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Measurement of the electromagnetic field radiating by commercial ESD generators with the Pellegrini target on insulating material

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ABSTRACT

The aim of this work is the investigation of the transient electromagnetic field radiating by two different commercial generators of electrostatic discharges. Measurements of both magnetic and electric field generated by contact electrostatic discharges have been carried out a few centimeters away from the discharge point. In this paper the current transducer, which is used for the measurement of the discharge current is not mounted on a grounded metal plate, but on an insulating material. With this aberration to the Standard a closer simulation to the electromagnetic field produced by the electrostatic discharge generators on the equipment under test is obtained. This experiment is closer to real conditions of electrostatic discharges, which do not involve a metal plate. It is proved by measurements that each generator produces a different transient electromagnetic field, which has different repercussions on the equipment that is tested. Comparisons of the radiating field between the two generators and useful conclusions for the variation of the electromagnetic field are also presented.

1. Introduction

Electrostatic discharge (ESD) may be destructive for electronic or integrated circuits, which are very sensitive to these discharge currents even though the ESD phenomenon lasts a few hundred nanoseconds. Therefore, the International Electrotechnical Committee (IEC) prescribed the 61000-4-2 [1] in order to define the procedure, which must be followed for the tests on electrical or electronic equipment against electrostatic discharges.

Little attention has been paid to the measurement of the electromagnetic field less until the end of the 1980s. Wilson and Ma [2] were the first, who simultaneously measured the current and the electric field during electrostatic discharges at a distance of 1.5 m, using a broadband, TEM horn antenna. Many researchers have conducted measurements of the electromagnetic fields associated with the ESD event. Pommerenke [3] measured the electric and the magnetic field at a distance between 0.1 and 1 m, for both air and contact discharges. He found that the magnitude of the magnetic field strongly depends on the $1/R$ factor (where R is the distance from the point where the ESD occurs). He also found that after a period of decrease, the magnitude of the electric field increases.

Studies have also been conducted [4,5] which involve calculation of the electromagnetic field waveform, using analytical formulas. In order to improve the repeatability of the ESD generator, in [6,7] the current waveforms and the produced electromagnetic fields have been investigated by taking into consideration, correlated parameters to the ESD event. This work depicts that the most important factor, which affects an equipment under test (EUT) is the transient field. In [8,9] measurements of the

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produced electromagnetic field during electrostatic discharge at the calibration set-up have been carried out, proving that the field measurement is a challenging task and its results may vary depending on the field probes and the measurement system.

Bendjamin et al. [10] measured the optical radiation, the magnetic field generated by electrostatic discharges and their ESD current. They found that the peak current is linearly correlated to the peak of the optical radiation. In another work [11] they measured the magnetic field in the time domain very close to an ESD event.

In another recent publication [12] the transient magnetic field radiating by two different commercial generators of electrostatic discharges for various charging voltages was investigated, when the current transducer was mounted on the center of a grounded metal plane. Measurements proved that each generator produces a different transient magnetic field, which affects on the equipment that is tested in a different way. Also, each generator produces different magnetic field depending on the orientation of the generator.

2. The problem

The study presented in this paper is conducted with the aim of contributing the upcoming version of the Standard through experiments that have been carried out at the facilities of the High Voltage Laboratory of the National Technical University of Athens, Greece. It was observed that there is a strong probability that the EUT will pass a test, when conducting measurements using a certain ESD generator and fail when using another, both cases referring to the same charging voltage and to the same discharge current. This rises from the fact that each ESD generator produces a different electromagnetic field, causing the induced voltage to differ. These observations are made clear through the results of this work. The experimental data demonstrate that each generator may result in a different way on the EUT, depending on its orientation. Such an observation has not been made until today and should be taken into consideration in the next revision of the Standard, in order to define the construction of each generator, in order the radiating electromagnetic fields to be the same in all directions. The validity of this is proved by the experiments presented in this work.

This work attempts to investigate the electromagnetic field radiating by contact electrostatic discharges for two different types of commercial ESD generators. The current transducer (Pellegrini target) is not mounted on a grounded metal plate, but on an insulating material. Thus, it is attempted to investigate both the radiating electric and magnetic field in a state closer to reality, since the current transducer affects the electromagnetic field, when it is mounted on a metal plate. The produced electromagnetic fields and their induced voltages on the equipment that is usually tested are produced without the presence of grounded metal plates, which alter the radiating electromagnetic fields. The presence of an insulating material instead of a grounded metal plate, where the Pellegrini target is mounted has smaller effect on the produced electromagnetic field. The presence of the metal plate produces reflected waves, which distort the field produced by the ESD generator, which happens to a lesser extend with the insulating material.

3. Measurement system

Fig. 1 shows the experimental set-up. The current and the magnetic field strength (H-field) or the electric field strength (E-field) for various charging voltage levels were measured simultaneously, by the 4-channel Tektronix oscilloscope model TDS 7254B, whose bandwidth ranged from dc to 2.5 GHz. The electrostatic discharges were contact discharges and they were conducted using two Schaffner's ESD generators. The experiment was conducted only for contact discharges, because air discharges are difficult to be reproduced. In air discharges the produced electric arcs are different. Therefore, the produced electromagnetic fields can be compared only if the electric arcs of the air discharges are the same. This is also the reason why the verification of the ESD generators is made only for contact discharges.

The ESD generators used were the NSG-433 and the NSG-438. The discharge electrode in both generators had the same length and it was equal to 5 cm. In order for the measurement set-up to be unaffected by surrounding systems, the experiment was conducted in an anechoic chamber. The generator's capacitance was charged at ± 2 kV and the discharge electrode of the ESD generator used for the contact discharge measurements had a sharp point. The temperature and relative humidity were 23 ± 1 °C and 40 ± 4%, respectively. For the current measurement a resistive load was used, as the IEC defines. This resistive load (Pellegrini target MD 101) was designed to measure discharge currents by ESD events on the target area and its bandwidth ranged from dc to above 1 GHz. The Pellegrini target was mounted on an insulating material made of plastic and this material was placed on a wooden surface. The pulses that the ESD generators produce are reproducible, as it was found by the palm graphs of the ESD current for many electrostatic discharges for the same charging voltage and for both the ESD generators. The calibration certificates of the ESD generators can also prove their reproducibility. Therefore, the pulses are reproducible in spite of the fact that the Pellegrini target is on an

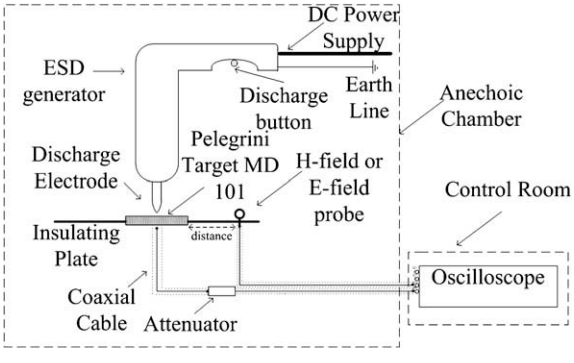

Fig. 1. Experimental set-up.