in cost. The surge capabilities most of Motorola’s zener diode lines are discussed in Motorola’s Application Note AN784.

In the data sheets of some protective devices, the parameter for response time is emphasized. Response time on these data sheets is defined as the time required for the voltage across the protective device to rise from 0 to $V_{(BR)}$, and relates primarily to the effective series impedance associated with the device. This effective impedance is somewhat complex and changes drastically from the blocking mode to the avalanche mode. In most applications (where the protective device shunts the load) this response time parameter becomes virtually meaningless as indicated by the waveforms in Figures 1b and 1c. If the response time as defined is very long, it still would not affect the performance of the surge suppressor.

However, if the series inductance becomes appreciable, it could result in “overshoot” as shown in Figure 1d that would be detrimental to circuit protection. In Mosorb devices, series inductance is negligible compared to the inductive effects of the external circuitry (primarily lead lengths). Hence, Mosorbs contribute little or nothing to overshoot and, in essence, the parameter of response time has very little significance. However, care must be exercised in the design of the external circuitry to minimize overshoot.

**SUMMARY**

In selecting a protective device, it is important to know as much as possible about the transient conditions to be encountered. The most important device parameters are reverse working voltage ($V_{RWM}$), surge current ($I_{RSM}$), and clamp voltage ($V_{RSM}$). The product of $V_{RSM}$ and $I_{RSM}$ yields the peak power dissipation, which is one of the prime categories for device selection.

The selector guide, in this book, gives a broad overview of the Mosorb transient suppressors now available from Motorola. For more detailed information, please contact your Motorola sales representative or distributor.
Some Straight Talk About Mosorbs Transient Voltage Suppressors

Motorola TVS/Zener Device Data

Figure 1.

Figure 1a. Figure 1b.

Figure 1c. Figure 1d.

$V_{in}$, $V_{out}$, $V_{RSM}$, $V_{(BR)}$, $V_{RWM}$

$t_p$ = PULSE WIDTH OF INCOMING TRANSIENT

$tp =$ PULSE WIDTH OF INCOMING TRANSIENT

$V_{clamping}$, VERY SHORT

$V_{clamping}$, VERY LONG

$V_{OVERSHOOT}$
TYPICAL MOSORB APPLICATIONS

DC Power Supplies

Input/Output Regulator Protection

Op Amp Protection

DC Motors — Reduces EMI

Memory Protection

Inductive Switching Transistor Protection

Microprocessor Protection

Computer Interface Protection