TECH
BRIEF

ESD Protection Ethernet Data Lines

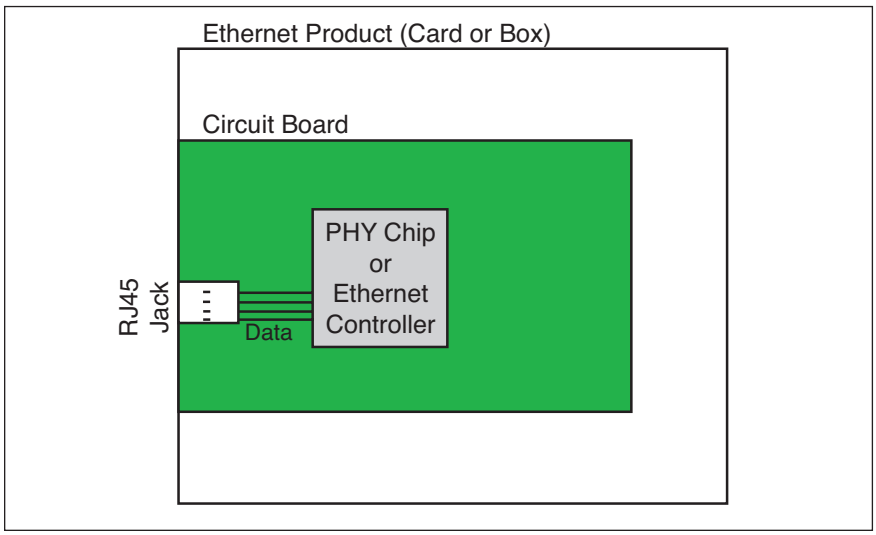

Figure 1. Simple Ethernet circuit diagram (ESD suppressors protect the data lines which have exposure to the outside world. Ethernet and Fast Ethernet use 4 data lines, while Gigabit Ethernet uses 8 data lines).

Background

Ethernet products (PCI adapter cards, hubs/routers, etc.) can be susceptible to ESD events when the cable is disconnected from the Ethernet 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 Ethernet functionality can be compromised.

The Problem

After the ESD pulse is introduced into the Ethernet 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 **PHY chip** and/or **Ethernet Controller**. Without sufficient protection, the PHY/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 Fast Ethernet and Gigabit Ethernet, suppressors with very low capacitance levels should be used. Suppressors with high capacitance can affect the data stream by distorting the data waveforms

Littelfuse offers MHS multilayer varistors, SP series rail clamp arrays, and PulseGuard® ESD suppressors as a solution for Fast and Gigabit Ethernet ESD protection. These products are surface mount devices with 3.0 pF (or less) of capacitance. So they will provide ESD protection and maintain the integrity of the Ethernet signals.

Examples of Ethernet products which can benefit from ESD protection include:

- PCI adapter cards
- Hubs and routers (Layer 2-3 switches)
- Intelligent content managers (Layer 4-7 switches)
- PLC units, Process controller units
- Residential gateways and other broadband internet access products

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Capacitance and Signal Integrity

As new I/O data protocols continue to be introduced, it is important to realize that the non-suppression characteristics of an ESD suppressor must be taken into account during the design process.

For example, at the 10BaseT Ethernet data bit rate (10 Mbps), a higher level of capacitance can be tolerated than at the 100/1,000BaseT Ethernet data bit rate (125 Mbps). The following eye diagrams can be used to demonstrate this phenomenon.

In the first set of diagrams, data is shown for the USB 1.1 (12 Mbps) data rate and is used to replicate the 10BaseT system. The first diagram shows the eye diagram for a control board which only contains traces for the data lines. The second diagram shows the response of a data line which has a V18MLE0603 (75.0 pF) multilayer varistor installed. The third diagram is included for reference, and shows the response when a 3 pF capacitor is installed on a data line and is used to replicate Littelfuse 3 pF multilayer varistors and diode arrays. The multilayer varistor and capacitor were referenced to ground.

The second set of diagrams replicates the same tested devices, but raises the data rate to 100 Mbps. So, for the 10BaseT system, the higher capacitance multilayer varistor can be used for ESD protection and EMI filtering without affecting signal integrity. However, in the 100/1,000BaseT system, it is necessary to use lower capacitance devices (3 pF and lower) such as the MHS series multilayer varistor, the SP series rail clamp array, or the PulseGuard® polymer suppressor. In all cases, the overall system capacitance should be considered when choosing an ESD suppressor.

The signals replicate the USB 1.1 (12 Mbps, section 7.1) and IEEE 1394-1995 (100 Mbps, section 4.2) protocols; created on Agilent 81250 ParBERT equipment and measured with an Agilent Digital Communications Analyzer.

10BaseT

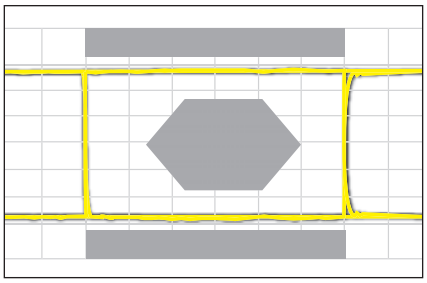

Figure 2. Test board traces for an Ethernet 10BaseT data line

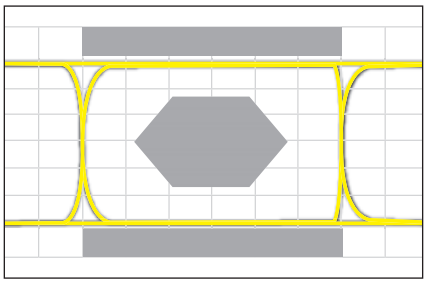

Figure 3. MLE traces for an Ethernet 10BaseT data line

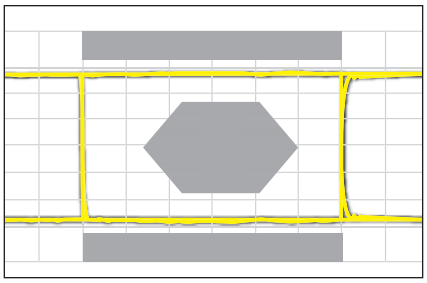

Figure 4. Surface mount capacitor (3pF) traces for an Ethernet 10BaseT data line

100BaseT / 1000Base T

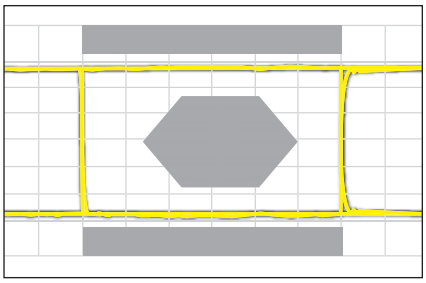

Figure 5. Test board traces for an Ethernet 100BaseT / 1000BaseT data line

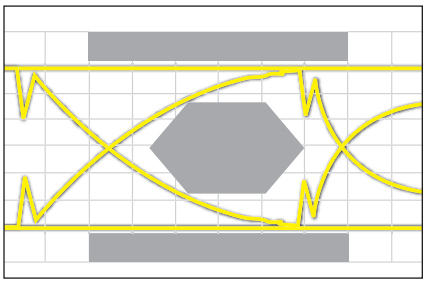

Figure 6. MLE traces for an Ethernet 100BaseT / 1000BaseT data line

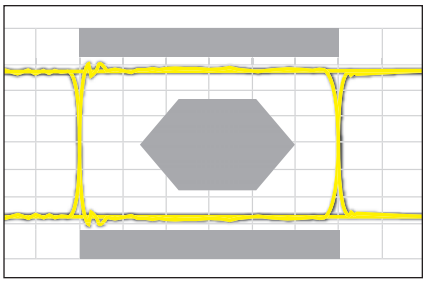

Figure 7. Surface mount capacitor (3pF) traces for an Ethernet 100BaseT / 1000BaseT data line

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