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The Study of Transient Fields Generated by Typical ESD Models*

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Abstracts: The transient electric fields and magnetic fields generated by ESD of several typical models were tested. The spectrum of the fields is analyzed. The results show that the peak-to-peak electric field radiated in the distance of several centimeter is very large ranging from several 100 to 1000V/m and the magnetic field can be several 10A/m in the distance of 3cm from the 3kV ESD. The band of spectrum of the field is extremely wide, ranging from 0 to above 4GHz.

Key words: Electrostatic discharge (ESD), Field, Model

0. Introduction

The electro static discharge (ESD) is a process of high voltage and large current. The rise time of ESD current is about 1 ns (10^{-9}seconds). Intensity electromagnetic field with wide band frequency will be generated by ESD. It is the close interference source field for the electronic equipment. With the electromagnetic compatibility (EMC) becoming more and more important, more attentions have been paid to the test of electromagnetic fields generated by the electrostatic discharge. Honda[1] (1991) tested the impulsive fields generated by low voltage(<3kV) ESD between metals using different of short monopole antennas. Wilson [2] tested the ESD-field in the distance of 1.5m and the result show that the field is great than 150V/m. Pommerenke [3] (1996) tested the electric and magnetic field radiated by the ESD. Bendjamin[4](1999) et al. tested the electric current and magnetic field radiated by ESD at different distance. The results show that the magnetic field very close to an ESD is similar in wave shape to the ESD current. The peak close magnetic field approximately varies inversely to the distance (1/R) from the ESD. The transient fields of simulator are influenced by different parameters such as the length and position of the ground strap than that of the human ESD. Huang Jiusheng [5-6] et al tested the field of low voltage ESD for the real human body discharge. The results show that band of the frequency of the fields radiated by the low voltage ESD is very wide from several MHz to several GHz. This paper is to test the transient of ESD electric and magnetic fields for typical ESD models and analyze the spectrum of the fields.

1. Test System

The system used to test the ESD-field is shown in figure 1. It consists of oscilloscope HP54845A 8Gsa/s (1.5GHz bandwidth) with four input channels and antenna. The electric field antenna is a monopole antenna and the magnetic field antenna is a loop of 12mm in diameter which is electrically shielded so that the electric fields are shielded. The cable connected the antenna to the oscilloscope is short than 5cm in order to reduce the inductance and the capacitance of the test system to prevent the oscillations of the waveform. In the HBM and

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HMM test, the tester of the human body is charged to 3kV via a very high resistance (10^8Ohms) to keep the stable voltage of the tester. The tester is discharged to the grounded metal ball with diameter of 9cm directly or holds a metal tool. The relative humidity in the room was $45\pm5\%$ and the temperature was 20 ± 5 Celsius degrees.

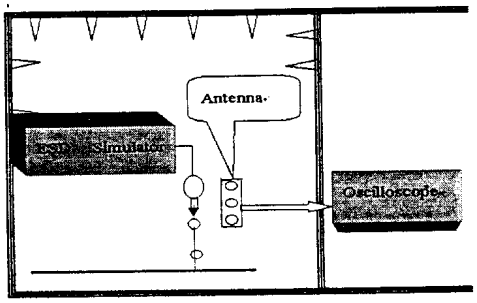

Fig. 1. Test system

2. Experimental results

2.1 Electric field radiated from ESD of HBM

The tested typical electric field radiated from ESD of HBM (Human Body Model) is shown in figure 2. The tester is charged to 3kV and then directly discharged to the grounded ball with diameter of 100mm. The distance from the field test point to discharge is 10cm. It shows that the peak-to-peak electric field Ep-p is up to 383.2V/m.

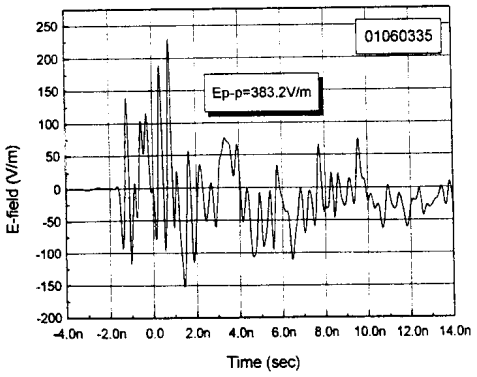

Fig. 2. Waveform of the electric field generated by ESD of HBM

The spectrum of the electric field radiated from the ESD of HBM is shown in figure 3. It shows that the spectrum of the electric field generated by ESD of HBM is very wide ranging from 0-4GHz.

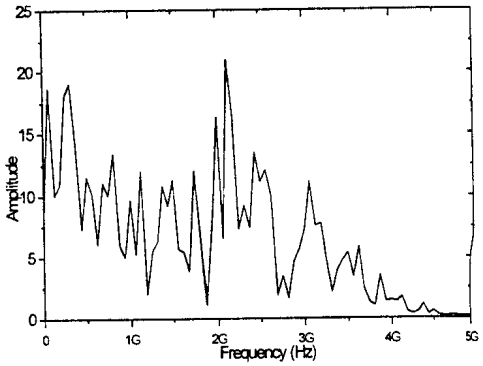

Fig. 3. Spectrum of the electric field radiated from the ESD of HBM

2.2 Electric field radiated from ESD of BMM

The electric field radiated from the ESD of BMM (Body Metal Model) is shown in figure 4. The tester holds a metal pinchers and charged to 3kV, then quickly discharge the metal pincher to the grounded ball with diameter of 100mm. The distance from the discharge to the test point is 10cm. Figure 4 shows the electric field waveform radiated from the discharge. It can be seen from the figure that the peak-to-peak field Ep-p is 1774.4V/m, which is very larger than that of the discharge directly from the finger.

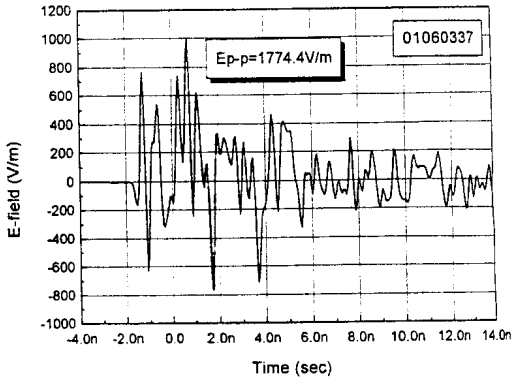

Fig. 4. Waveform of the E-field generated by ESD of BMM

The spectrum of the electric field radiated from the ESD of BMM is shown in figure 5. It is shown that the spectrum of the electric field generated by

ESD of HBM is similar to that of the ESD of HBM. The range is from 0 to above 4GHz and the amplitude is larger than that of the ESD of HBM.

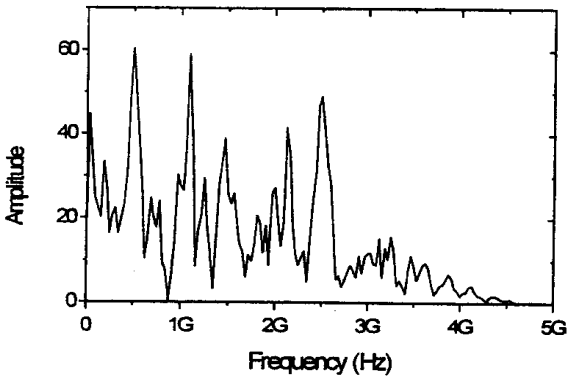

Fig. 5. The spectrum of the electric field generated by ESD of BMM

2.3 Electric field radiated from ESD of MM

The electric field radiated from the ESD of MM (Machine Model) is shown in figure 6. A capacitor with capacitance of 100pF is charged to 3kV, then quickly discharged to the grounded ball with diameter of 100mm. The distance from the discharge to the test point is 10cm. Figure 6 shows the electric field waveform radiated from the discharge. It can be seen from the figure that the peak-to-peak field Ep-p is 2089V/m, which is slightly larger than that of the ESD of BMM.

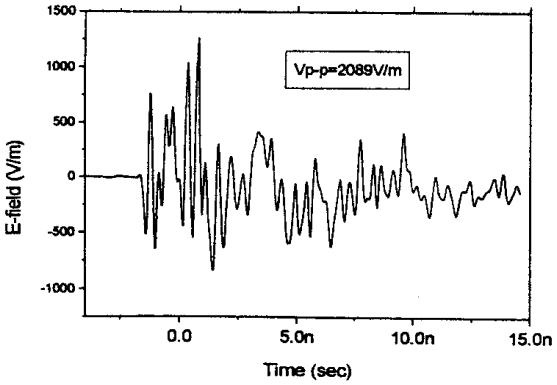

Fig. 6. Waveform of the electric field generated by ESD of MM

The spectrum of the electric field radiated from the ESD of MM is shown in figure 7. From figure 7 it can be seen that the spectrum of the electric field generated by ESD of MM is similar to that of the ESD of HBM. The range is from 0 to above 4GHz and the amplitude is larger than that of the ESD of HBM.

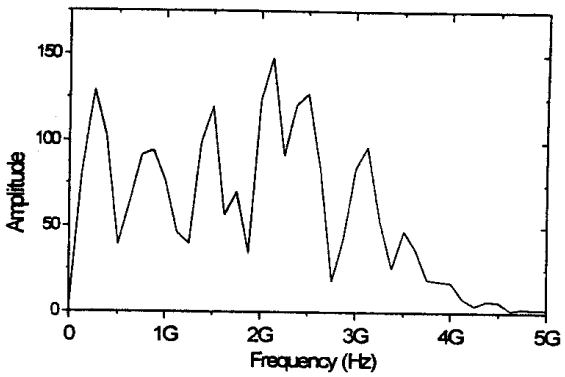

Fig. 7. The spectrum of the electric field generated by ESD of MM

2.4 Magnetic-field radiated from ESD

The magnetic field may be obtained by the H-probe which is connected to another input of the oscilloscope. Figure 8 shows the time derivative of the B-field. The peak-to-peak of the dB/dt is about 70kT/s. The magnetic field strength H can be obtained by numerical integral calculus of the measured derivative waveform of the magnetic field.

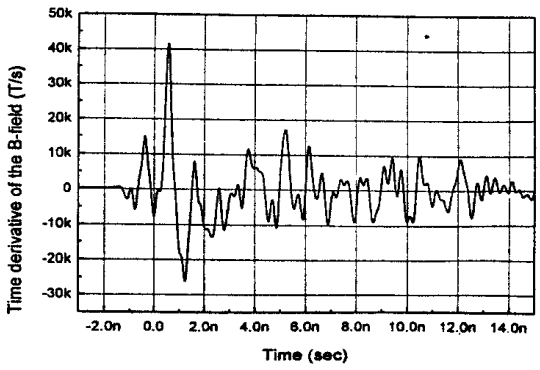

Fig.8. Waveform of Magnetic flux density derivative

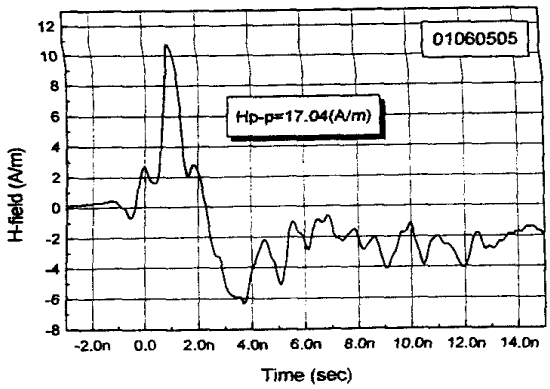

Fig. 9. Magnetic H-Field generated by 3kV ESD

3. Conclusions

The peak-to-peak electric field radiated in the distance of several centimeter is in the range of several hundred to several thousand V/m and the magnetic field is in the range of 10-100A/m for the 3KV ESD. The bandwidth of the spectrum of the electrostatic discharge electric field is extremely wide, it may be above 4GHz. The peak-to-peak electric field radiated from the electrostatic discharge of BMM and MM is many times than that of HBM which the human is discharge directly from the fingers to the ground.

The electromagnetic field radiated by the electrostatic discharge is one of the most common electromagnetic interference (EMI) sources to the electronic equipment due to the strong amplitude and wide band spectrum of the ESD field.

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