Welcome to the ESD training module.

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Objectives

Upon the completion of this module, you will be able to

- describe how ESD is created
- list the causes of ESD
- describe and use ESD protection methods

The main objectives of this module will be to teach you

• to describe how electrostatic discharge is created,
• to list the causes of electrostatic discharge to components, and
• to describe and use the correct protection methods to avoid electrostatic discharges on workshop and field work operations.
This module is designed for persons who have basic knowledge of electronics. If you are unfamiliar with some terms or keywords, you may find a list of terminology and links at the end of this presentation.
Definitions

- Electrostatic discharge (ESD)
- Electrostatic discharge sensitive device (ESDS)
- ESD protected area (EPA)

Electrostatic discharge is developed by a transfer of charge between bodies at different electrostatic potentials. Every item has its own electrical potential. Discharge is caused by direct contact or induced by electrostatic field.

Electrostatic discharge sensitive device is a discrete device, integrated circuit or assembly, that may be damaged by electrostatic fields or electrostatic discharge encountered in routine handling, testing or transit.

In EPA area the electrostatic discharge sensitive device can be handled with accepted risk of damage as a result of electrostatic discharge or fields.
ESD damage is easily caused without even noticing the discharge.
Creating the charge

**TYPICAL ELECTROSTATIC VOLTAGES**

<table>
<thead>
<tr>
<th>EVENT</th>
<th>10%</th>
<th>40%</th>
<th>55%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking across carpet</td>
<td>35,000</td>
<td>15,000</td>
<td>7,500</td>
</tr>
<tr>
<td>Walking across vinyl floor</td>
<td>12,000</td>
<td>5,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Motions of bench worker</td>
<td>6,000</td>
<td>8,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Remove DIPs from plastic tubes</td>
<td>2,000</td>
<td>700</td>
<td>400</td>
</tr>
<tr>
<td>Remove DIPs from vinyl trays</td>
<td>11,500</td>
<td>4,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Remove DIPs from Styrofoam</td>
<td>14,500</td>
<td>5,000</td>
<td>3,500</td>
</tr>
<tr>
<td>Remove bubble pack from PCBs</td>
<td>25,000</td>
<td>20,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Pack PCBs in foam-lined box</td>
<td>21,000</td>
<td>11,000</td>
<td>5,500</td>
</tr>
</tbody>
</table>

*Source: AT&T ESD Control Handbook 1986*

This table shows the typical electrostatic voltages created by common operations. The charge is created even when walking on a tiled or carpeted floor, or by the movement of a bench worker. The magnitude of the charge is also a function of the friction during the contact.

Pay attention to the importance of correct packaging materials when handling replaced components that are to be sent for repair. The original fault for the component is mostly not caused by ESD. Mishandling may damage a repairable board so that it becomes unrepairable.

The relative humidity has a significant effect on the magnitude of electrostatic voltage. In low relative humidity, the voltage is higher.

ESD protection must also be used when operating in a higher relative humidity environment.
Hearing, seeing and feeling of an electric discharge occurs when the body potential exceeds about 3000 volts.

Many electronic components are susceptible to ESD damage at relatively low voltage levels. Most sensitive devices can be damaged at levels far below our sensitivity levels, even below 100 volts.
How Devices Fail – discharge types

ESD damage is caused by:

- Discharge to the Device
- Discharge from the Device
- Field Induced Discharges

An ESD event can occur on a galvanic connection when any charged conductor (e.g. human body, table, etc.) discharges to, or from, an ESDS device. The direction of the discharge is dependent on the potential levels.

Another event that can directly or indirectly damage devices is termed Field Induction. Whenever any object becomes electrostatically charged, there is an electrostatic field associated with that charge. As an example, such field can be observed near a television (in traditional cathode-ray tube models).
ESD based device failures fall into two categories:

- Catastrophic failure
- Latent defect

In a catastrophic failure, an electrostatic discharge can change the electrical characteristics of a semiconductor device, degrading or destroying it.

In case of latent defect, an electrostatic discharge may also disturb the normal operation of an electronic system, causing equipment malfunction or failure. The component is damaged partially, but the device still remains operable.
A catastrophic failure is an immediate failure which can be spotted in production testing. ESD can also cause unseen damage to electronic components during manufacture of electronic assemblies and equipment. Faults cause increasing production losses and therefore additional manufacturing costs.
In case of a latent defect, a component may be partially damaged and weakened. It may suffer a change or drift in characteristics but remain within specification, but fail later when in use by a customer.

It has been estimated that approximately 90% of damaged devices may be discovered to be damaged in this way.

This is the most expensive type of failure, as it represents:

- extra costs from time consuming and difficult troubleshooting and repair, and
- customer dissatisfaction and the possibility of loss of product reputation and future sales.
Dielectric breakdown is a predominant failure mechanism in MOS devices when the voltage across the oxide exceeds the dielectric breakdown strength. The failure mechanism is basically voltage dependent. The thinner the oxide, the higher the susceptibility to ESD.

The oxide thickness of MOS circuits is about 20 nm. The dielectric breakdown strength is typically about 800 MV/m. A potential of only 16 V can damage the oxide.
Thermal breakdown is mainly an energy-dependent failure mechanism which occurs when the bonding materials melt.

ESD pulse shape, duration and energy can produce power levels resulting in localized heating and eventually junction or lead melting, even though the voltage is below the level required to cause dielectric breakdown.
Failure types

Scale of ESD failure

- transistor failed by ESD
- discharge energy surge has buried through the weakest point(s) in the oxide layer through to the silicon

Photo:
Rohm Electronics
Electrostatic Solutions Ltd

These pictures visualize the scale of problems caused by ESD. Nowadays bipolar devices are becoming smaller and smaller, and therefore also more susceptible to ESD.
The effect of electrostatic discharge can be compared to a situation where lightning strikes on a tree. In both cases, the energy density is the same (1000Ws/g). And, as seen in the earlier pictures the results are also comparable.
Principles of ESD Control

- controlled charge/discharge

Electrostatic discharge based faults can be avoided by controlling the charge or discharge.

When an electrostatic discharge happens it causes a short current peak. The peak is higher when the voltage change time is shorter. The situation can be compared to the acceleration time of the drive. The shorter the acceleration time, the higher the motor current. High resistance on ESD material and against the ground potential prolongs discharge time. Therefore, the current peak is smaller.

ESD materials and protection prevent the creation of electrostatic charges by humans and materials.
In an ESD protected area, all materials are ESD approved, such as plastic bags in trash cans, and so on. The area is connected to ground potential from one point. A worker must wear ESD approved work clothing. To reduce the risk of creating electrostatic charges, other clothing than working clothes should be made of cotton or similar natural or synthetic fabrics. Wool should not be used.

No item or activity within an EPA should cause significant damage to ESD sensitive device. All permanent EPA should have defined boundaries and markings indicating EPA.

Examples of ESD protected areas are:

- warehouses,
- workstations and equipment (e.g. a solder flow machine),
- a field work area, or
- a full industrial site.
A temporary EPA area can be created for field work by using a so-called field service ESD kit. When doing field work, the operator, any temporary work surface, flooring and the equipment being serviced should be ground-connected.
When ESD sensitive devices are removed from equipment and transferred to a temporary work surface, they should be placed in protective packaging.

Handle unprotected ESD sensitive devices only when bonded to the system, and always place them in a protective package that is sealed for transit.

Faulty ESD sensitive devices which may require failure analysis or repair should be placed in protective packaging prior to removal from the EPA. It is easiest to use the spare parts ESD package. Place the protective package on the ESD carpet before opening.
Field Service Kit

Code: 0001ESD
Description: MS-ANTISTATIC
Type: ESD-FIELD SERVICE KIT

ABB Logistics Center
www.abb.com/partsonline

The field service kit is a portable static controlled station for mobile personnel. The kit is made of rugged, dissipative vinyl material.

The field service kit contains:
• a (610 x 610 mm) mat with two pockets,
• a carrying wallet with a snap fastener,
• a coil cord with an adjustable wrist strap, and
• a 3 m grounding cord and a large alligator clip.
ESD safe blower / vacuum cleaner kit

Code:
0006ESD

Description:
MUNTZ 555-ESD-S-E

Type:
ESD VACUUM CLEANER KIT

ABB Logistics Center
www.abb.com/partsonline

The ESD vacuum cleaner is designed for the professional removal and collection of dry dust particles.

When using the cleaner, wear personal ESD protection. Don’t touch the components with the vacuum cleaner hose. Use the ESD brush to remove the dust.

The ESD vacuum cleaner kit contains:
• a carrying case,
• two rubber nozzles,
• ten paper filter bags,
• a micro-motor filter,
• two ESD brushes (25mm, 50mm),
• five pairs of ESD gloves, and
• three dust respirator filters.

Note that if larger areas are to be cleaned, for instance cabinet mechanics, an industrial vacuum cleaner equipped with an ESD approved hose may be used.
Summary

Key points of this module

- electrostatic charges are easily created
- correct packaging methods
- correct working methods
- ESD protection

Here are the key points of this module.

• electrostatic charges are easily created
• correct packaging methods
• correct working methods, and
• ESD protection
Additional Information

- Link to related information
  - Electrostatic Solutions Ltd - ESD Guide

- ESD Training
  - if needed 0,5 days course is available in Training Center Helsinki

Here is some additional information.
Glossary

- **DIP**
  Dual in-line package, integrated circuit

- **MOS**
  metal oxide semiconductor

- **PCB**
  Printed circuit board
Thank you for your attention. You may now go ahead and move on to the next unit.