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Circuit Protection Designs For a Mobile World

Matthew Williams, Global Applications Engineering Manager
Tyco Electronics

The mobile functionality of portable media players (PMPs), smart phones, play stations and other battery-powered portable devices offers consumers an increasingly connected lifestyle between their home, office and vehicle. However, this convenience comes with certain risks. Every time these products are connected or disconnected, they may be exposed to circuit damage caused by user error, wrong supply voltages or voltage or current transients.

Protecting mobile devices has become a critical design issue for manufacturers of consumer electronics and general electronics systems, who must meet safety requirements, reduce warranty costs and provide the end-user with a reliable product. This article describes the operation principle of the polymer protected Zener diode and how it can be used to help protect portable devices from damage caused by improper power supplies, overvoltage transients, reverse bias and overcurrent conditions.

Protecting Mobile Devices

The number of cell phones now surpasses the number of people in countries like Australia; and in many countries, including the US, there are more cell phones than land lines. This growth of portable devices not only increases the potential for customer error, but the proliferation of higher power applications leads to increased power demands along with greater risk of inductive spikes and other connection/hot disconnect transients.

The evolution of mobile multimedia equipment from audio-centric devices to video-centric storage devices is also resulting in higher power requirements, higher data transmission rates and smaller circuitry. For example, MP3 players and PMPs, with their ability to download and store music, movies, TV programs and games, are becoming more popular. According to the In-Stat report, "*Worldwide Demand Remains Strong for MP3 and Portable Media Players*," the continued decline in the cost of incorporating video into portable devices will push shipment growth of video-enabled PMPs by the end of 2008, and will result in video-enabled PMPs outselling audio-only models by 2009. This move to video over audio-centric portable products means higher power charging interfaces (i.e., a recently released USB charging spec raises the interface maximum current from 0.5 to 1.5 A).

In addition to the risk of connecting the wrong power supply, voltage transients can also damage a portable device. Although typical computer power supplies provide regulated lines at 5 V +/- 5 percent, and 12 V +/-5 percent, under certain circumstances, the voltage at these lines may exceed 5.25 V, and 12.6 V, causing potential damage to the system or unprotected peripherals. Voltage spikes can occur when there is inductance in the power bus, and a rapid change in current occurs.

This change can result from a hot disconnect of a peripheral, an internal system shutdown or other internal power fluctuations. Inductance does not require magnetics, but can also be generated by long cables and other power bus artifacts. The more inductance in the power bus, the worse the voltage spike seen by the peripheral is likely to be. In short, portable consumer electronics exposed to voltages (well in excess of the bus voltage) may require protection to help prevent premature failure.

Circuit Protection Solution

Transient protection is critical when designing peripherals that may be powered off computer buses and automotive power buses. On computer buses, inductively generated voltage spikes can exceed 8 V on the 5 V line and 16 V on the 12 V line, which can damage unprotected peripherals. With the advent of low-cost third party AC to USB converters, and car cigarette lighter-to-USB converters, the potential for transients to be seen on computer buses continues to increase.

Automotive power buses are notoriously dirty. Although they are nominally 12 V, they can range in normal operation from 8 V to 16 V. Still, battery currents can exceed 100 amps and can be stopped instantly via a relay or fuse, generating large inductive spikes on the bus and increasing voltage by five times or more. With the growth of high-power electronics content in vehicles, so grows the potential for inductive spikes.

Third party power converters are increasingly common how-

ever, and may filter some transients. Testing by Tyco Electronics shows that their transient suppression capability varies widely.

Custom-keyed power connectors are sometimes employed to prevent the use of incorrectly rated or improperly designed power supplies. This solution incurs custom tooling costs though and is not necessarily insulated from the creation of third party adaptors.

In another protection scheme, high voltage capable silicon solutions can be designed to provide a regulated voltage output and overvoltage lockout. The problem with the integrated silicon approach is that there is usually a significant price premium associated with this method.

Traditional clamping diodes represent the simplest protection solution. However, in order to withstand the potential power output of a non-approved charger while still providing resettable protection, this diode must be capable of dissipating nearly all of the power that a non-approved charger could deliver. The resultant protection solution would therefore require both a large diode and significant heat-sinking infrastructure, thus making it an impractical choice.

Through accelerated research in materials science and more efficient design, PPTC (polymeric positive temperature coefficient) device manufacturers are keeping pace with portable equipment challenges by developing new devices that meet existing performance levels within smaller and more convenient packaging.

An example of how circuit protection device manufacturers are addressing these market demands is by utilizing a polymer protected Zener diode (shown in Figure 1), which offers designers the simplicity of a traditional clamping diode while obviating the need for significant heat sinking. This device not only helps protect sensitive electronics from damage caused by the use of improper power supplies, it also helps provide transient suppression, reverse bias protection and overcurrent protection in a small, single package.

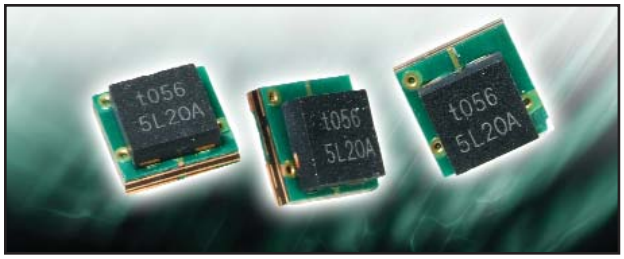

Figure 1. Polymer protected Zener diodes.

Figure 2 illustrates how the Tyco Electronics PolyZen device integrates a precision, low resistance Zener diode for crisp voltage clamping with a resistively non-linear, PPTC layer. The PPTC layer responds to either diode heating or overcurrent

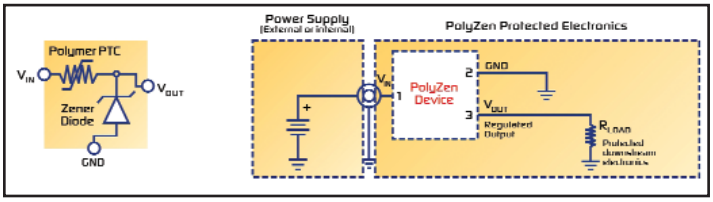

Figure 2. The PolyZen device helps provide input power protection for portable electronics.

events by transitioning from a low to high resistance state. In the event of a sustained high-power overvoltage condition, the tripped PPTC element limits current and generates voltage drop to help protect both the Zener and the follow on electronics, effectively increasing the diode's power handling capability.

The polymer protected Zener diode is particularly effective at clamping and smoothing inductive voltage spikes. In response to an inductive spike the Zener diode shunts current to ground until the voltage is reduced to the normal operating range. In the case of a wrong voltage power supply, the device clamps the voltage, shunts excess power to ground, and eventually locks out the wrong supply, as shown in Figure 3.

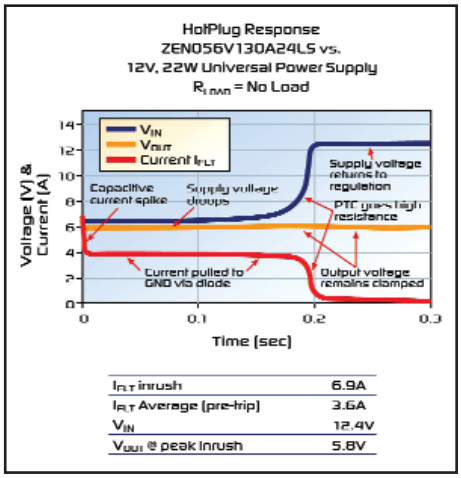

Figure 3. Polymer enhanced Zener diode clamps and smoothes inductive voltage spikes.

The relatively flat voltage verses current response of the polymer protected Zener diode helps clamp the output voltage, even when input voltage and source currents vary. Simply put, the polymer enhanced device helps provide coordinated protection with a component that protects like a Zener diode, but is capable of withstanding very high power fault conditions without requiring any special heat sinking structures beyond normal PCB traces.

Conclusion

By integrating polymeric materials with conventional products, PPTC technology has been expanded to a wider range of industries and applications, from automotive navigation systems to smart phones and portable media players. These pioneering designs help support emerging technologies and keep pace with customer needs. New polymer protected Zener diodes can be used to help protect portable devices from damage caused by improper power supplies, overvoltage transients, reverse bias and overcurrent conditions. They also help meet the needs of shrinking mobile designs that require smaller, more reliable circuit protection devices.

Matthew Williams is a Global Applications Engineering Manager for Raychem circuit protection products at Tyco Electronics. He received both his BSEE and BSEC from Phoenix Institute of Technology and has been in the industry since 1984.

Contact Matthew Williams at mattwilliams@tycoelectronics.com or 650-361-2058.

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7355 E. Orchard Rd., Ste. 100, Greenwood Village, CO 80111 USA Phone 720-528-3770 • Fax 720-528-3771 • www.infowebcom.com