BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVII (LXI), Fasc. 5, 2011
Secţia
ELECTROTEHNICĂ. ENERGETICĂ. ELECTRONICĂ

ANALYSIS OF DISTURBING MAGNETIC FIELD ASSOCIATED WITH ELECTROSTATIC DISCHARGES

BY

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Received, July 5, 2011
Accepted for publication: August 16, 2011

Abstract. Electromagnetic radiation generated through charge transfer in electrostatic discharge (ESD) phenomenon is an event that affects the functionality of integrated electronic circuit, in particular, and the electronic and ICT environment, in general. Measurements of magnetic fields generated by electrostatic discharges are made at different distances from the point of discharge. Measurements results showed that the generator produces a transient magnetic field which could affect test equipment differently. Also, the ESD gun produces various magnetic fields for different charging voltage.

Key words: electrostatic discharge; ESD gun; magnetic field.

1. Introduction

Electrostatic discharges are a kind of electromagnetic radiation, and additional to those events can be determined the magnetic fields involved in the processes. The phenomenon becomes extremely important when in the discharge area are present different types of electronic components and even in the nearby of communication technology (ICT). According to the international standard that settles the distances, norms and parameters for an electrostatic

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generator (IEC 61000-4-2, 2001), the discharge tests must be realized in specific environment and taking into account the potential factors that may influence the values of the interest parameters.

The IEEE Guide on Electrostatic Discharge (1992) makes a characterization of the electrostatic discharge environment and of the parameters that influences the magnetic field's waveform.

The discharge will be generated using a commercial ESD gun.

The magnetic radiated field derives from the discharge current, and because in the standard does not exists an analytic expression for estimating the field's value, this will be determined by multiple contact discharges in different points and directions.

From the literature we concluded that the waveforms of magnetic fields are different, depending on the ESD generator's construction.

2. Network Configuration

The tests were made on the horizontal coupling plane. The probes are placed at different distances (10, 25 and 40 cm) and 10 cm high from the grounded metal plane surface, as shown in Fig. 1. The ESD gun is placed in point *1*, in the middle of the table plane. It is known that the position of the

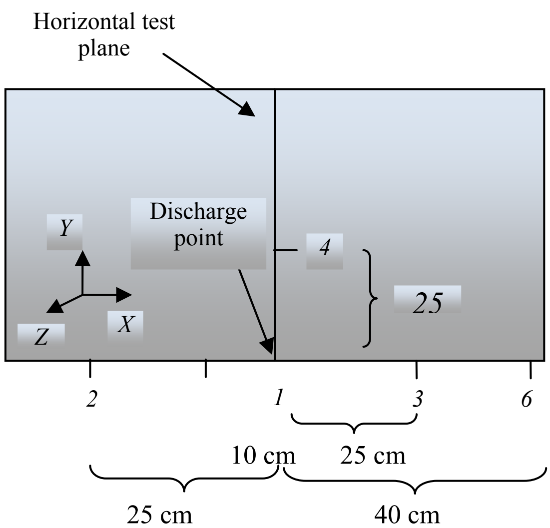


Fig. 1 – Measuring points on horizontal and vertical directions, on which magnetic field sensors are placed at different distances.

grounding cable has an influence on waveform testing. To minimize the risk of getting the wrong measurements, the grounding cable is settled in loops as big as possible, according to the standard IEC 61000-4-2 (Keenan & Rosi, 1991).

Measurements of the magnetic field produced by the contact discharges are made only a few centimetres far from the discharge point (Leuchtmann & Sroka, 2000). The results have shown that the generator produces a magnetic field which could affect in a different way the tested equipment. Also the ESD gun produces different magnetic fields for different charge voltages. The testing of the magnetic field uses a magnetic field loop sensor. In each point the magnetic field was tested on three directions (*X*, *Y* and *Z*). The loop sensor was placed on a 10 cm height of the test plane, and in order to protect the oscilloscope a 20 dB attenuator was used for all measurements (Neacşu *et al*., 2010).

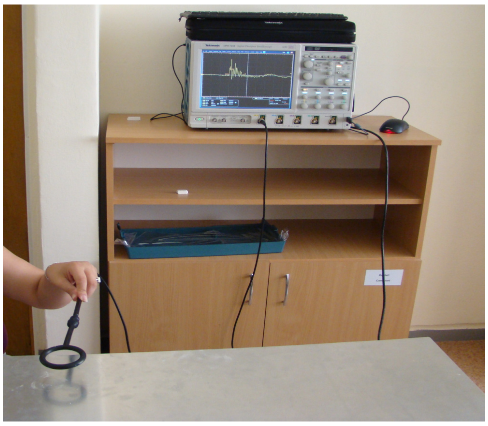


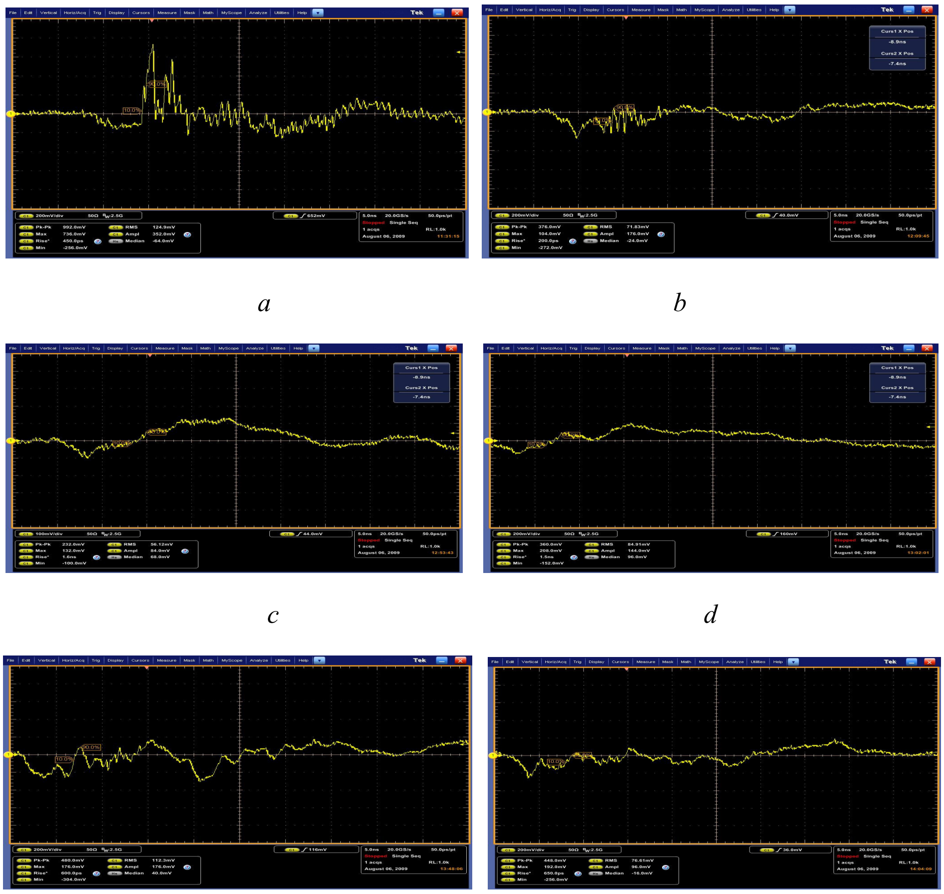
Fig. 2 – Testing configuration for the magnetic field.

Fig. 2 shows the experimental testing configuration for magnetic field associated with electrostatic discharge. We have used an oscilloscope Tektronix DPO 7254 with four channels that allows the visualizing of the waveform, an ESD gun, produced by Shaffner, NSG 435, and it was used the 6 cm diameter loop magnetic sensor of the EMCO 7405 set.

3. Measurements Regarding the Magnetic Fields Associated with Electrostatic Discharges

Fig. 3 shows the waveforms of the magnetic field in six different points, for a charge of the ESD generator of +2 kV, on *X*-axis direction of the magnetic field sensor. Fig. 3 *a* shows the form of the magnetic field in point *1* of the horizontal plane (the discharge point), Fig. 3 *b* shows the magnetic field in point *2*, on the left side and 25 cm far from discharge point, Fig. 3 *c* shows the magnetic field in the right side, 25 cm far from the discharge point, Fig. 3 *d* shows the magnetic field 25 cm vertically from the discharge point, Fig. 3 *e* shows the magnetic field in point *5* at 10 cm horizontally far from the discharge point, Fig. 3 *f* shows the magnetic field in point *6* at 40 cm far from the discharge point.

The graphic of magnetic field distribution allows to determine the peak-to-peak value of the induced voltage in sensor and even the root mean square.



a *b*

c *d*

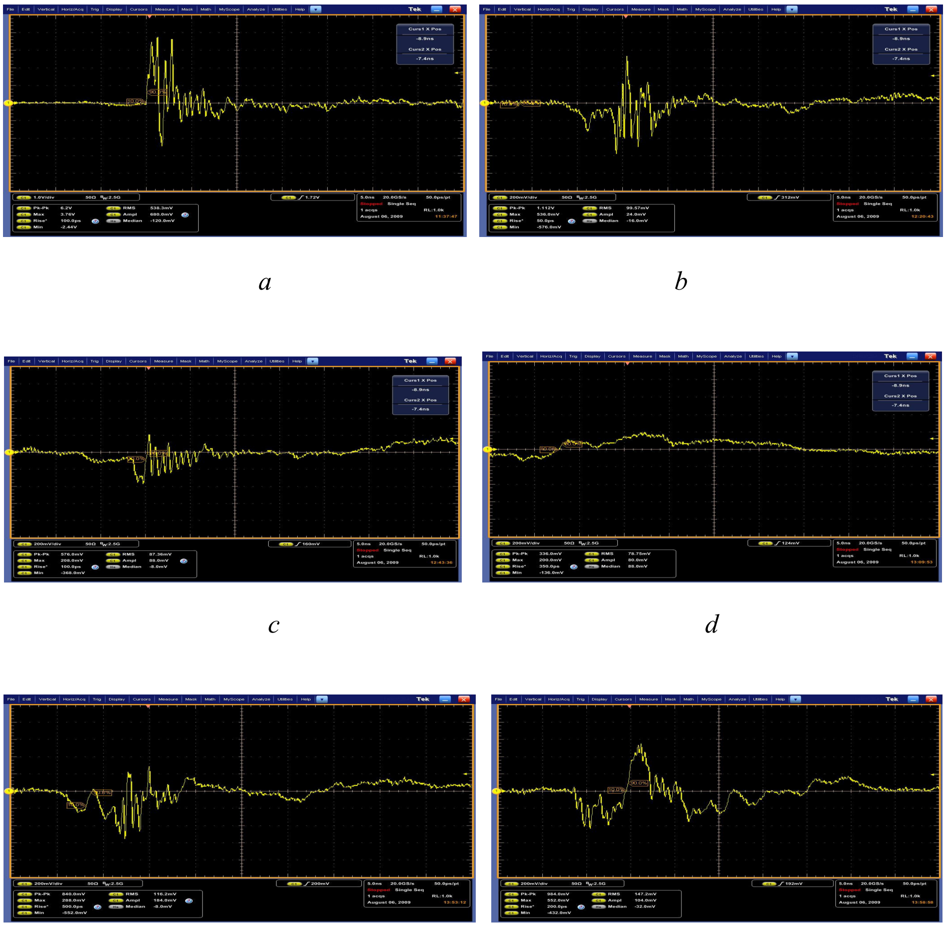
e *f*

Fig. 3 – Waveforms of the magnetic field for +2 kV of charge (*X*-axis).

In Fig. 4 are illustrated the waveforms in the same six points like in Fig. 1 but for *Y*-axis orientation of the magnetic field sensor, for the same +2 kV charge of the electrostatic discharge generator.

In Fig. 5 are illustrated waveforms in the same six points like in Fig. 1 but for *Z*-axis orientation of the magnetic field sensor, for the same +2 kV charge of the ESD gun.

Even if expected, the discharge generator has not produced the same magnetic field in all directions. For example the magnetic field produced horizontally is different from the magnetic field produced vertically for the same charge, as shown in Table 1.



a *b* *c* *d* e *f*

Fig. 4 – Waveforms of the magnetic field for + 2 kV charge (*Y*-axis).

Table 1 shows the obtained results from the measuring of the magnetic field associated to the electrostatic discharges, for +2 kV charge, on all three axis orientation of the sensor.

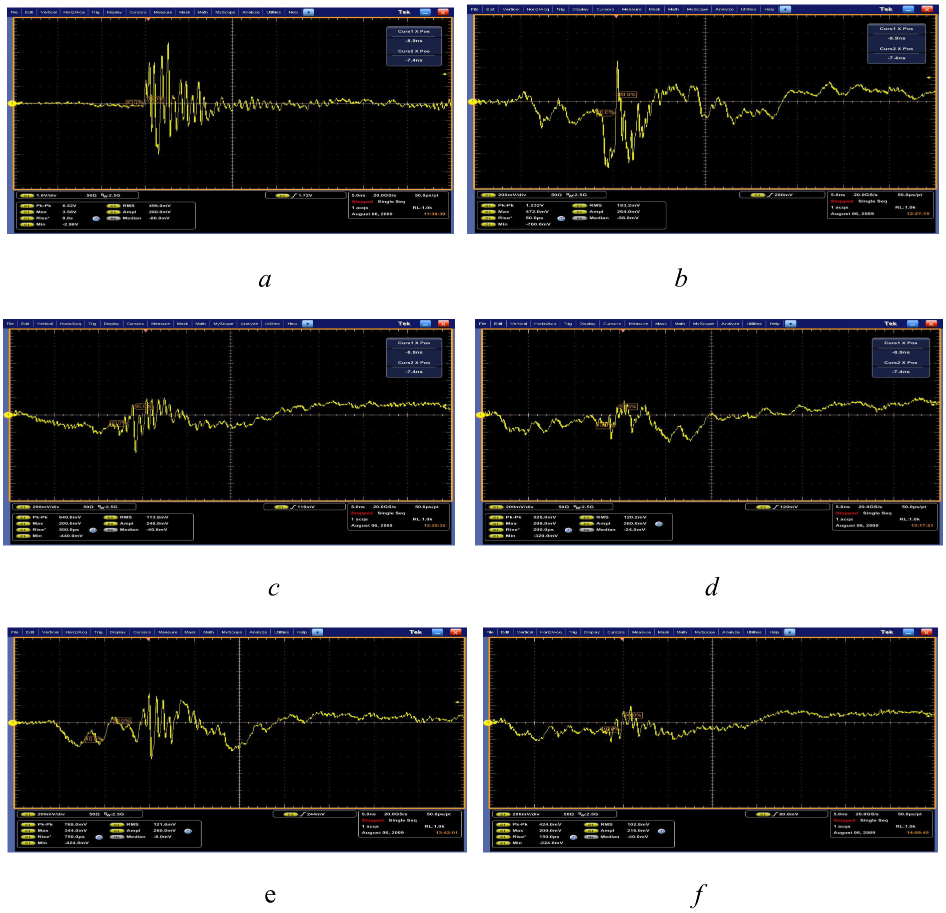
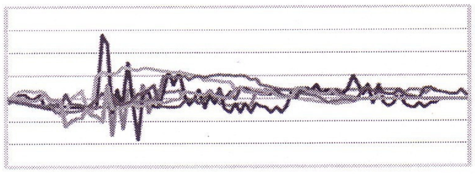


Fig. 5 – Waveforms of the magnetic field for + 2 kV charge (*Z*-axis).

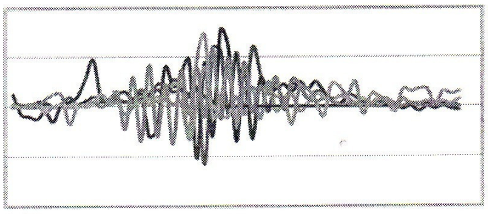
Table 1
Magnetic Field Associated to the Electrostatic Discharges

Testing points	*X*-axis		*Y*-axis		*Z*-axis	
	U_{vv}, [V]	RMS value mV	U_{vv}, [V]	RMS value mV	U_{vv}, [V]	RMS value mV
Point *1*	0.992	124.9	6.2	538.3	6.52	496
Point *2*	0.376	71.83	1.112	99.57	1.232	183.2
Point *3*	0.232	56.11	0.576	87.36	0.640	113.8
Point *4*	0.360	84.91	0.336	78.75	0.528	120.2
Point *5*	0.480	112.3	0.840	116.2	0.768	121.6
Point *6*	0.488	76.61	0.984	147.2	0.424	102.8

Fig. 6 *a* shows the magnetic field on *X*-axis direction, for all six measuring points; in Fig. 6 *b* is represented the magnetic field on *Y*-axis direction for all six measuring points; in Fig. 6 *c* is shown the magnetic field on *Z*-axis orientation of the magnetic sample for all six measuring points.



a



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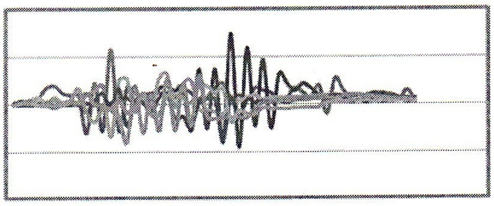

c

Fig. 6 – Magnetic field associated to the electrostatic discharges for *X*- (*a*), *Y*- (*b*) and *Z*-axis orientation (*c*) of the magnetic sensor.

Fig. 7 presents the magnetic field for *X*-, *Y*- and *Z*-directions in point *1* of discharge. We can see that the values for the magnetic field are lower on *X*-axis orientation of the sensor, 10 cm above the point, and for *Y*- and *Z*-direction are obtained higher and much closer values.

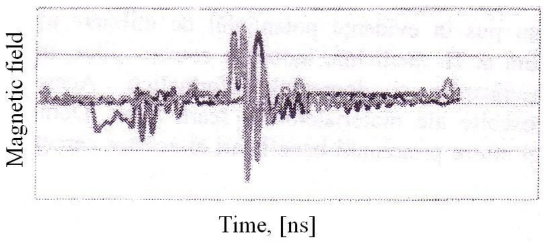

Fig. 7 – Magnetic field associated to the electrostatic discharges for all three directions orientation of the sensor, in point *1* of discharge.

Magnetic field depends on the electrostatic discharge current and varies inversely proportional with the distance to the discharge point. When the distance is increasing, the magnetic field can be inferred from the current provided by the electrostatic discharge simulator.

4. Results

The tests for the magnetic fields associated to electrostatic discharges, for vertical and horizontal coupling, for different charge voltages and groundings and the necessary conditions to increase the repeatability of the ESD tests are according to the standard terms.

The measurements were made using the 6 cm diameter loop probe of the EMCO 7405 set on three axis indicating a quasi-linear growth of the induced voltages with the increasing of the discharge current, best linearity being recorded on the most sensitive *Z*-axis.

For this reason the orientation of the device under test is very important, specifications are needed in the ESD standard in order to ensure the repeatability of tests.

Acknowledgments. This paper was supported by the project PERFORM-ERA "Postdoctoral Performance for Integration in the European Research Area" (ID-57649), financed by the European Social Fund and the Romanian Government.

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* * * *IEEE Guide for Electrostatic Discharge (ESD): Characterization of the ESD Environment*. IEEE std. C62.47-1992.

ANALIZA CÂMPULUI MAGNETIC PERTURBATOR ASOCIAT DESCĂRCĂRILOR ELECTROSTATICE

(Rezumat)

Radiația electromagnetică generată prin transfer de sarcină în fenomenul de descărcare electrostatică (DES) este un fenomen ce afectează funcționalitatea circuitelor electronice integrate, în particular, şi a mediului electronic şi ICT, în general. Măsurările câmpului magnetic generat de descărcări electrostatice sunt efectuate la diferite distanţe faţă de punctul de descărcare. Rezultatele măsurărilor arată faptul că generatorul DES produce un câmp magnetic tranzitoriu care poate afecta echipamentul de testare în mod diferit. De asemenea, pistolul DES produce câmp magnetic variabil în funcţie de tensiunea de încărcare.