

INTRODUCTION TO ESD

Electrostatic Discharge (ESD) is the sudden flow of electricity between two charged object due to contact, electrical short or dielectric breakdown. The reason of electrostatic charging is **tribocharging** (separation of electric charges that occurs when two materials are brought into contact and then separated) or **electrostatic induction** (occurs when an electrically charged object is placed near a conductive object isolated from ground since the electric field created by the charged object causes electrical charges on the other object.).

ESD can create electrostatic sparks (lighting with a sound like sound of thunder). However smaller forms of ESD may not be seen or heard but still can cause damage to sensitive electronic devices. In industry ESD causes harmful events such as gas, fuel vapor or coal dust explosions. In electronic engineering one of the most dramatic effect of the ESD is failure of solid state electronic components such as integrated circuits or sensors. These components suffer from permanent damage due to electrostatic discharge and once they are subjected to ESD they do not work anymore (if they do not have protection circuit.). Moreover metal routings of PCB are damaged from ESD which results in tapering or breaking metal routings.

Table 1. Examples of Electrostatic Charge Stored on Body

Event	Electrostatic Voltage Range
Walking across a carpet	1500-3500 Volts
Walking over untreated vinly floor	250-12000 Volts
Working at a bench	700-6000 Volts
Unwinding a regular tape	9000-15000 Volts

When we look at the examples (Table 1) it is understood that, we are charged even just sitting. The charges stored are discharged when the electrons find a proper path. This event is called as ESD. People can feel ESD if the discharge is larger than 3000 Volts.

A. ESD Effects on Electronic Devices

Unprotected devices are damaged from 50 V ESD. Capacitors, MOSFETs, BJTs and any types of transistors (MESFETs, HEMTs and HBTs etc.) suffer from ESD and every device has an ESD limit it can withstand. In Fig. 1, effect of ESD is illustrated. In the photograph, metallization of the integrated circuit has melted due to excessive amount ESD exposure.

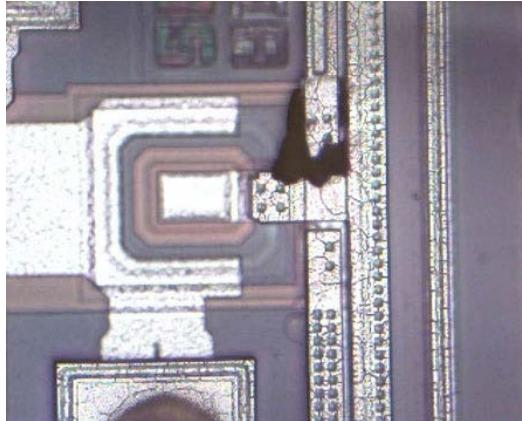


Fig. 1: Poorly protected integrated circuit suffering from metallization melting due to ESD (Taken from <http://mobiledevdesign.com/site-files/mobiledevdesign.com/files/archive/mobiledevdesign.com/images/ESD-system-protection-Figure02.jpg>)

Therefore every electronic device should be properly protected against ESD shocks and each pin in a device should have protection circuits.

B. ESD MODELS

These models are used to model ESD effect on electronic devices.

HBM (Human Body Model)

This model is the most used ESD model and models the ESD when human touches an electronic device. In Fig. 2, test circuit of HBM is illustrated.

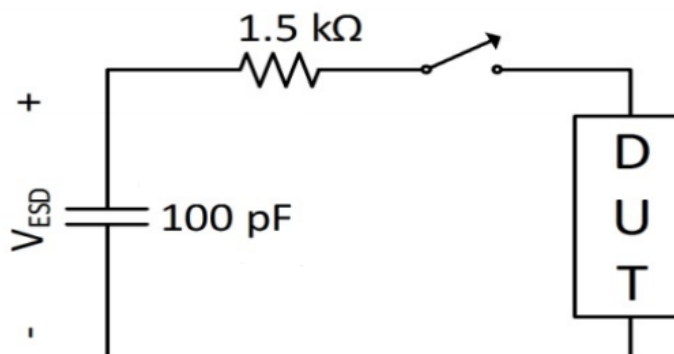


Fig. 2: Test circuit of Human Body Model

An exponential decaying waveform is observed. Human body capacitance can be modeled 50 pF to 200 pF with a series resistance 1 kΩ to 5 kΩ.

C. Machine Model (MM)

It is used to model discharge through automated handling equipment or hand tools and the part to ground. In this model much faster discharge is observed. The test circuit is shown in Fig. 3.

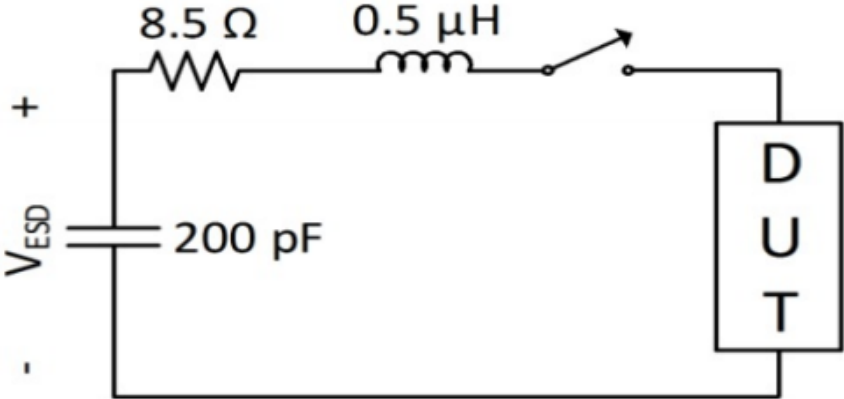


Fig. 3: Test Circuit of Machine Model

D. Charged Device Model (CDM)

CDM is used to model discharge into or out of a part due to charge accumulation within the part itself. The test circuit is shown in Fig. 4.

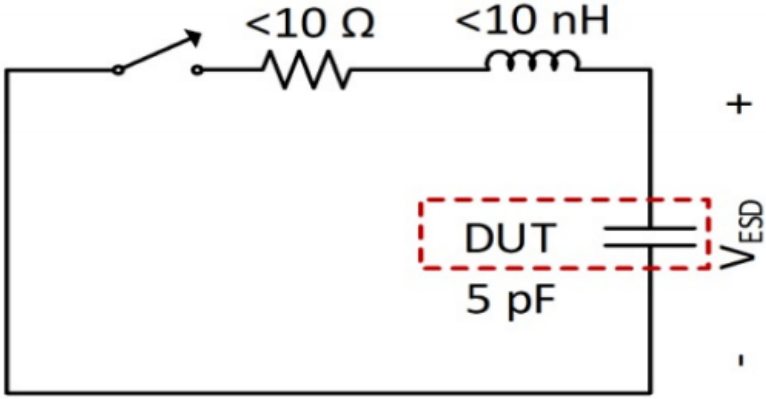


Fig. 4: Test Circuit of CDM

E. ESD PROTECTION CIRCUITS

To protect electronic circuits from damage, special protection circuits are designed. It is a very crucial and expertise required subject. Such circuits are placed in integrated circuits and PCBs. A basic ESD protection circuit which is constructed with diodes is given in Fig. 5.

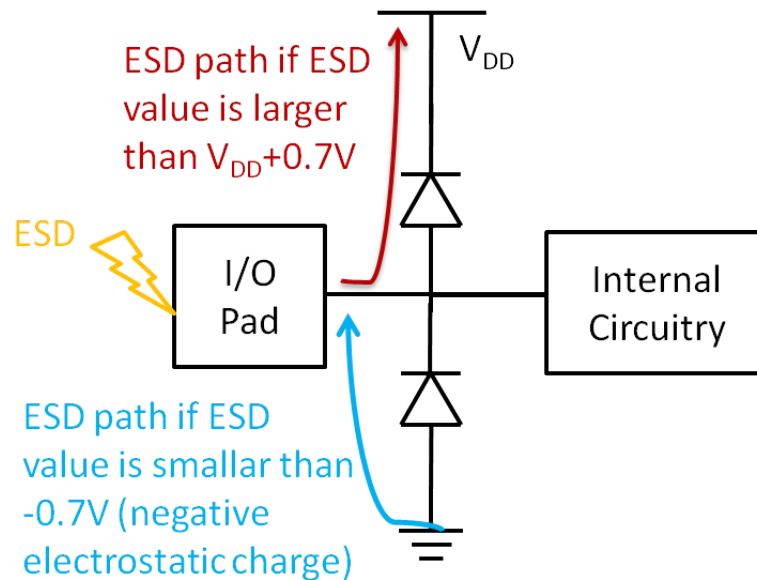


Fig. 5: An ESD protection circuit and working principle

Protection capability of the circuit in Fig. 5, depends on durability against high current values. There are more complicated ESD protection circuits.

To design protection circuits is not enough to be protected against ESD. Moreover environment should be protected against ESD. In the following section ESD protection methods will be mentioned.

F. ESD PROTECTION METHODS

To be protected against ESD, antistatic materials are needed to be used in workstation. First of all, people should not touch any electronic device without anti-static wrist strap. This strap creates a path from body to ground and discharges electrostatic charge directly and prevents ESD on electronic devices. In EE314 laboratory you are supposed to use these kind straps which are available in the laboratory. You are not allowed to touch any electronic device (integrated circuits, Altera DE1 board etc.) without the strap. In each desk, there is one strap available. Therefore only one person in each group can touch the electronic devices at a moment. Usage of the strap is very easy. You should connect one end of the cable to ground of

power supply or earth and wear the strap. The metal on the strap should touch your wrist. In this way your hand is becoming electrostatically free. In Fig. 6, how that wrist strap is used is shown.

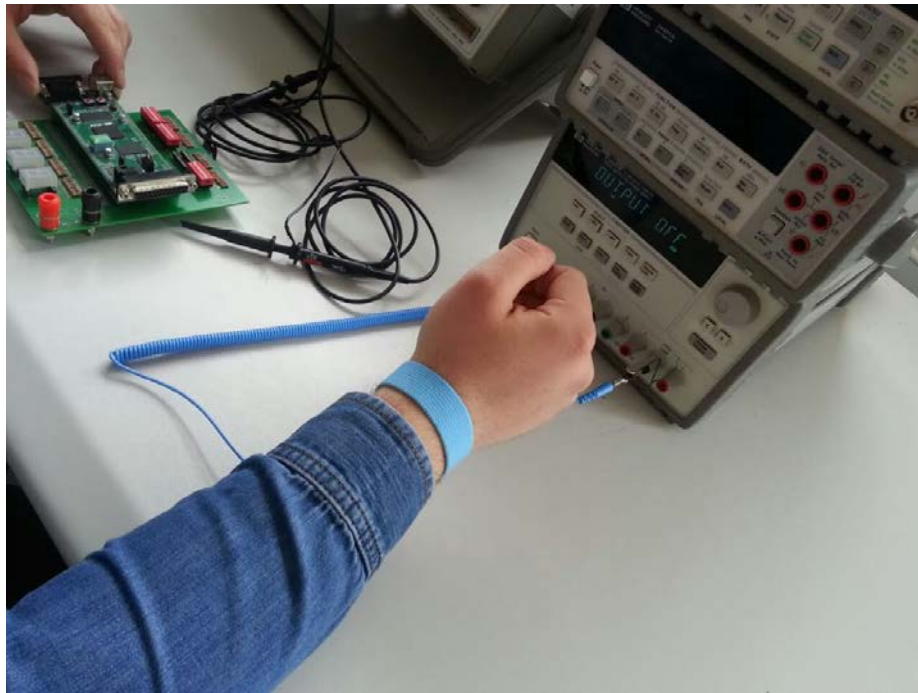


Fig. 6: Illustration of usage of antistatic wrist strap

Moreover to have further protection from ESD antistatic mats are put on the desks and floor of the workstation is needed to be painted with conductive anti-static floor paint or anti-static conductive carpet should be placed on the floor of workstation. Footstraps are needed to be worn as well. Furthermore, some ESD testing equipments are needed to make sure anti-ESD equipment is working properly.

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