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ESD Protection

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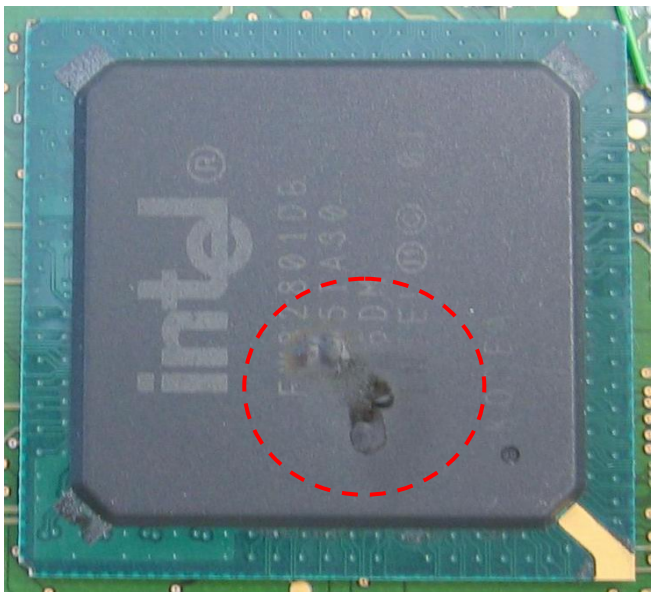
1 Sample of Damaged Chip by ESD



2 Background ESD

2.1 Scope

This application note provides a brief introduction to electrostatic discharge (ESD), methods for testing of ESD events, and ways to protect USB interfaces against ESD events.

2.2 Introduction to ESD

In today's electronic devices, ESD (Electrostatic Discharge) is being looked upon as a reliability threat. All electronic equipment that is sold into the European Union must possess the CE mark which designates it has passed a required set of test standards. These test requirements include system testing for ESD protection. The purpose of the ESD test is to demonstrate that a device can withstand static discharges encountered in normal handling and/or operation of the equipment.

2.3 What Is ESD?

A static charge is an unbalanced electrical charge at rest. A static charge is created when insulator surfaces rub together or pull apart causing an imbalance of electrons. Once the voltage charge on opposing surfaces becomes sufficiently high enough to break down the dielectric strength of the medium separating the two, the resultant is an electrostatic discharge, referred to as ESD. Movement of the electrons between the surfaces occurs until both surfaces are equally charged once again. Movement of charge, referred to as current flow, is the cause of damage to semiconductor devices. ESD can occur in several common ways: charged body discharge to an IC, charged IC can discharge to grounded surface, or a charged machine can discharge to an IC.

2.4 Realistic ESD Levels

ESD levels produced depend heavily on the environment. In some manufacturing environments, highly charged machinery and materials can become a huge capacitor, capable of storing in excess of 50,000 volts of static electricity. This highly charged “capacitor” could cause uncomfortable shocks to operators, even burns, or injury due to physical reaction from receiving a shock.
In dry environments it is possible for humans to be charged up to 35,000 or more volts just by walking across a rug. Human sense can ESD once levels have reached 3-4KV, generally above the threshold of damage to semiconductors. To avoid this type of damage, devices must be continuously provided with ESD protection.

2.5 Latent Failures

Depending on the ESD characteristics and level encountered, the failure mode of semiconductors will behave and occur differently. Outside the instantaneous logic error or catastrophic failure (damage), repetitive ESD stress can produce degradation or failures over time and is referred to as latent ESD defects. This occurs when an ESD pulse is not strong enough to destroy a device but still causes damage. Although the device may suffer this degradation, it may still function within datasheet specifications. A device can be subjected to numerous weak ESD pulses, with each one further degrading a device before it succumbs to a catastrophic failure. There is no known practical methodology able to screen for devices with latent ESD defects.

2.6 Neutralizing Static

Some basic methods to neutralize static electricity are using humidification, antistatic coatings and carbon loading to make an insulator behave more like a conductor. If an insulator can be made to behave more like a conductor, earth grounding would be more effective at preventing the building up of static charges. In addition, ionization is commonly used to reduce static fields. Ionization is made possible by the process of splitting air molecules into positive and negative charges, An ionizing device emits quantities of negative and positive ions in the vicinity of the statically charged object. Since opposite charges attract, the charged object takes on a sufficient number of negative or positive ions, depending upon which is required for charge neutralization.

2.7 Proper ESD Handling

The best way to avoid ESD damage is to provide proper training and documentation to manufacturers and end-users on proper ESD protection. It is important to keep ICs and everything that comes in close proximity to them at ESD ground potential. Several rules should be followed when handling sensitive ESD devices in the manufacturing environment:

- ESD wrist straps and footwear are to be used by persons handling board or component. Static generating clothing must be covered with an ESD protective lab coat.
- All insulator materials must either be removed from the work area or neutralized with an ionizer.
- Work stations must be used with a conductive or static dissipative floor or floor mat.
- Work surfaces where devices are placed for handling, processing and testing must be made of static dissipative material and be grounded to ESD ground.
- When boards or components are being stored, shipped or transported between locations, they must be kept in an antistatic container with inside surfaces (contact with the board) being static-dissipative.
- Environment climate should be maintained with the range of 40-60% humidity.

Manufacturers should provide clear ESD handling instructions to the end-user. Labelling shall clearly indicate by words and/or symbol that ESD sensitive devices are contained in system and may be susceptible to ESD. User manuals should contain a statement referencing proper handling, for example: “Upgrading or repairing of system should be done at an ESD workstation using an antistatic wrist strap and a conductive foam pad. If such a station is not available, you can provide some ESD protection by wearing an antistatic wrist strap and attaching it to a metal part of the system chassis.

A comprehensive guideline to proper device ESD handling can be referenced from JEDEC document JESD625-A.”

3 Systems ESD Conformity

The ESD system must conform all current ESD standards.
Critical points in a system are:

- Use only guide rails with grounded ESD contacts
- All screws of a front panel must be fastened to the system
- The cabinet must be grounded with large diameter, short cabling to potential earth
- Slots that are not in use, must by close with blind front panel

4 USB need for ESD Protection

USB 2.0's interface is comprised of a differential signal pair utilizing data rates up to 480 Mbps and is found in most computer applications today. These ports are commonly handled by users and are subject to ESD events directly to either the connector, device or to the pins (differential signal pins and/or power) themselves as described above. Given this exposure, these USB ports and devices need ESD protection. Careful attention to design detail is required so that the ESD solution does not interfere with the signal quality of these high speed interfaces (i.e. the solution needs to be low capacitance).

5 External Solutions to Improving ESD Immunity

In the event that board changes can not be made, there are several alternatives that involve external devices. One such alternative is a small dongle like device that has TVS circuitry embedded. While not optimum, such a device should provide significantly increased protection ESD events. Alternatively, using external HUB devices that already provide such protection between the USB Port and an external device can provide similar protection for motherboards with lower than desired ESD performance. These are some possible solutions for end user environments.
When handling CPCI-boards on the factory floor and in the end user environment, care should be taken to minimize ESD events. This typically can be done with the use of ESD wrist straps properly grounded. There is a whole industry serving the ESD protection field providing products from wrist straps to floor mats.
A comprehensive guideline to proper ESD device handling can be referenced from JEDEC document JESD625-A.

6 Conclusion

Electrostatic discharge (ESD) events can damage the USB interface devices if precautions are not taken. We have found devices to be effective in reducing the effects of ESD pulses on the USB interface. Several devices tested have been identified as effective, but board manufacturers should carefully assess the characteristics of a particular TVS device for suitability.

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