Why does USB 2.0 need Circuit Protection?

- As USB transmission speeds and communication baud rates between host and peripherals increase, the reliability and robustness of devices when exposed to circuit transients become more important.
- As products shrink to accommodate faster speeds, the circuitry becomes smaller and more sensitive. Frequent occurrences of potential transient over-voltage and overcurrent events exist that can cause soft, latent or even catastrophic failures.
- Every time the device is connected or disconnected, the circuit receives a voltage/current transient. An electrostatic Discharge (ESD) event is one such transient.

What type of transients occur?
USB is susceptible to two main types of events:
1) Overvoltage transients
2) Overcurrent events

Protecting Against Over-Voltage Transients
- A common source of over-voltage transients is ESD. The typical maximum level of ESD protection included in modern IC chips is 2000V. While this is sufficient to provide survivability in the manufacturing process, much higher ESD levels will be experienced when the final product is put to use.
- Humans can generate ESD levels of greater than 15kV simply by walking across a carpet. This level of ESD can easily be discharged into a USB port and damage on-chip protection circuits.
- As USB 2.0 data rates increase to 480Mbps, the selection of the correct ESD suppression type is critical. PulseGuard® ESD suppression devices have very low capacitance which allows them to be used in circuits with higher data rates than other technologies. Figure 1 shows the effect of waveform distortion caused by excess capacitance on a data line.
Outside World

USB Port Shield

ML1 ML2 PG1 PG2

USB Controller/Transceiver

USB Port Shield

Table 1. Symbol Definition

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shield</td>
<td>(Chassis Ground)</td>
</tr>
<tr>
<td>GND</td>
<td>(Signal Ground)</td>
</tr>
<tr>
<td>PTC 1, 2</td>
<td>1206L/1812L Series Resettable PTC</td>
</tr>
<tr>
<td>ML1, 2</td>
<td>V5.5MLA0603</td>
</tr>
<tr>
<td>PG1, 2</td>
<td>PGB0010603</td>
</tr>
<tr>
<td>SOT1</td>
<td>PGB002ST23</td>
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</tbody>
</table>

Option: SOT23 PulseGuard Surface Mount
ESD Suppressors provide High Speed Data Line Protection on both D+ and D- lines in one package.

Figure 3. USB 2.0 port protection reference design.

• Other over-voltage transients that occur on the USB power line, due to events such as hot plugging, can be clamped by surface mount MLVs (Multi Layer Varistors.) The impulse energy caused by the voltage transient is clamped by the suppressor at a level low enough to ensure survival of the sensitive circuit components.

• Figure 2 shows the general clamping operation of a voltage transient by an MLV. The voltage is clamped to a level below that which could cause damage to the circuit.

Figure 2. Operation of MLV in ESD event.

Protecting Against Over-Current Events

• Over-current events that occur on the USB power line can be dealt with effectively by the polymer-based PTC (Positive Temperature Coefficient) device. The PTC reacts to an excessive current by changing to a high impedance state.

• The PTC’s ability to reset itself, after the power source is removed, ensures its effectiveness in plug and play applications, such as USB.

Figure 3 above shows the schematic layout for protecting a USB device against voltage and current transients.

• The USB system consists of four lines which connect the various USB components; two data lines, Vbus and GND.

• The protection devices are connected from all four USB lines directly to the chassis ground, separating the ESD ground return path from the data ground.

Benefits

• To ensure reliable and safe circuit operation of USB products, protection against voltage and current transients must be carefully considered. Due to the higher data rates of USB 2.0, attention to the electrical characteristics of protection solutions is required.

• Littlefuse offers the broadest selection of overvoltage and overcurrent circuit protections solutions to suit any USB 2.0 application.

USB Schematic

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EC616

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