

ESD Protection USB 2.0 Data Lines

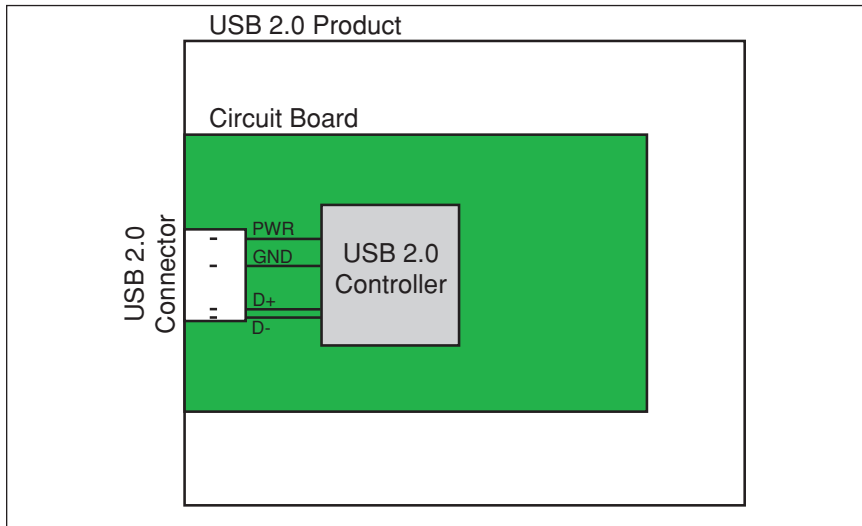


Figure 1. Simple USB 2.0 circuit diagram (ESD suppressors protect the data lines which have exposure to the outside world. The USB 2.0 protocol uses 2 high-speed data lines).

Background

Universal Serial Bus (USB) products (PCI adapter cards, digital cameras, peripherals, etc.) can be susceptible to ESD events when the cable is disconnected from the data port. The ESD pulse can be introduced directly into the open port, or into the disconnected end of the cable. Either way, the integrated circuitry that controls the USB functionality can be compromised.

The Problem

After the ESD pulse is introduced into the data port, it will travel through the connector to the PC board. Once on the PC board, it

will propagate down the data lines toward the integrated circuitry. Specifically, the IC of concern is the **USB 2.0 Controller**. Without sufficient protection, the Controller chip can be rendered inoperable.

The Solution

In order to provide the IC with protection against ESD transients, the use of suppression products is recommended. The suppressors are installed between the data line and the chassis ground (parallel connection) and shunt the ESD transient from the data line to the ground.

For high-speed protocols like that of USB 2.0 (480 Mbps), suppressors with extremely low capacitance levels should be used. Suppressors with high capacitance can affect the data stream by distorting the data waveforms

Littelfuse offers PulseGuard[®] ESD suppressors as a solution for USB 2.0 data line ESD protection. These products are surface mount devices with 0.050 pF of capacitance. So they will provide ESD protection and maintain the integrity of the data signals.

Examples of USB 2.0 products which can benefit from ESD protection include:

- Computers (desktops and laptops)
- Peripherals (printers, scanners, etc.)
- Handheld devices (PDA's, cell phones, MPEG players, etc.)
- Repeaters and hubs
- Digital still cameras



Capacitance and Signal Integrity

In previous generations of I/O protocols (RS232, USB 1.1, 10BaseT Ethernet, etc.), the signal speed (rise/fall time of logic states) was sufficiently slow that the parasitic components of circuit protection devices was of minimal concern.

However, as data rates have increased, the capacitive loading that is presented to the data circuitry by the protection device becomes more of a concern. For example, the diagrams to the right show the effect capacitive loading has on USB full and high speed waveforms.

In the first set of diagrams, data is shown for the 12 Mbps data rate. The first diagram shows the eye diagram for a control board which only contain traces for the data lines. The second diagram shows the response of a data line which has a PulseGuard[®] ESD (0.050 pF) suppressor installed. The third diagram is included for reference, and shows the response when a 3 pF capacitor is installed on a data line. The PulseGuard device and capacitor were referenced to ground. The second set of diagrams replicates the same tested devices, but raises the data rate to 480 Mbps. Notice how the slower 12 Mbps data speed can tolerate a higher level of capacitance.

The signals replicate the USB, rev. 2.0 (Template 5 - section 7.1.2.2) protocol ($\pm 0.480V$, 12 and 480 Mbps); created on Agilent 81250 ParBERT equipment and measured with an Agilent Digital Communications Analyzer.

12 Mbps

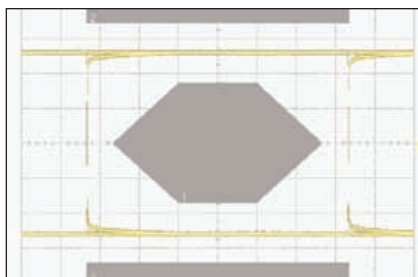


Figure 2. Test board traces for 12Mbps USB 1.1 data line

480 Mbps

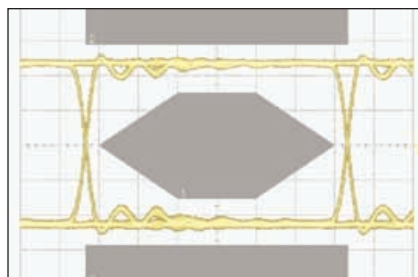


Figure 5. Test board traces for 480Mbps USB 2.0 data line

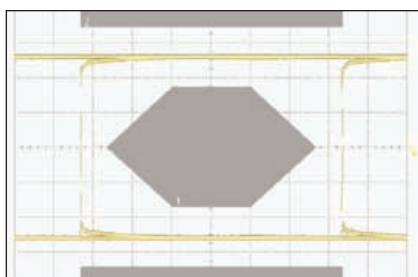


Figure 3. PulseGuard[®] suppressor traces for 12Mbps USB 2.0 data line

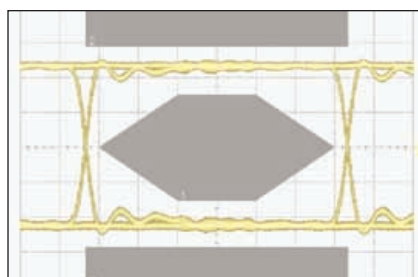


Figure 6. PulseGuard[®] suppressor traces for 480Mbps USB 2.0 data line

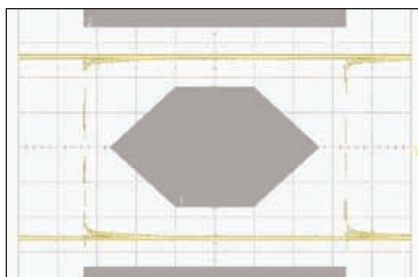


Figure 4. Surface mount capacitor (3 pF) traces for 12Mbps USB 2.0 data line

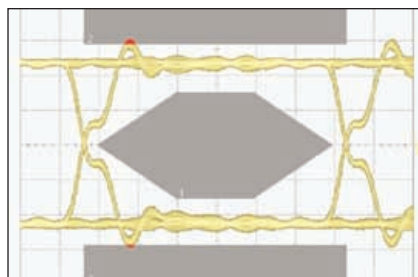


Figure 7. Surface mount capacitor (3 pF) traces for 480Mbps USB 2.0 data line

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