APPLICATION NOTE

Low Power Consumption PolyZen Device Addresses USB 3.0 Operating Current Requirement in Suspend Mode

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Introduction

The overwhelming majority of consumers want the convenience of using fewer cords to power their cell phones, MP3 players and other electronic equipment, as well as the flexibility to charge portable equipment from their computers. Because of this market demand, nearly all current and future handheld devices will be able to charge from USB sources. However, USB requirements present several circuit protection challenges for designers of portable equipment. Overvoltage, poor regulation, electromagnetic induction, electrostatic discharge (ESD), incorrect wiring, and reverse voltages are just a few of the events that a USB-enabled device may be exposed to.

Because high power-consumption can limit operation and battery life, proper power management is also a crucial issue for design engineers. For example, operating current from a USB-enabled device may be high enough to "wake-up" the device from sleep or suspend mode, thereby wasting battery power.

A solution for both circuit protection challenges and high-power- consumption issues in USB applications is now available from Littelfuse in a new line of low-power-consumption PolyZen devices that help provide protection against damage caused by overcurrent, overvoltage and ESD events. The devices also meet the USB 3.0 minimum operating current requirements during suspend mode.

Overvoltage Protection on USB Power Ports

Although USB defines the power bus, this does not eliminate the risk associated with overvoltage events. Overvoltage events can be caused by a variety of fault conditions, including user error, poorly regulated third-party power supplies, hot disconnect events, and EMI (electromagnetic interference). The interface and charging systems may also generate negative voltage, resulting in damage to unprotected peripherals. Although the USB 2.0 power rating is specified at 5V +/-5%, many high-volume systems using USB 2.0 interfaces are designed to withstand 16V and even 28V events (voltage inductive spikes).

Per the new USB 3.0 specification, operating current rating is 80% above the USB 2.0-rated current. The USB overvoltage protection devices designed for traditional 0.5A ports may be inadequate for the new USB 3.0 specification of 0.9A per port. If a 0.9A host disconnects, high-voltage inductive spikes can be generated that may negatively affect the devices that are left on the bus. A well-designed bus will absorb these spikes, thereby protecting peripheral devices.

Littelfuse internal testing demonstrated that hot connect and disconnect events, although very short, can cause transients of up to 16V and even exceeding 24V levels. Internal testing has also identified third-party chargers whose open circuit voltage significantly exceeds the 5V +/-5% USB requirements, which can pose a threat to sensitive electronic equipment. Placing overvoltage protection devices, such as Littelfuse PolyZen devices, on the power inputs of all USB powered devices – specifically on the VBUS port – can help protect against damage caused by overvoltage events.

For USB 3.0-enabled electronics, the PolyZen device can be placed on the VBUS of the USB input port, the DPWR port of the Powered-B plugs, the barrel jack power port, and VBUS input of USB hub devices.

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It should be noted that USB 3.0 will not support bus-powered hubs and will only support self-powered hubs. A power source is now needed to power-up all ports of the hub in USB 3.0 applications. If a DC power connector is used at the input to the hub, a circuit protection device may be warranted to help protect the hub electronics from damage caused by overvoltage events, from an unregulated or incorrect supply, reverse voltage, or voltage transients.

Figure 1 shows how installing a PolyZen device on the VBUS as well as six low-capacitance Silicon ESD (SESD) or Polymer ESD (PESD) protection devices from Littelfuse on a typical host and device circuit, can help provide a coordinated overvoltage solution.

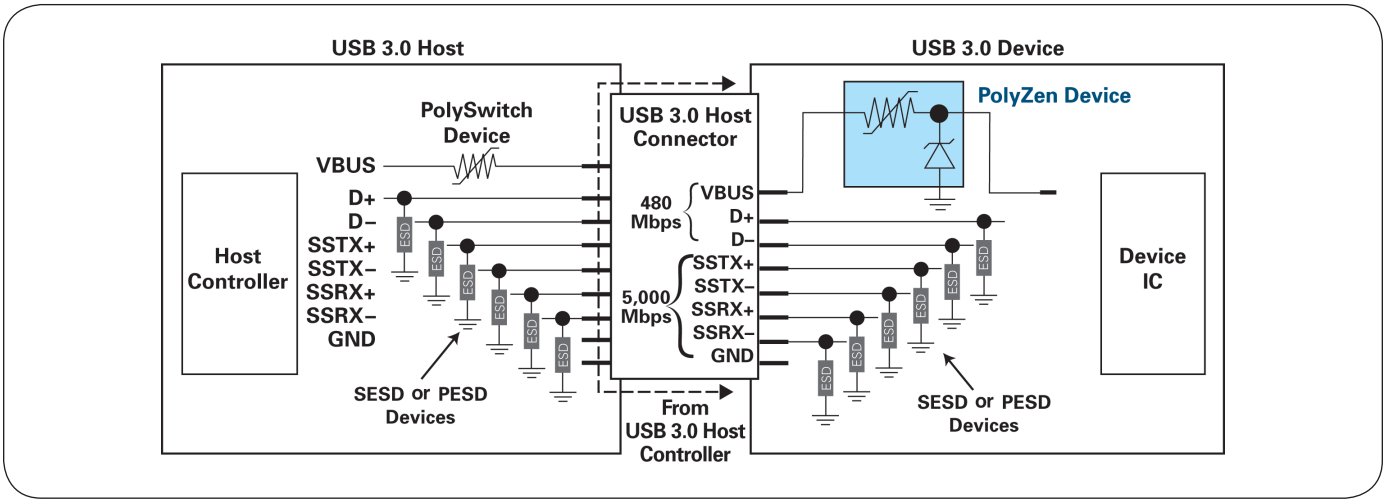

Figure 1. PolyZen devices and Silicon or Polymer ESD protection devices provide a coordinated protection solution on host and device side

Operating Current During Suspend Mode for USB

All USB-compliant devices support suspend mode, which generally refers to a sleep state where the device may not consume more than 2.5mA of current. A device transitions into suspend mode after it remains in a constant idle state on its upstream-facing bus line for more than 3msec. The device draws a suspend current from the bus after no more than 10msec of bus inactivity on all of its parts.

Some electronic devices have the capability to generate remote wake up signals. This enables the device to transition back to normal mode of operation from the sleep state.

The USB 2.0 specification states that all electronic equipment, either low- or high-power, must default to low power during suspend state. This means that when operating at low power, low-power devices such as flash drives or high-power devices such as external HDDs are limited to just 500µA of suspend current (i.e., 1/1000th of the rated current during normal operation mode).

USB-enabled devices with the capability of generating remote wake up signals are allowed (as per the specification) to draw up to a maximum of 2.5mA during suspend mode. This also holds true for configured bus-powered devices. Each available external port (up to 4 ports) is allocated 500µA, leaving the remainder available for the hub and its internal functions. An un-configured hub is considered a low-power device and suspend current is limited to 500µA.

The power control during suspend mode slightly differs for USB 3.0, or “SuperSpeed USB,” host controllers and most of the supporting devices. USB 3.0 does not define a low-power

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or high-power device. All USB 3.0 devices may draw a current of up to 2.5mA during suspend mode. Bus-powered compound devices may consume up to 12.5mA suspend current with 2.5mA suspend current for each port, up to a maximum of four ports, and 2.5mA suspend current for internal hub and its functions. The suspend current so defined includes the current from VBUS through bus pull-up and pull-down resistors.

It is always advantageous to have as little operating current as possible in order to improve the battery life of portable devices. Though typical standby modes consume less power than normal operating modes, operating current from the CMOS-based devices used may still occur. The operating current, if high enough, can wake up the device from sleep mode.

Figure 2 shows I-V comparison curves of pulse length at 300µsec for three low power PolyZen devices. As shown on the graph, the operating current for the PolyZen ZEN056V130A24LS device varies from 1mA at 4.75V to 4mA at 5V. For the PolyZen ZEN065V130A24L device the operating current at 5V is close to 5µA; however, its typical clamping voltage at 100mA is 6.5V. The third device depicted on the chart, the ZEN059V130A24LS device, has a typical current consumption of 500µA at 5V. The low-power-consumption PolyZen device bridges the gap between the ZEN056V130A24LS and ZEN065V130A24L devices by providing both low clamping-voltage and low current-consumption (at 5V). The new PolyZen ZEN059V130A24LS device helps protect downstream electronics sensitive to voltages above 6V.

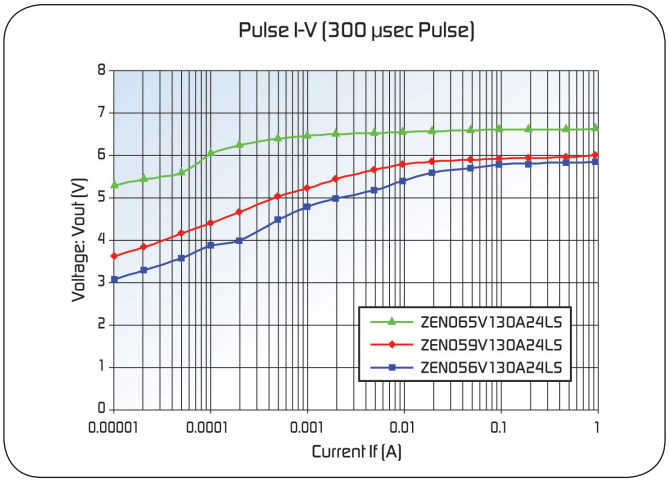

Figure 2. I-V comparison curves of PolyZen devices at pulse length at 300Qsec.

Recommended Devices

PolyZen devices offer designers the simplicity of a traditional clamping diode while obviating the need for significant heat sinking. This single device helps provide protection against the use of improper power supplies, as well as protection from damage caused by overcurrent events. A new low-power-consumption PolyZen device also provides low operating current during suspend mode, making it a suitable overvoltage protection device for USB controllers and compliant devices.

The table below shows recommended PolyZen devices for three typical applications.

USB 2.0/3.0 Recommendation	Typical Clamping Voltage @ 100 mA [Volts]	Typical Current Consumption @ 5V [mA]	Notes
ZEN056V13024LS	5.6	4	Low Voltage Clamping
ZEN059V130A24LS	5.9	0.50	Low Voltage and Low Power Consumption in Suspend Mode
ZEN065V130A24LS	6.5	0.005	Low Power Consumption

Table 1. Selection of PolyZen devices for USB 2.0 and USB 3.0.