

# Investigation of ESD Current and Induced Voltage from Different ESD Simulators

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***Abstract*—Electrostatic discharge (ESD) susceptibility of electronic equipment may be very different for different ESD simulators even if the simulators agree with the IEC61000-4-2 standard. This is important for the results to be comparability from different ESD simulators or factories. This paper investigates the ESD current, ESD induced voltage and susceptibility from different ESD simulators. ESD currents, induced voltage and immunity tests from more than six simulators are tested. The results show that all of ESD current agree with the standard. Although the immunity test results are dependent on the ESD current, electric and magnetic field produced by ESD simulators, it is shows that the ESD susceptibility is good correlate with the induced voltage of the ESD simulators.**

## I. INTRODUCTION

Electrostatic discharge (ESD) immunity test is one of the important immunity tests in the electromagnetic compatibility (EMC) since the publication of the standard of IEC61000-4-2 [1]. Many papers are published about the ESD current, ESD model, electric and magnetic field radiated from the ESD [2,3,4,5,6]. The repeatability of the ESD test for different simulators is still a problems even if some works have beendone [7,8,9,10]. The ESD susceptibility is related with the ESD current, electric and magnetic field radiated from the ESD. This paper in-

vestigates the ESD current, induced voltage and correlation between the ESD susceptibility and induced voltage.

## II. TEST

### A. Test Set-up

The setup is composed mainly the high speed digital sampling oscilloscope (sample rate: 20GS/s, analog bandwidth: 4GHz –TDS7404). The ESD current is measured by the ESD target. The induced voltage is measured by the semi loop with diameter of 28mm which is 40cm away from the discharge point. The oscilloscope is in a shielding chamber. More than six ESD simulators from different manufactories are tested

### B. ESD current from different ESD simulators

Figure 1 shows tested typical ESD current waveform from simulator Model A. It can be seen from the waveform that it agrees with the IEC614000-4-2 standard. The peak value is  $3.75 \text{ A/kV} \pm 10\%$ . The rise time is  $0.7 \sim 1.0 \text{ ns}$ . The current value at 30ns is  $2 \text{ A/kV} \pm 30\%$  and the value at 60 ns is  $1 \text{ A/kV}$ .

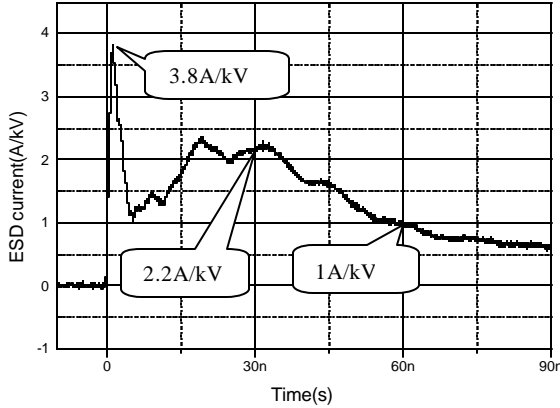


Fig. 1. Typical ESD current waveform from simulator Model A. The waveform is agree with the IEC614000-4-2[1] standard: the peak value is  $3.75 \text{ A/kV} \pm 10\%$ , rise time is with  $0.7 \sim 1.0 \text{ ns}$ , the value at 30ns is  $2 \text{ A/kV} \pm 30\%$  and the value at 60 ns is  $1 \text{ A/kV}$ .

Figure 2 and figure 3 also show the tested typical ESD current waveform from simulator Model B and C respectively. It can be seen from the waveforms that they also agree with the IEC614000-4-2 standard, that is the peak value is  $3.75 \text{ A/kV} \pm 10\%$ , rise time is  $0.7 \sim 1.0 \text{ ns}$ , the value at 30ns is  $2 \text{ A/kV} \pm 30\%$  and the value at 60 ns is  $1 \text{ A/kV}$ .

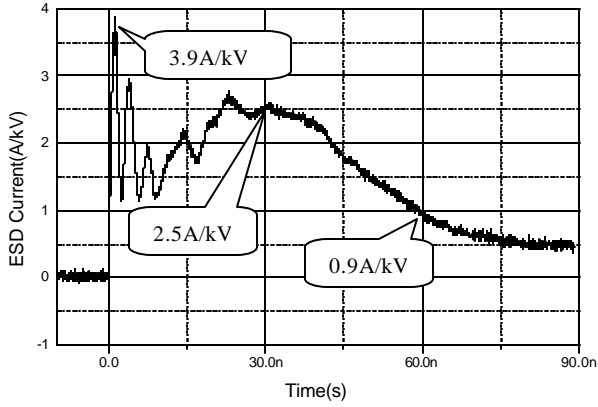


Fig. 2. Typical ESD current waveform from simulator Model B. The waveform is agree with the IEC614000-4-2[1] standard: the peak value is  $3.75 \text{ A/kV} \pm 10\%$ , rise time is with  $0.7 \sim 1.0 \text{ ns}$ , the value at  $30\text{ns}$  is  $2 \text{ A/kV} \pm 30\%$  and the value at  $60 \text{ ns}$  is  $1 \text{ A/kV}$ .

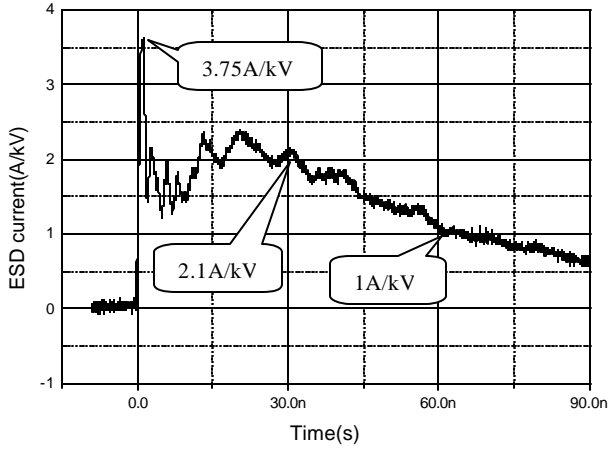


Fig. 3. Typical ESD current waveform from simulator Model C. The waveform agrees with the IEC614000-4-2[1] standard: the peak value is  $3.75 \text{ A/kV} \pm 10\%$ , rise time is with  $0.7 \sim 1.0 \text{ ns}$ , the value at  $30\text{ns}$  is  $2 \text{ A/kV} \pm 30\%$  and the value at  $60 \text{ ns}$  is  $1 \text{ A/kV}$ .

### C. ESD Induced Voltage[11]

Two channels of the digital oscilloscope connected to current target and half semi-circular loop respectively. One channel is for the record of ESD current and another channel is to capture induced voltage. The sampling rate for each channel is  $10\text{GS/s}$  ( $2\text{GHz}$ ). The test results are shown in figure4. The top curve is the waveform of ESD current and the bottom curve is the ESD induced voltage on

semi-loop with diameter of 28mm. It can be seen from figure 4 that the ESD induced voltage last less than 10ns even if the ESD current last more than 100ns.

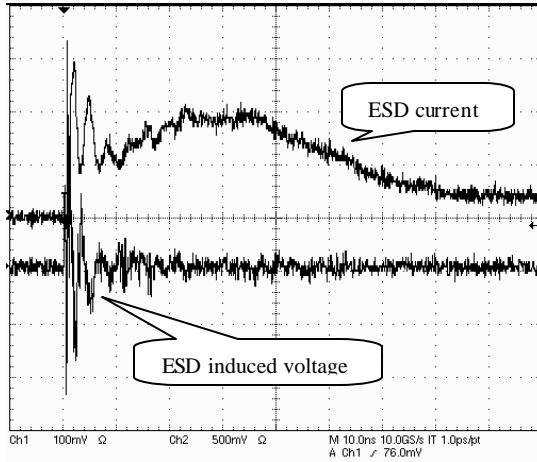


Fig. 4. ESD current and induced voltage. The top curve is the waveform of ESD current and the bottom curve is the ESD induced voltage on semi-loop with diameter of 28mm.

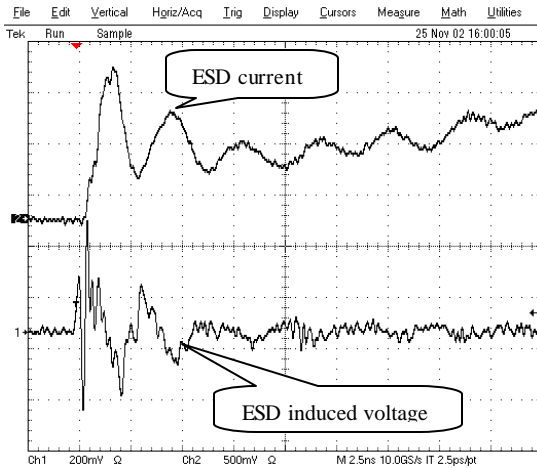


Fig. 5. ESD current and its induced voltage. The top curve is the waveform of ESD current and the bottom curve is the ESD induced voltage on semi-loop with diameter of 28mm.

Figure 6 shows that the ESD induced voltage is non-linear with the discharge voltage especially in the lower voltage.

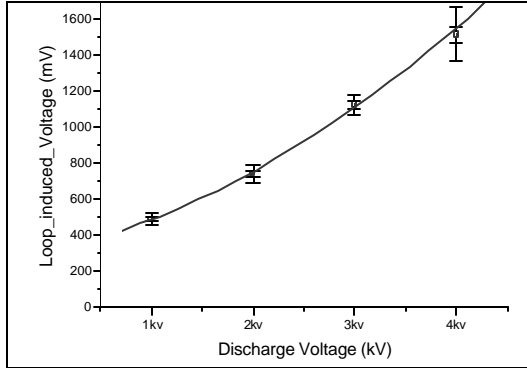


Fig. 6. ESD induced voltage

#### D. ESD Susceptibility and Induced Voltage from Different Simulators

For the same electronic equipment, there should be equal ESD susceptibility voltage with different ESD simulators if all the simulators have the same characteristics. The ESD current for nine ESD simulators from different manufactures are tested according the standard. All of them have the same specifications described in IEC61000-4-2[1]. Figure 7 shows that the ESD susceptibility voltage of the same equipment is much different from simulator to simulator.

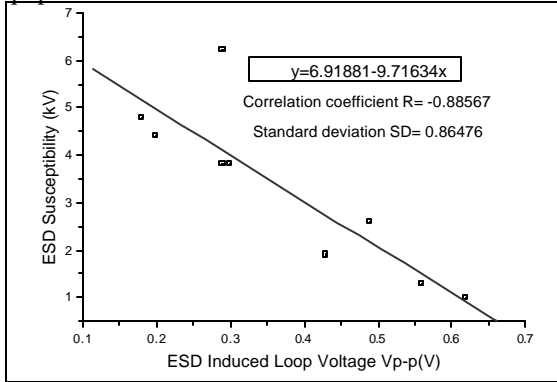


Fig. 7. ESD susceptibility and induced loop voltage. For the same equipment the failure level of discharge may be from 1kV to 6kV. But there is good correlation between the ESD susceptibility and induced voltage from different simulators[12].

It can be seen from figure 7 that for the same equipment the failure level of discharge may be from 1kV to 6kV. The comparability of the results from different ESD simulators or manufactories seems unavailable. But there is good correlation between the ESD susceptibility and induced voltage from different simulators

[12]. The correlation coefficient is equal to -0.88567 and the standard deviation is 0.86476.

### III. CONCLUSION

ESD current and ESD induced voltage from different ESD simulators are tested. The results show that the ESD susceptibility is not correlated with the ESD current. There is a good correlation between ESD susceptibility and ESD induced voltage.

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