

THE MEASUREMENT OF TRANSIENT ELECTROMAGNETIC FIELD RADIATED BY ELECTROSTATIC DISCHARGE

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Abstract - With the rapid development of electronic industry, the threat of field radiated by electrostatic discharge (ESD) to the electronic equipment is becoming more and more dangerous. A custom short monopole antenna and test method to measure the ESD electric field is presented. A series of tests of electric field radiated by real human body ESD have explicitly revealed how strong is the electromagnetic field generated by ESD. The result shows the peak-peak ESD field in 10 cm by human holding a metal pen with potential of 2kV discharging to ground is 410V/m. The band of the field spectrum is extremely wide, ranging from several MHz to above 1GHz. The experiments also show that the amplitude of electric field radiated by ESD when holding a metal screw driver discharging to the ground metal is about many times larger than that of the finger discharge directly to the ground.

INTRODUCTION

Human body is one of the most common dangerous electrostatic sources. When the electrostatic potential on the human body exceeds some degree, electrostatic discharges (ESD) may occur. Many research have been done on the human body electrical parameters such as the capacitance and the resistance of human body[1-3]. Many ESD model have been presented, but most of the researcher focus on the heat effects of the discharge current. With the electromagnetic compatibility (EMC) becoming more and more important to the modern electronic equipment, More attention has been paid to the effects of field radiated from the human discharge[4-7]. This paper is to present the test method and the results of the electromagnetic field radiated by electrostatic discharges from human body in the office operation.

TEST METHODS AND APPARATUS

The test apparatus is shown in Figure.1. One hand of the human body in the test is connected to the high voltage source via a high resistance (108Ohms) in order to maintain a stable potential. The other hand may discharge to the metals directly or through a metal tool. The high voltage in all the experiments is about 2kV, so that the electric shock is insensitive when the discharge occurs[8]. A 10 mm-length short monopole antenna and a digitizing oscilloscope (Tek TDS680B) with sample rate of 5GS/s and band width of 1GHz were used so that the discharge transient field in the time domain could be observed. The waveform is recorded in the *.csv format documents in a 3.5 inch floppy diskette. The waveform document contains two columns and 500 rows of data (Table1). The first column data is the time, and the second column data is the voltage.

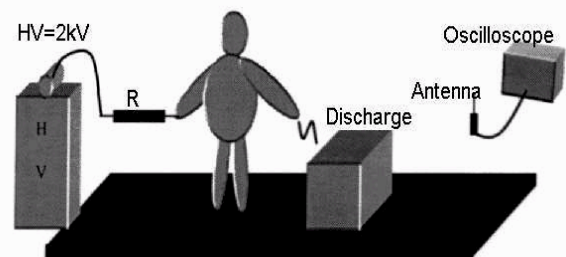


Figure 1. Test Rig

A computer software is used to analyze the waveform of ESD field (Figure.2). The time domain E-field can be easily transformed into the frequency domain of amplitude and power spectrum via an FFT operation. The power spectrum can also be obtained (Figure.3).

Table 1. Waveform Data

1	2.4932E-8	-0.01875
2	-2.4832E-8	-0.34063
3	-2.4732E-8	-0.4375
4	-2.4632E-8	-0.18437
5	-2.4532E-8	0.18437
6	-2.4432E-8	0.39687
7	-2.4332E-8	0.31875
...
500	2.4968E-8	7.15938

TEST RESULTS

Field radiated by human holding a wooden handle screw driver discharging to ground

Figure. 2 shows the electric field in the distance of 34cm radiated by human holding a metal screw driver with a wooden handle discharging to a grounded metal ball with diameter of 8cm. The human body is charged with electrostatic potential of 2kV. The capacitance of the human body to the ground is about 80pF. It indicates that the field is a very short duration (about many nano seconds) ringing waveform which takes a long time for dumping. It can be seen that the peak to peak field Epp is 110V/m. Figure.3 shows the amplitude and power spectrum of the electric field in the frequency domain. The band of the spectrum is very wide, from several MHz to above 1GHz. The main amplitude of the field is about 500MHz. The power spectrum of is above 3GHz.

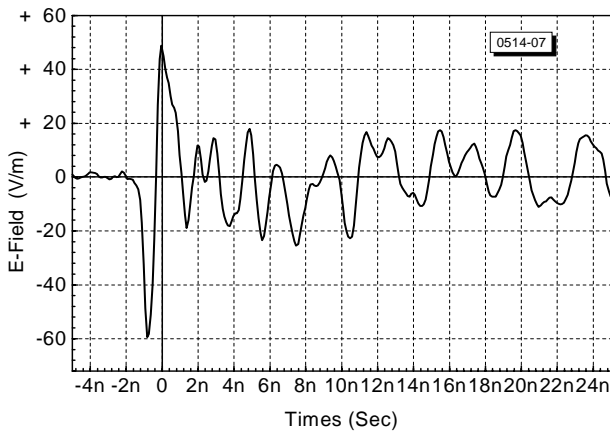


Figure 2. ESD Field Waveform
(2kV, 34cm, Epp=110V/m)

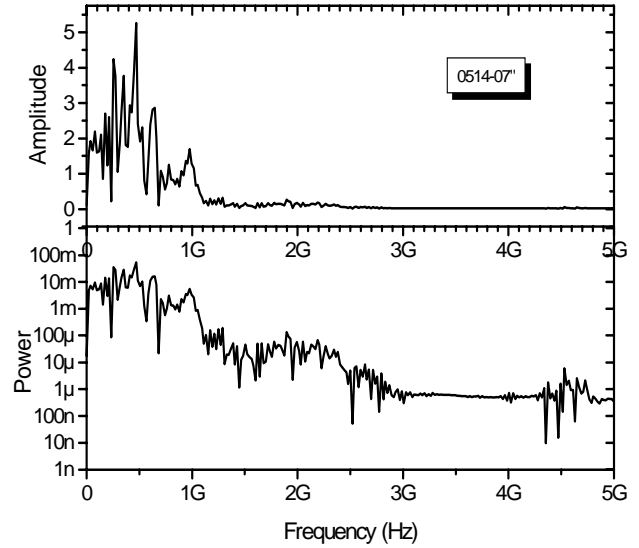


Figure 3. Amplitude and Power Spectrum of E-Field

Field radiated by human holding a metal screw driver discharging to ground

Figure. 4 shows the electric field in the distance of 10 cm radiated by human holding a metal screw driver discharging to a grounded metal. The human body is charged with electrostatic potential of 2kV. The capacitance of the human body to the ground is about 80pF. It indicates that the waveform is ringing waveform and the peak to peak field Epp is 410V/m. Figure.5 shows the amplitude and power spectrum of the electric field. The band of the spectrum is very wide, from several MHz to above 1GHz. The main component of the field is about 300MHz.

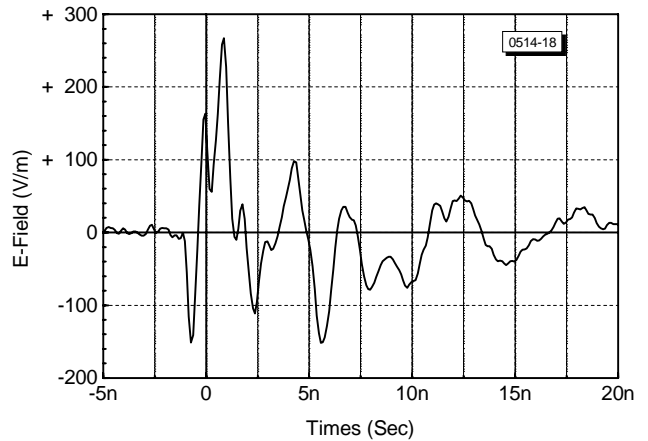


Figure 4. ESD Field Waveform
(2kV, 10cm, Epp=410V/m)

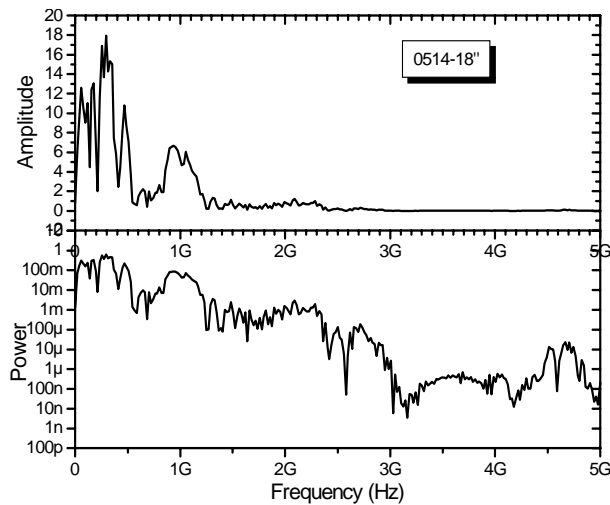


Figure 5. Amplitude and Power Spectrum of E-Field

Field radiated by human finger discharging directly to computer desktop metal

Figure. 6 shows the electric field in the distance of 126 cm radiated by human discharging directly to a personal computer metal parts. The human body is charged with electrostatic potential of 2kV. The capacitance of the human body to the ground is about 80pF. It indicates that it is a very short duration ringing waveform. It can be seen that the peak to peak field E_{pp} is 60V/m. By comparison with Figure.2 and Figure.4, it is much lower than that of the near (10cm) field radiated from metal to metal ESD. Figure.7 shows the amplitude and power spectrum of the electric field. The band of the spectrum is very wide from several MHz to above 1GHz.

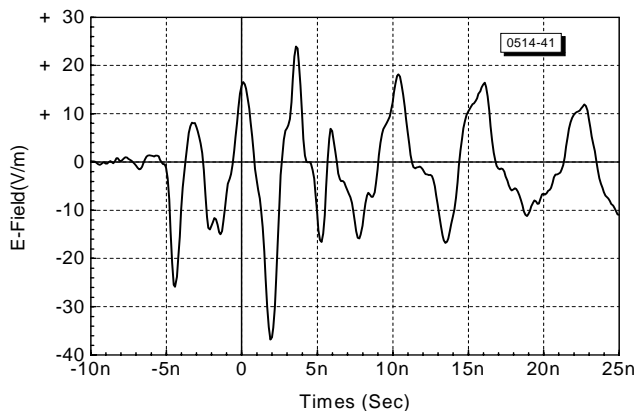


Figure 6. ESD Field Waveform
(2kV, 126cm, $E_{pp}=60V/m$)

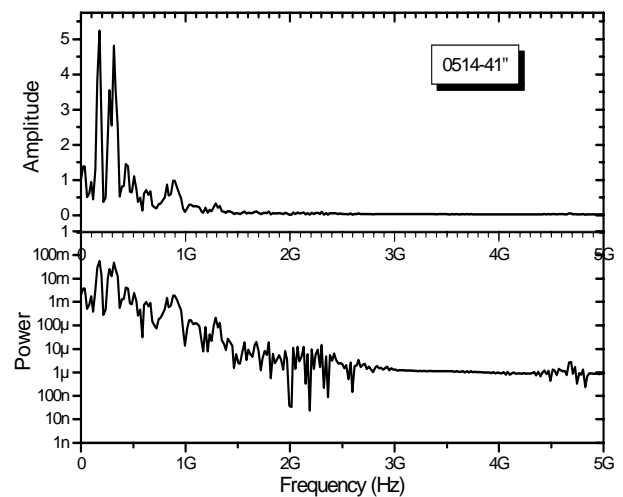


Figure 7. Amplitude and Power Spectrum of E-Field

Field radiated by human holding a metal pen discharging to Computer desktop metal

Figure. 8 shows the electric field in the distance of 10 cm radiated by human holding a metal metal pen discharging to a grounded computer desktop metal. The human body is charged with electrostatic potential of 2kV. The capacitance of the human body to the ground is about 80pF. It can be seen that the peak to peak field E_{pp} is 410 V/m. It is similar to that in Figure.4. Figure.9 shows the amplitude and power spectrum of the electric field. The band of the spectrum is very wide from several MHz to above 1GHz. The main component of the field is in the range of 500MHz and 1GHz. Comparing with Figure.5, the main amplitude is shifted to the high frequency.

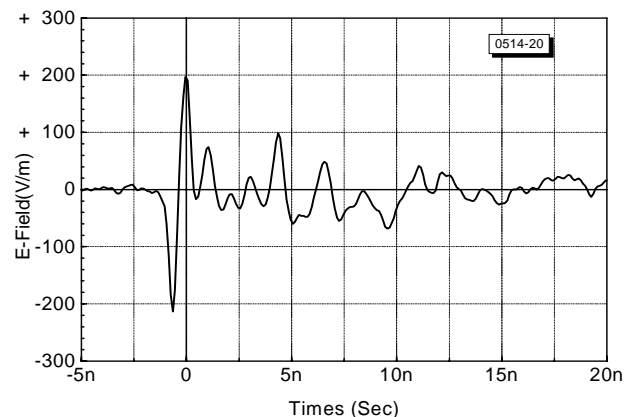


Figure 8. ESD Field Waveform
(2kV, 10cm, $E_{pp}=410V/m$)

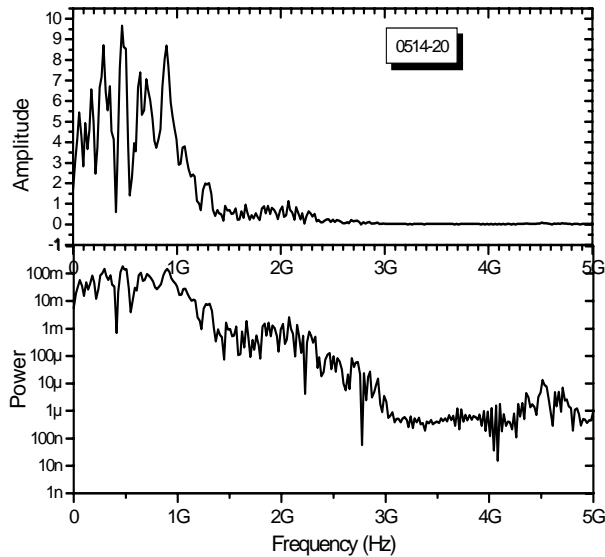


Figure 9. Amplitude and Power Spectrum of E-Field

CONCLUSIONS

The electric field radiated from the human body electrostatic discharge is measured and the characteristics of the waveforms and spectrums are analyzed. Some important results are:

- Even if the shock of the low potential (2~3kV) electrostatic discharge is insensitive, the peak to peak electric field radiated in the distance of several cm is several 100V/m.
- The band spectrum of the electric field is extremely wide, ranging from several MHz to above 1GHz.
- The electric field radiated from the electrostatic discharge when a human body holds a metal tools discharging to the ground is many times larger than that of discharging directly from the human finger.

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