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Approaches on pollutant fields associated to electrostatic discharge over the working and electronic environment – modeling and simulatio

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Abstract – It is extremely important to evaluate the pollutant fields associated to electrostatic discharges (ESD), since those can be harmful for electronic equipments from the working environment, leading to programs breakdowns, software blockage, permanent failures or even integral crash of miniature electronics. The present paper proposes determining the effects of pollutant fields associated to ESD in electronic and working environment using direct measurements, modeling and simulation aided by a specialized software as well as comparison of the obtained results.

Keywords: electrostatic discharge, pollutant fields, electronic environment, discharge generator

I. INTRODUCTION

Static electricity is the development of electrical charges on the surface of some object, being a high voltage, but low power form of electricity. The disadvantages of static electricity are that it can easily destroy sensitive electrical components. The static electricity can produce the magnetization of electronics' switches and cause them to not be able to function anymore. As a result, the electronic equipment can experience significantly reduced performance or even abate to function entirely. So, electrostatic discharges constitute a major source of electromagnetic pollution in electronic environment in the context of rapid development of electronic industry. The phenomenon occurs when a transfer of charges takes place between two conducting pieces with different potentials.

It was demonstrated that during those type of discharges are generated both electric and magnetic fields, that can be approached as pollutant fields for the laboratory environment.

ESD can be produced by a wide variety of sources, including the human operator that can be charged up to several kilovolts by simply walking on a carpet or by undressing a sweater. In those conditions, when a human body comes in contact with electronic devices can induce them a certain level of voltage. This is transmitted as a discharge current, that may reach values of amperes and affect the system's functionality partially or completely [1].

In the last years were conducted various studies on the disturbing influence of the ESD on electronic equipments. So, some researches [2] showed that in this event are involved both electric and magnetic fields, the magnetic field being inverse proportionally with the distance where the discharge occurs while the electric field varies with the time.

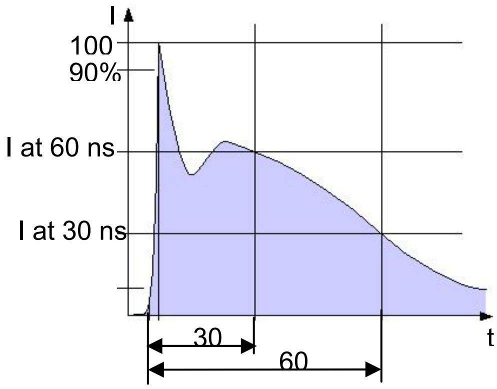

Fig.1. Discharge current waveform according to IEC 61000-4-2

Static charges are easily generated in the working and testing areas. The most common charge threat to electronic devices is in the form of a charged human or machine contact. So, in this case, according to the international standardization, during handling, personnel are required to wear protective cloths and straps to prevent them from becoming charged.

But this approach is usually found in the manufactures, but cannot be applied for all the working environments.

Since the current created by ESD discharges can be high (more than 1A), depending on the magnitude of the discharge, stressing an electronic circuit can lead to thermal destruction making the components inoperable.

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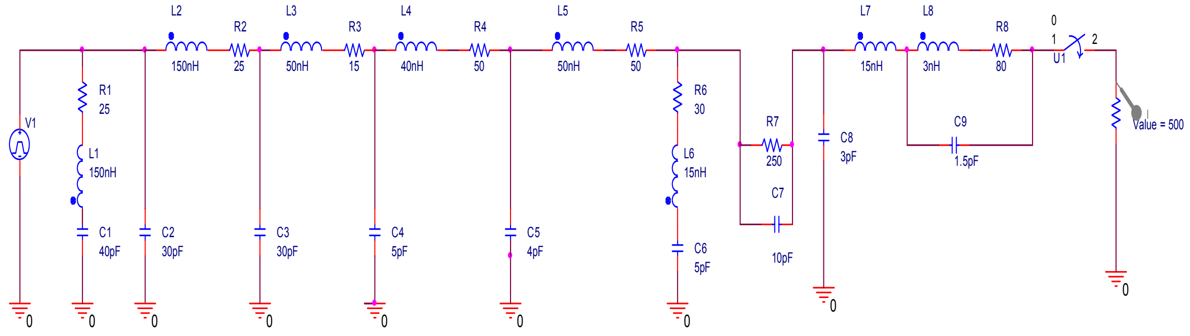

Fig.2. SPICE model for human body discharge

II. INTERNATIONAL REGLEMENTATIONS FOR ELECTROSTATIC DISCHARGES

The most important international standard that regulates the tests at electrostatic discharges is IEC 61000-4-2, prescribed by the International Electrotechnical Committee. This is the basis of tests on electrical or electronic equipment against electrostatic discharges and defines the methods through that can be simulated the air discharge or contact discharge [3].

According to this standard there are several voltage levels for which can be realized the discharges and the discharge generator must be able to produce a human body model pulse as in illustrated in Fig. 1.

In the figure presented above, it can be observed that the waveform has two peaks, one being caused by the human hand and the other by the human body.

In our days, most circuit design and simulation is carried out using SPICE, a simulator that does not include thermal effects. This software is useful because can give information about the circuit's current and voltage characteristics.

In Fig. 2 it is displayed the human body equivalent circuit modelled in SPICE program. We modelled the human hand using a RLC series circuit (R_6, L_6, C_6) connected in series with a RC parallel circuit (R_7, C_7).

To reproduce the ESD environment, it were adopted the requirements presented in the IEEE Std. C62.47-1992 – Guide on Electrostatic discharge, which describes the electromagnetic threats caused by electrostatic discharges supplied by the human operator or by furniture. According to this standard, the full arm of a human body has a capacitance around 20 pF and a inductance of 0.27 µH, while the whole body capacitance is around 150 pF [4,5].

III. TEST CONFIGURATION AND EXPERIMENTAL SETUP

Strictly using the EN-61000-4-2 standard's requirements concerning the electrostatic discharge it was realized the following system, composed by: oscilloscope Tektronix DPO 7254, with four input channels, electrostatic simulator NSG 435, produce by Schaffner, near field electric or magnetic sensors, EMCO 7405, and metallic plane horizontal / vertical with dimension specified by normative. The network configuration is presented in Fig. 3.

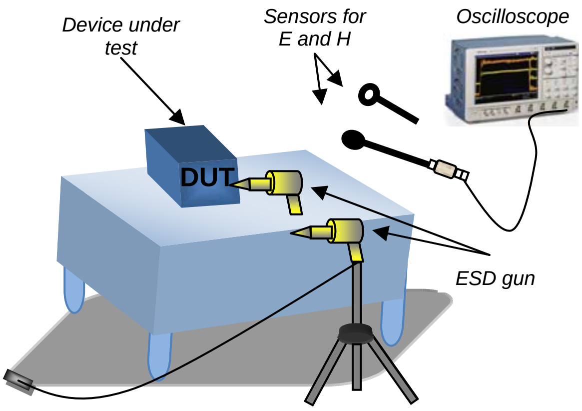

Fig. 3. Network configuration for determining the fields associated to ESD

To determine the disturbing fields, measurements were performed on the horizontal plane in 10 points at different distances from the point of discharge, at 10 cm above the table. We also made a set of measurements with downloading the application on the test equipment under test (DUT). After carrying out these tests we compared the measurement results.

We modelled the system using a specialized software testing and have executed various measurements.

The results were compared with results of measurements made. The magnetic field depends on the electrostatic discharge current and is inversely proportional to the distance from the point of discharge.

The electric field has a different behaviour compared with the magnetic field, which consists of a function of time derivative of the latter. It also decreases with distance, almost linearly. Since the phenomenon is transient, the time domain waveforms are quite complex and leads to difficulties in making time domain comparison and in the determination of rise time.

The waveforms of electric and magnetic fields radiated by ESD reveals how significantly is the electromagnetic pollutant field generated over electronic devices and working environment. Electrostatic discharge with different polarities, but with equal absolute values produces different electromagnetic fields. Field distribution around the generator takes the form of asymmetric rotation, and this affects the test equipment in different ways. Two possible causes for this phenomenon may be: a) within an electrostatic discharge generator, high voltage relays have rotational symmetry; b) positioning the return path and also high voltage cable directly affects the simulator [6].

III. FIELD MEASUREMENTS AND GRAPHICAL INTERPRETATION

Using the system described in the first part of this paper, it was modeled the RLC circuit (Fig.2) for the human body ESD, hand held metal, and then run a simulation. The graphical waveform of the discharge is illustrated in Fig. 4. As it can be seen, the waveform has two peaks as is presented in the standard's discharge current waveform, showed in Fig. 1.

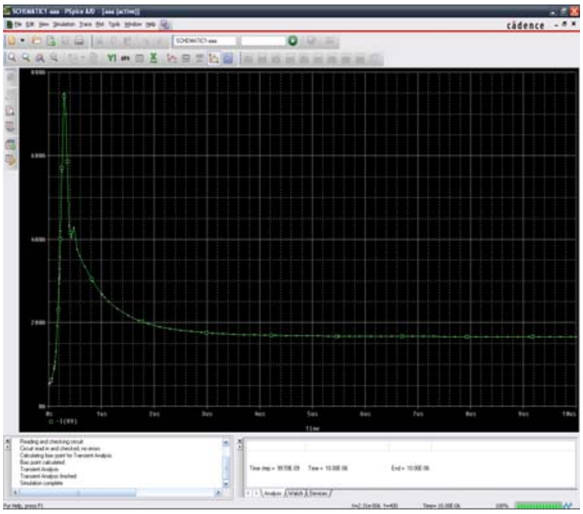

Fig.4. HBM discharge current waveform

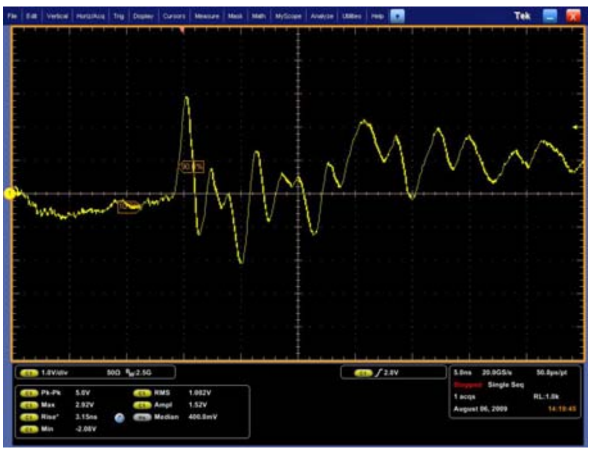

Fig.5. Electric field at 40 cm from discharge point

Following the procedure described above, in our study were determined electric and magnetic fields generated during electrostatic discharges induced with the commercial ESD generator. The tests were realized with a charging voltage of the discharge generator of +8kV [7].

Fig.5. illustrates the electric field measured during the discharge from the NSG 435, the sensor being applied on the horizontal metal plane at a distance of 40 cm far from the discharge point.

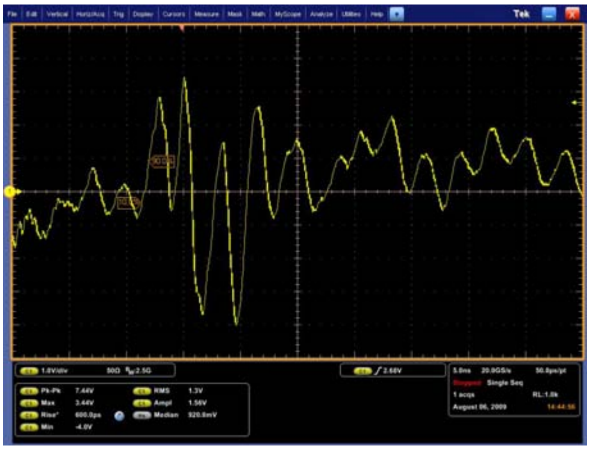

Fig.6. Electric field at 20 cm from discharge point

Fig. 6. presents the same field, but the field probe is placed at a distance of 20 cm from the discharge point. From those two figures can be observed that the peak to peak value of induced voltage has values in the range 5 ÷ 7.44 V/m.

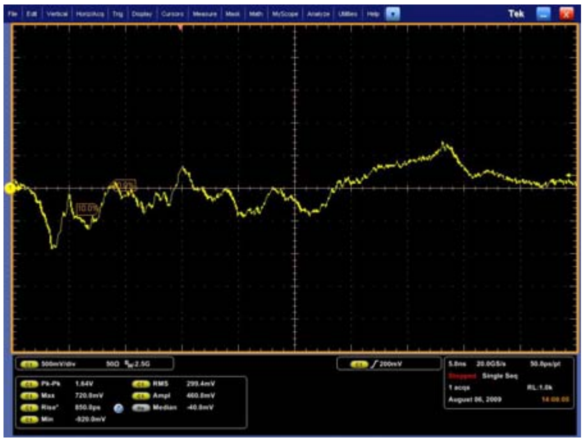

Fig.7. Magnetic field at 40 cm from discharge point, axis X

Fig.7, 8 and 9 presents the magnetic field involved in the ESD event, but since the magnetic field probe has loop geometry, the measurements are realized on the three axes: X, Y and Z.

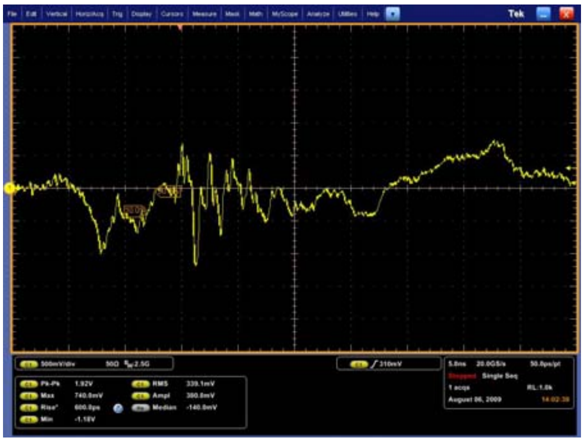

Fig.8. Magnetic field at 40 cm from discharge point, axis Y

The tests were realized at the same distance as the measurement in the case of electric field and from the three waveforms can be concluded that the magnitude of magnetic field is much smaller than that of the E-field.

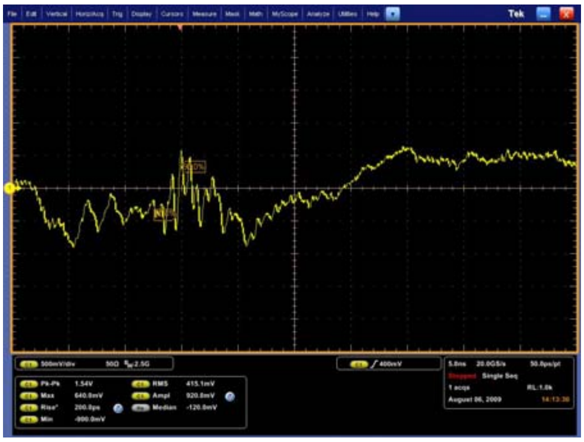

Fig.9. Magnetic field at 40 cm from discharge point, axis Z

IV. CONCLUSIONS

The pollutant electric and magnetic fields generated by electrostatic discharge are measured and analyzing the spectrums and waveforms characteristics and therefore results that for low potentials discharges, around 8 KV, the induced voltage for electric field has a value (peak to peak) about 8 V/m, which leads to damages in electronic sensitive components. So, it is extremely important to determine the pollutant electric and magnetic fields, released into the working environment, which interacts with electronic devices, in order to assure their minimization and to provide the equipments with electrostatic filters.

V. ACKNOWLEDGEMENT

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