VERSALOGIC CORPORATION

A VersaLogic
Focus on Reliability White Paper

The Invisible Foe – Understanding and Controlling ESD Damage

Contents

Introduction

How much is your company losing to electrostatic discharge (ESD) damage each year and what can you do about it? Although often unrecognized, the costs related to ESD are a significant financial drain on many high-tech companies. The purpose of this white paper is to expose the hidden costs of ESD and help original equipment manufacturers (OEMs) take the steps required to attack the "invisible foe" of ESD damage. Through the development of effective ESD control processes and programs, OEMs can improve manufacturing yields, reduce field failures, lower warranty costs, and improve product reliability.

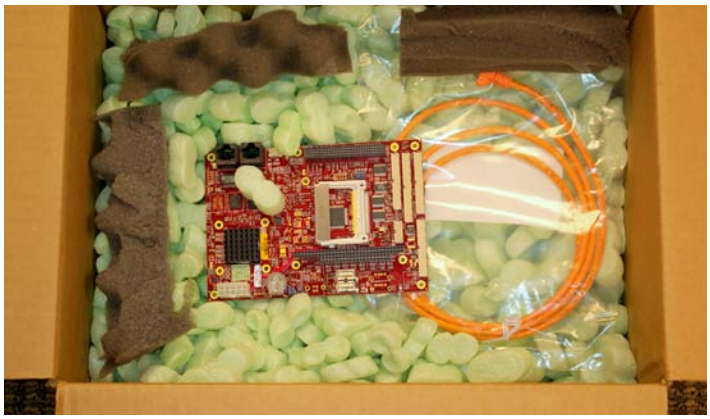
Understanding ESD

ESD is the sudden flow of electricity between two objects. ESD occurs after a buildup of static electricity on an object. Electrostatic charge is most commonly created by the contact and separation of two similar or dissimilar materials. For example, a person walking across the floor generates static electricity as shoe soles contact and then separate from the floor surface. An electronic device sliding into or out of a bag generates an electrostatic charge as the device makes multiple contacts and separations with the surface of the bag. As shown in **Figure 1**, even the seemingly inconsequential act of picking up a poly bag generates more than enough static electricity to cause damage.

Figure 1. Examples of Static Generation, Typical Voltage Levels

Means of Generation	10-25% Relative Humidity	65-90% Relative Humidity
Walking across carpet	35,000V	15,000V
Walking across vinyl tile	12,000V	250V
Working at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Sitting in chair with urethane foam	18,000V	1,500V

Source: www.esda.org/fundamentalsP1.html



Improper packaging of static-sensitive product. Clear plastic bubble wrap, styrofoam packing, and crumpled newspaper are all potential sources of static electricity and may damage a sensitive component.

Humidity is also a major factor in the generation of static electricity. Greater amounts of static electricity are generated when humidity is low. This is due to the amount of water molecules in the air (humidity) that conduct some of the static charge and drain it into the ground. While the magnitude of electrostatic charge may be different in these examples, static electricity is indeed generated.

ESD is undeniably the "invisible foe" of electronic product quality and reliability. Hundreds of times a day ESD events occur below the human sensitivity threshold of 3,000 volts. An ESD can result in spectacular electric sparks, but often they are neither seen nor heard. Although silent, these unseen discharges are large enough to cause damage to electronic devices. With circuit boards and other delicate electronic components, this rapid discharge of static electricity to ground causes significant and expensive damage. Devices vary significantly in their sensitivity to ESD, but a mere 100 volts of static electricity can damage many complex components.

The risk of ESD damage has increased as components have become smaller and have smaller internal geometries. As a result, unshielded electronic devices are becoming increasingly sensitive to damage at lower voltage levels. In fact, a mere wave of an arm can generate enough static electricity to damage many components. Due to this increase in sensitivity to ESD, quality and reliability practices that were largely effective just a few years ago may be insufficient to protect products from ESD damage today.

The Cost and Impact of ESD

A typical high-tech OEM may be losing tens to hundreds of thousands of dollars annually to ESD damage, perhaps without knowing either the cause or the total impact. Gaining a better understanding of the impact that ESD has upon an OEM builds the case for allocating time and resources to control ESD.

High-tech companies lose at least 4% to 6% of annual gross sales due to ESD every year according to Stephen Halperin, president of the Electrostatic Discharge Association. "I know of companies who are aware of ESD losses totaling 10% or more of their gross sales — and that is only the losses above which they had budgeted for," notes Halperin.[1]

An OEM has much more to lose to static discharge than a component manufacturer, due to the cost of finished assemblies. A component that costs only $10 to replace and retest on its own could cost hundreds or thousands of dollars to repair or replace when it fails in the field. Estimates are that the cost of repairing an ESD damaged product increases tenfold at every level — from component to system.

[1] Source: Steven Hilperin, "Guidelines for Static Control Management," Eurostat. 1990 www.halperinassoc.com/Downloads/GuidelinesforStaticControlManagement.pdf

Proper packaging of static sensitive product. The sensitive board is sealed in a nickel coated static shield bag.

For example, a manufacturer of a complex million-dollar system tracked their ESD losses with astounding results. When a small (under $5) electronic part failed, the technician had to break the seal on the system, pull the subassembly, and replace or repair it. Not including the cost of the part that failed, the company's cost to disassemble, repair, retest, and reassemble each system ranged from $28,000 to $30,000.

In addition, much of the financial impact of ESD damage is not immediately apparent and the results are not always easy to attribute or calculate. Today it is recognized that less than 5% of the total cost of ESD failure is the device cost. When the costs of repair and rework, shipping, labor, increased inventory to cover projected product failure, paperwork, warranties, and overhead are included, the real cost to the OEM of inadequate static control becomes apparent.

Establishing Effective ESD Control

Establishing an ESD control program is the first step to mitigating ESD damage loss and potentially realizing significant improvements in quality and reliability. The Electrostatic Discharge Association (ESDA) standard S20.20-2007 outlines the requirements for an ESD control program. The standard advises, "When handling devices susceptible to less than 100 volts Human Body Model (HBM), more stringent ESD Control Program Technical Requirements may be required, including adjustment of program Technical Element Recommended Ranges." So, it is up to each company to define the level of ESD protection it requires and to develop acceptable minimum standards for ESD control.

Unfortunately, the level of ESD protection needed varies greatly among companies and many programs are not stringent enough to adequately protect against ESD damage and loss. Defining and implementing a rigorous ESD control program is essential to delivering superior product reliability.

Eight Steps to an Effective ESD Control Program

A complete ESD control program includes a plan, training, protective equipment, management, and system audits. The following steps provide a framework for establishing an ESD control program:

1. **Research and Consult with Experts**
   Learn all you can about preventing ESD damage at your company. Check with industry groups such as the ESD Association (Rome, NY) and IPC Association (Northbrook, IL). Many engineering and consulting companies also provide specialized expertise. ESD-safe-product companies can provide good advice, but be aware that they can be biased. As a result, be sure to take your own measurements. See **Figure 2** for some suggestions on where to start your research.

Figure 2. ESD Control Program Resources	
ESD Association	www.esda.org
IPC Association	www.ipc.org
ESD Products Manufacturers	Talk to several vendors
Compliance Engineers' ESD Help Desk	www.ce-mag.com/esdhelp.html
ESD training resources	training.ipc.org/ *(choose ESD Control under Electronics Assembly)* www.staticspecialists.com/esdawareness.html

2. Identify Sensitive Work Areas

Work areas requiring ESD protection include assembly and packaging stations, engineering and testing areas, and anywhere else that unshielded products or components are handled or stored (see **Figure 3**). To achieve the highest standards, include areas that are not always thought of as requiring ESD protection.

Figure 3. Typical Facility Areas Requiring ESD Protection	
■ Receiving ■ Inspection ■ Stores and warehouses ■ Assembly ■ Test and inspection	■ Research and development ■ Packaging ■ Field service repair ■ Offices and laboratories ■ Clean rooms
Source: www.esda.org/fundamentalsP3.html	

3. Identify the Sources of ESD within Work Areas

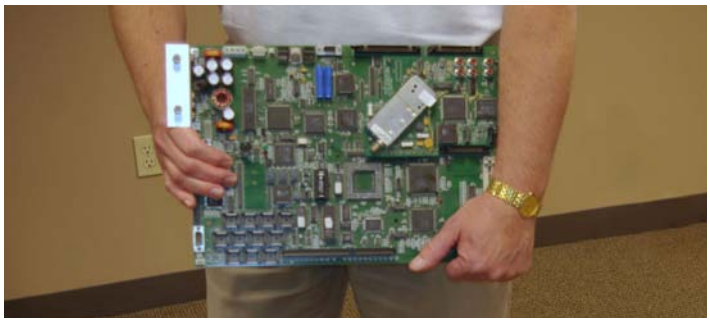
Non-conductive materials such as plastic parts, tape, cardboard, and Styrofoam are common sources of ESD. High-voltage items like computer monitors or laser printer paper also generate static charges. Measuring ESD levels with a static meter will show problem areas and items.

4. Establish the Level of Protection Required for Each Work Area

Areas with high static generation may require special solutions, even when ESD-sensitive components are not handled directly. For instance, a plastic injection molding plant may have static levels high enough to require a wireless keyboard and mouse for each computer to prevent ESD damage from occurring through the I/O cables.

5. Develop a Plan

The ESD Control Program Plan should include the tasks, activities, and procedures necessary to adequately protect sensitive components and systems. Prepare written procedures and specifications that clearly communicate



Improper handling of static-sensitive products: at a minimum, the board should be transported in an antistatic tote or antistatic shield bag.

roles and responsibilities. The plan must include guidelines for personnel training, verification that the plan is being followed, and a list of the technical requirements and ESD-protective products approved for use in the program.

6. Institute Static Protection Solutions

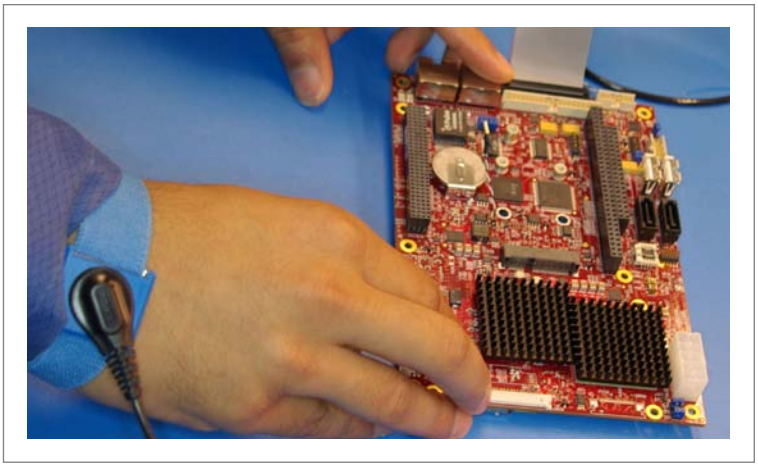
Protection methods include a combination of signage, grounding systems, and charge generation control. A well-protected area may be one in which grounding floor mats and work surface mats are installed, protected areas are marked with tape, and personnel wear wrist straps, heel straps and ESD-protective clothing. See **Figure 4** for additional static protection solutions. Dry environments benefit from installation of ionization and humidification systems to reduce charge generation. ESD protection devices vary in capability and the protective range should be checked against the sensitivity of the products being handled. **Figure 5** provides a list of common materials used creating ESD protection.

7. Build Teams and Educate Staff

Enroll employees from relevant areas of the company to be team members. Make it their program and delegate the responsibility of auditing and maintenance to them. Quality management can then verify records and conduct periodic compliance audits. Delegating in this way not only minimizes the drain on management resources, but also allows the affected employees to take ownership of the process, thus increasing employee participation and compliance. Train and retrain your personnel to instill a mindset that ESD awareness

Figure 4. ESD Causes and Solutions

ESD Causes	ESD Solutions
People	■ Grounded wrist straps ■ ESD-protective floor mats and finishes ■ Dissipative shoes or heel straps ■ ESD-protective coats ■ ESD-protective workstations and work surfaces
Carts and other wheeled equipment	■ Carts with drag chains or conductive casters or wheels
Production and test equipment	■ Grounding
Production aids (hand tools, soldering irons, tapes, adhesives)	■ Grounding — 3-prong grounded-type AC plug for electrical tools, grounding of work surfaces and personnel ■ ESD-protective labels
Material handling	■ ESD-protective packaging and material handling containers — preferably materials that are anti-static and provide discharge



Proper handling of static-sensitive products: grounded wrist strap, grounded conductive work surface, and antistatic smock protect against ESD damage.

is a valuable ongoing effort that can mean the difference between the company's profitability and loss. Make sure that the program is understandable, even to non-technical employees. No ESD program will be completely successful without the complete participation of all staff.

8. **Maintain the ESD Control System**
   Protection of production floors, testing stations, and other areas takes planning, education, maintenance, and testing. Ongoing maintenance and system audits are essential to ensure that

Figure 5. Common Materials Used in Creating an ESD Control Area

ESD Control Material	Description
Wrist strap	Connected to a ground point, a wrist strap keeps the wearer at near-ground potential.
ESD-protective work surface	The ESD-protective work surface is usually a conductive map, with fairly high resistance, that is connected to ground. Such a surface provides controlled dissipation of static charge built-up on any materials that come into contact with it.
ESD-protective floor surface	ESD-protective floor surface is conductive flooring connected to ground. It provides a path of dissipation for charge built-up on personnel or equipment in contact with it.
Antistatic chair	An antistatic chair is made with conductive components and fabric. It is designed to conduct any static charge off of the user's body, into the grounded floor.
Foot strap	Foot straps are typically worn over a non-conductive item of footwear. The foot strap provides contact with an ESD-protective (conductive) floor and the users skin, in order to drain any static charge off of the wearer before it builds up.
Conductive shoes	Conductive shoes are used in conjunction with an ESD-protective floor surface, such shoes provide electrical contact for dissipation of charge away from the wearer.
Antistatic smock	Electrostatic charge may build up on a person's clothes, despite the fact that they are wearing a wrist strap. An antistatic smock should be used to prevent a charge from building up on the user's clothing.
Air ionization	Ionizers are used when it is not possible to properly ground everything and as backup to other static control methods. Using an ionizer, a charge built-up on insulated or isolated objects can be effectively neutralized as the opposite polarity charges are attracted from the air.

VERSALOGIC CORPORATION

12100 SW Tualatin Rd.
Tualatin, OR 97062
(503) 747-2261

www.versalogic.com

VersaLogic has built its reputation on reliability through quality products and superior service. It works continuously with its customers and within the industry to help promote the highest standards of product reliability. Part of this effort is VersaLogic's ongoing series of "Focus on Reliability" white papers, which are intended to provide impartial guidance and advice to promote product reliability.

ESD control programs remain effective. Many ESD devices lose effectiveness over time. Periodic cleaning keeps the equipment and devices working properly. Wrist straps, heel straps, and other personal grounding devices require testing and occasional replacement. Periodic testing, either with static locators or grounding test equipment, is needed to identify problems. A static charge meter can indicate the strength of the entire system. If an area is found to have minimal static charges, it is evidence of an effective system.

Audit your plan to verify that the ESD control system is successful. Technological changes will dictate improvements and modifications. Provide feedback to management and employees. Adjust company practices to keep the program on track. To ensure ongoing compliance, invest in quarterly ESD audits.

Conclusion

By shedding light on the hidden costs of ESD, OEMs can learn to address this problem head-on. Although not readily apparent, the many hidden costs related to ESD are a significant drain on the financial wellbeing of many companies. It is critical that OEMs that handle electronic components keep a close watch on this issue. Through the development of effective ESD control processes and programs, OEMs can improve manufacturing yields, reduce field failures, lower warranty costs, and improve product reliability.

Endnotes

1 Stephen Halperin. Interview by Kristin Allen. (June 26, 2002) www.allenmarketingdesign.com/samples/esd.wino2.pdf

2 Compliance Engineering. (2002, March/April) "Controlling ESD though Polymer Technology" by Neil T. Hardwick. Retrieved May 29, 2002 from www.ce-mag.com/archive/02/03/hardwick.html

3 ESD Association. (2001, August 15) "Fundamentals of ESD, Part One – An Introduction to ESD" Retrieved May 29, 2002 from www.esda.org/fundamentalsP1.html

4 Lonnie Brown and Dan Burns, "The ESD Control Process is a Tool for Managing Quality," Electronic Packaging and Production, April 1990, pp 50-53

5 ESD Association. (2001, August 15) "Fundamentals of ESD, Part Two – Principles of ESD Control" Retrieved May 29, 2002 from www.esda.org/fundamentalsP2.html

6 IPC - Association Connecting Electronics Industries. VT-54 Training Package, "ESD Control" Copyright 2000.

7 ESD Association. "Fundamentals of Electrostatic Discharge, Part Three - Basic ESD Control Procedures and Materials" Copyright 2010.