JonJu Tech Ltd.

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Title: Electrostatic Discharge Damage to Electronics (ESD)

Contents

What it is all about

Electrostatic discharge (ESD), something we have all felt while touching something metal and feeling pain from a spark discharge, can destroy electronics. An understanding of it is of profound importance if failures of electronic products are to be minimised. This is the subject of this White Paper.

Quick Learn

- ESD is usually only of concern when handling PCBAs directly, or when humans can touch something metal or conductive that connects directly to the PCBA in the product.
- The causes and blame can be through:
  - Inappropriate handling and conditioning during manufacture (Supplier)
  - Inappropriate handling during installation (not having equipment)
  - A design that has not allowed for the use the product will see in service.
  - A design not being used as intended.
- It is costly and expensive to prove that a PCBA has failed because of damage caused by ESD, so remedial action is almost always of a preventive nature.
- A PCBA can be 'weakened' by ESD and then fail prematurely. The phenomenon is insidious.
- ESD usually manifests itself as about 15 to 20% of inexplicable field failures.
- Convincing clients that the cause of failure is ESD can be very problematic: it can be seen as a straw being clutched at and the taking the right action takes a long time to become effective, meanwhile the client continues to suffer failure.

Key Actions/Advice

- Get the manufacturer of the PCBAs to confirm the precautions taken to prevent ESD (compliance with a BS EN ESD standard and ISO registration involving audit is a good start)
- Consider visiting the PCBA manufacturer.
- Make sure that installers take precautions to limit the effects of ESD.
- Audit the design to confirm that reasonable ESD limiting techniques have been used.
- Consider having the PCBA conformally coated (thin highly insulating plastic layer over the surface of the PCBA). This is a catch all and usually very effective.
- Consider involving an expert if the situation is serious enough (www.jonjutech.com).

Rigour

The problems that ESD can cause for electronic circuits are probably some of the most misunderstood and misinterpreted in the electronics engineering profession. The issue is a fine example of the adage 'a little knowledge is dangerous'. The following is not an exhaustive description of the topic, but it should give a sound basis upon which the interested reader can study further without fear what they have learned is mythical: and most importantly it provides the material necessary to recognise myths.

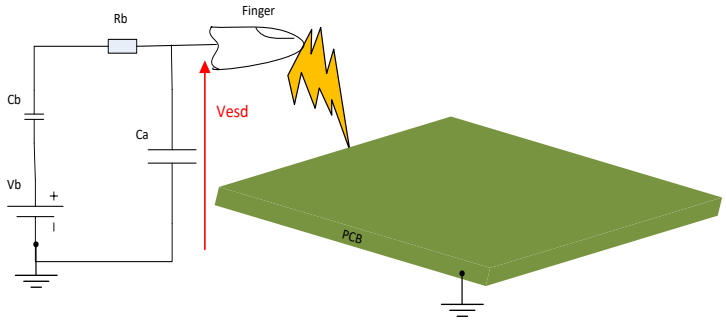


Fig 3.1

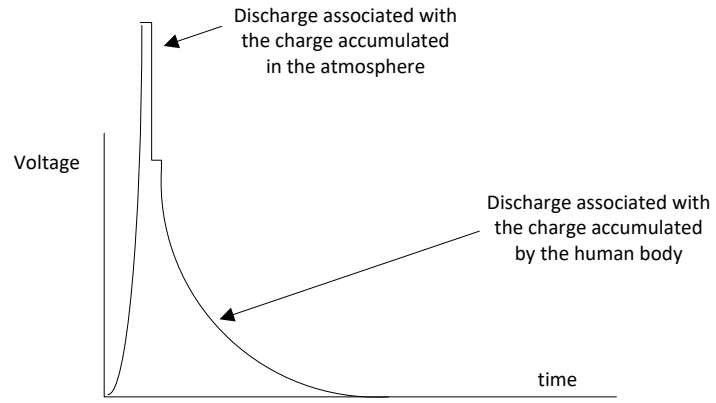
There are two vessels for the charge that can result in a damaging discharge: the human and the atmosphere. The latter is important, but usually overlooked.

Human beings build up charge through friction with their clothes, i.e., via the triboelectric effect. This is mitigated in manufacturing/industrial environments by: making people in the environment wear clothes that are unlikely to generate charge; using wrist straps and footwear that dissipate charge when a suitable discharge path exists; providing the discharge path using dissipative mats, floors, furniture, etc.; and ensuring that sensitive components are transported and stored in dissipative bags and containers. The circuit in Fig 3.1 illustrates the charged human via Vb (human body charge), Cb (human capacitance) and Rb (human resistance), which is a system with a relatively long time constant and lower peak voltage when compared to its atmospheric counterpart (Ca [atmospheric capacitance set up between target PCBA and human] with a very low indeterminate value of Ra [resistance limiting discharge by the atmosphere via Ca]).

The atmosphere becomes charged and it is through this that the most damaging ESD occurs, and it is this that is commonly misunderstood. The circuit of Fig 3.1 illustrates this via Ca and Vesd. Ca is the capacitance of the air between the conductor formed by blood flowing in the victim's finger, and the insulating properties of the skin and air between this conductor and the conductor on the PCB that suffers the electrostatic discharge. The charge is equal to the Vesd x Ca. The resulting discharge has a high peak voltage and short time constant. Since the discharge is principally a function of the charge held in the atmosphere, no amount of ESD clothing, equipment or training for people will prevent it (the most effective way to reduce it is to introduce de-ionising machines in the workplace [note air conditioning units charge the atmosphere]). Charge tends to accumulate in the atmosphere when humidity is low (dry air), and by monitoring humidity it is possible to identify times at which the risk of damaging atmospheric discharge is present: handling of PCBAs should cease when this is the case. When humidity is high the atmosphere is less likely to hold significant charge, but the likelihood that discharge will occur is higher (wet air). This suggests that there should be both lower and higher trigger values of atmospheric humidity outside of which no handling of PCBAs should occur.

Electronic chips were relatively susceptible to ESD decades ago, but modern chips usually quote a 'body model voltage' which is normally in the region of 2kV. Good designs also include protective measures outside the chips such as clamping diodes and transzorbs so that failure is now much rarer than it used to be, but it still

occurs, and it would be remiss of a designer or manufacturer to not be seen to be taking steps to reduce the effects of ESD.



Further Investigation

Tim Williams. *EMC for Product Designers* (Newnes 2010).

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Definitions

BLE: Bluetooth Low Energy

ESD: electrostatic discharge

FMEA: failure mode and effect analysis

JJ: JonJu Tech Ltd

PCB: printed circuit board without components assembled on it

PCBA: printed circuit board with components assembled on it

Production Release (PR): date at which production is launched without any involvement or supervision from a design authority.

SLEEP: a low current condition that a device can be put into to reduce its requirement for current, and hence longevity if powered by a battery.

WP: white paper