

Modeling of Electrostatic Discharge (ESD)

Nowadays electronic devices become smaller and smaller, what makes them very sensitive to static electricity. Electrostatic discharge, caused by charge accumulation on the object surface, may upset the normal operation of an electronic system, causing equipment malfunction or failure. Electrostatic discharge can change the electrical characteristics of a semiconductor device, degrading or destroying it. Also ESD event may have caused a metal melt, junction breakdown, or oxide failure.

Electrostatic damage to electronic devices can occur at any point from manufacture to field service. ESD damage is usually caused by one of three events: direct electrostatic discharge to the device, electrostatic discharge from the device or field-induced discharges.

In order to control ESD event and to prevent electronic devices from the failure, standard test are performed at the development stage.

Computer simulation of such kind of phenomena is a good alternative to a widely used laboratory tests and a significant aspect of finding countermeasures against failure of electronic equipment.

Simulations of ESD test according to IEC standard are performed within EMC Studio and compared with measurement data.

Problem Definition

For investigation of ESD coupling into cable the standard measurement setup developed by the IEC organization is used. According to this standard the straight cable of length 1.7 m is located at the height of 5 cm above the metallic table with dimensions 2x1 m. Both cable terminations are loaded with 25-Ohm resistances. It is required to measure the level of the voltage coupled to the cable caused by discharges applied to the different points 01, 1, 4, 7, 03, 3, 6, 9 shown in the Fig.1.

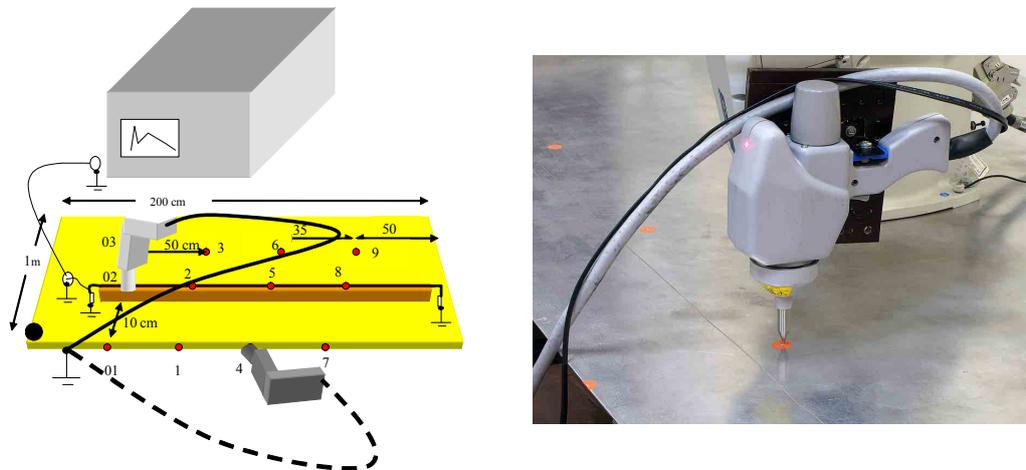


Fig. 1. ESD Coupling measurement according to IEC

ESD Gun Model

Simplified model of ESD gun consists of discharge resistance, generator body and ground strap.

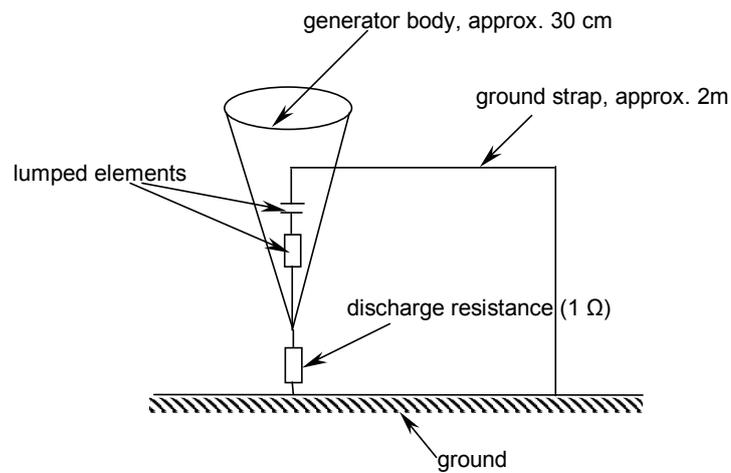


Fig. 2. Simplified model of ESD generator

The approximate equivalent circuit of ESD generator is shown in figure below.

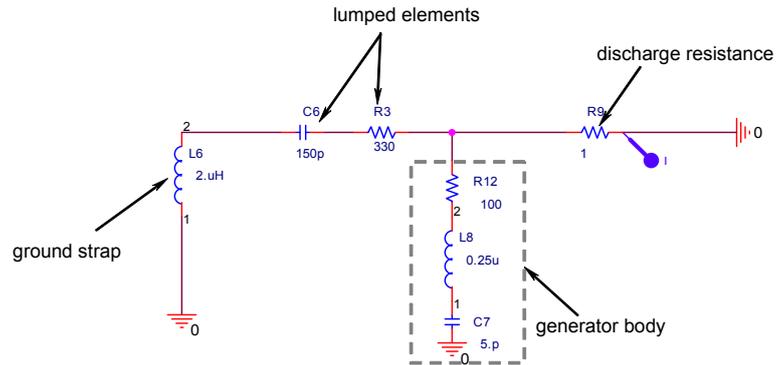


Fig. 3. Equivalent circuit for the ESD gun model

For the full wave problem solution with Method of Moments (MoM) model of ESD gun represented in the Fig. 4 is used.

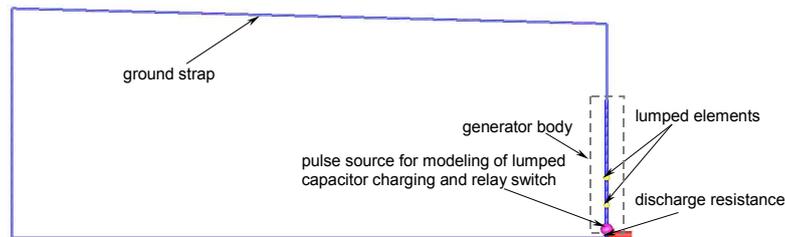


Fig. 4. MoM model for the ESD gun

Discharge capacitor (150 pF) and resistor (330 Ohm) are represented by lumped elements.

Table. 1. Dimensions of ESD gun MoM model

Length of ground strap [m]	2.0
Radius of ground strap [mm]	1
Length of ESD generator body [m]	0.3
Radius of rods modeling ESD generator model [mm]	5

According to IEC standard discharge current has shape shown in the Fig.5. The system is fed by pulse voltage source show in the figure Fig. 6.

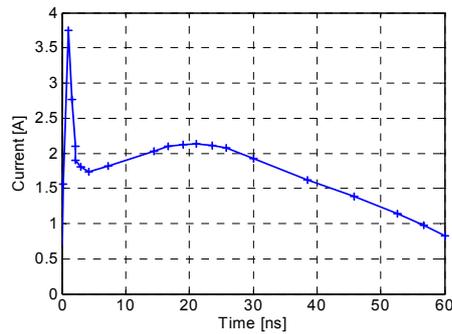


Fig. 5. Discharge current IEC standard

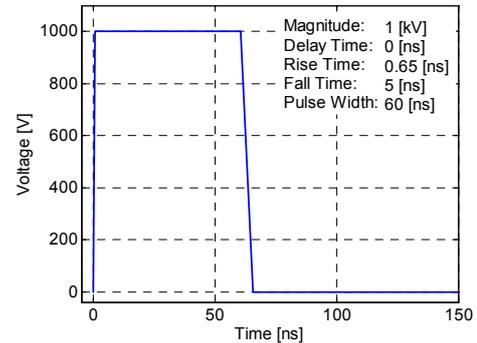
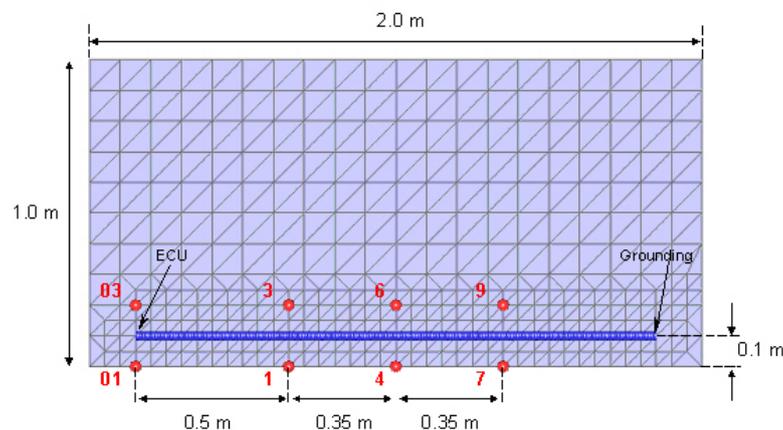


Fig. 6. Pulse voltage source

Simulation Model of Measurement Setup

According to the IEC standard with help of EMC Studio the following model of the measurement setup has been built.

Length of cable subjected to ESD is 1.7 [m], cable cross section is 0.45 [mm²].



Models used for simulations of problem for discharge points 3 and 4 and corresponding comparison of simulation results with measurement data is represented in the Fig.7 - Fig.10

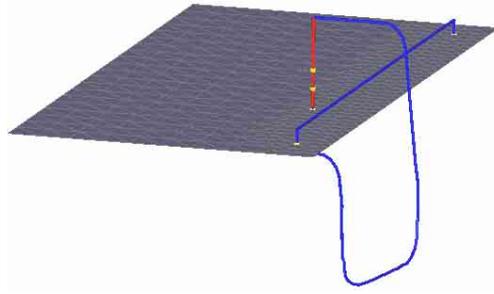


Fig. 7. Vertical orientation of ESD gun for discharge point 3

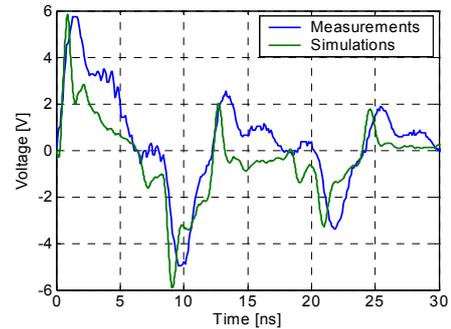


Fig. 8. Comparison of simulation results with measurement data for discharge point 3 (vertical)

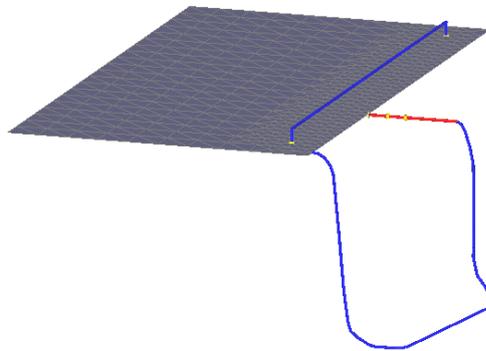


Fig. 9. Horizontal orientations of ESD gun for discharge point 4

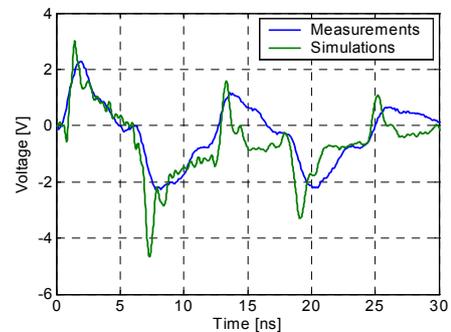


Fig. 10. Comparison of simulation results with measurement data for discharge point 4 (horizontal)

Conclusions

- Equivalent model for ESD gun and measurement setup according to IEC standard are constructed in EMC Studio
- Modeling is performed using Method of Moments (MoM)
- Simulated TD voltage coupled from ESD to cable termination is in good agreement with measurement data