The Use of Metallized Material for Shielding Against Transient Electromagnetic Waves

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INTRODUCTION

Problems occur with electronic circuits and systems based on their level of immunity to electromagnetic transients. Several test standards, including IEC 801, Parts 2, 4 and 5, characterize electronic systems under transient conditions. According to IEC 801 the following three different transients may be defined:

A method has been developed to characterize metallized material for shielding against transients.

- Electrostatic Discharge (ESD) results when people accumulate charge as they walk across a carpet, for example, and then discharge when touching a grounded conductor. Because it is possible for charged people to touch the walls of shielded enclosures, this transient is discussed in this article.
- Electric Fast Transient (EFT) is a simulation of the transients occurring on the main power supply during switching, such as heavy inductive loads. Because this transient is directly related to the main power leads, this type of transient is not addressed herein.
- Surge testing is a simulation of a lightning stroke discharging on the interconnection or power supply wires of an electronic system, or over the walls of an enclosure. Because of the latter possibility, this type of surge transient is included in this article.

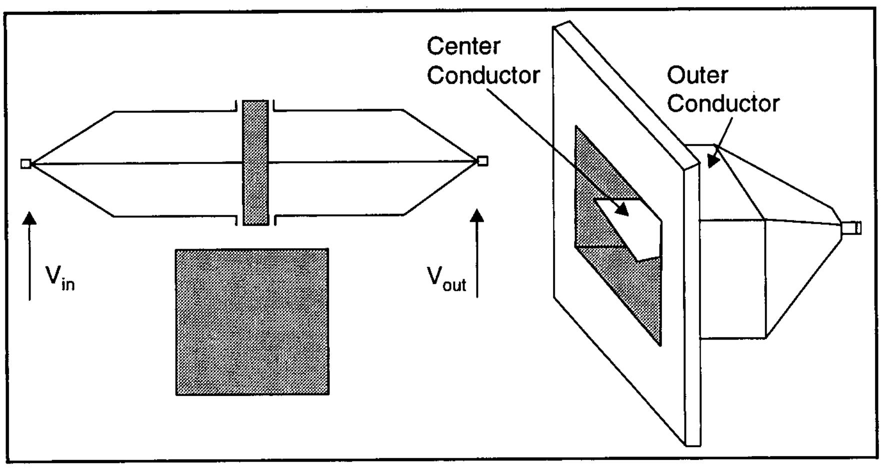

Figure 1. TEM-t Cell.

BASIC MATERIAL CHARACTERISTICS

Using small test cells, far-field and near-field conditions may be simulated. For far-field conditions, all testing methods are based on the assumption that the wave impedance (the ratio of E-field to H-field) is constant. Therefore, all test cells are based on a coaxial transmission line where the ratio of voltage and current (characteristic impedance) is constant, normally 50 ohms.

In the near field, measurements can be done in the E-field and H-field. Test methods have been developed for both field conditions.

TEM-t CELL

The recently developed TEM-t cell can be used to characterize shielding materials under transient conditions. It is based on the standard measuring technique set forth in the ASTM-D4935-89 method, and also takes into account that ASTM-D4935 can be problematic when composite materials with low conductivity at the surface of the materials are used. The TEM-t cell is similar to a TEM cell, but features an interrupted inner conductor and a rectangular cross section (Figure 1).

Measurements are taken in a non-contacting, capacitively coupled manner for a variety of materials. Shielded material samples must completely cover the outer flanges. Smaller samples and gaskets can be measured using special sample holders. Even for the reference measurement, no sample preparation is needed. A good correlation is obtained with both theoretical values and measured ASTM-D4935-89 values when applying a correction factor based on the cell construction.

H-t CELL

The H-t cell uses two electrically shielded loop antennas at both sides of the sample and at a distance of 3 mm (Figure 2). The system is a closed system and the loop antennas are coplanar, so the measurements are done under conditions similar to those specified by MIL-STD-285. The system is compatible with the TEM-t cell. Again, no sample preparation is needed. Technical and application details are given in the articles listed in the bibliography.

A copper-coated nylon non-woven material with a final weight of 42 grams/m^2 and containing 20% (W/W) copper metal has been tested for its behavior against transient electromagnetic waves. The material can be used in the construction of shielded enclosures and rooms. The test results for the material are shown in Figure 3. It should be noted that due to the construction and the characteristics of the TEM-t cell, the values below 50 MHz are not accurate in this case because of the dynamic range of the measuring equipment used. Therefore a typical shielding effectiveness (SE) value of 65 dB is estimated for far-field or plane-wave conditions. H-t magnetic field SE values are based on only 3-mm distance between the small loops and the sample. This explains the relatively low SE values obtained for the frequency range from 10 MHz to 500 MHz. However, an estimation of the MIL-STD-285 magnetic field SE values is possible.

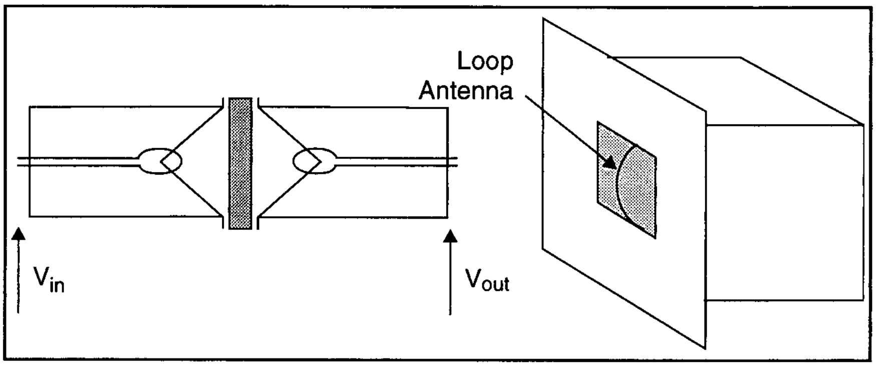

Figure 2. *H-t Cell.*

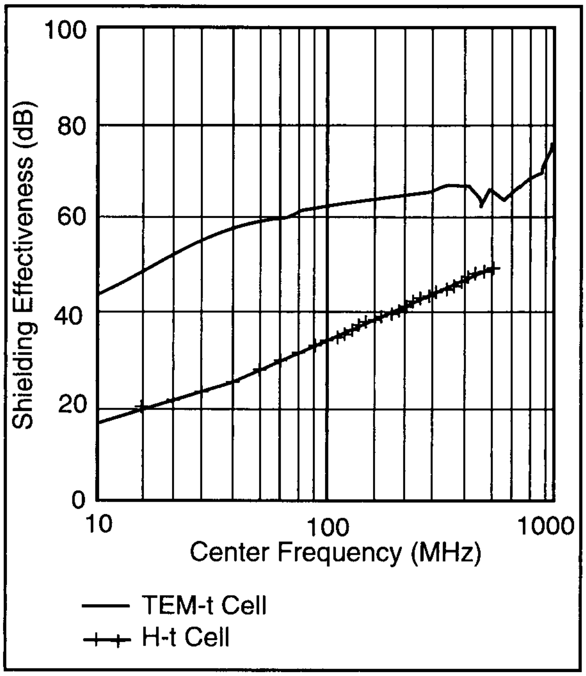

Figure 3. *SE Results for Non-woven Metallized Material.*

MEASURING SYSTEM

As a spin-off from other research programs, a specific measuring method has been developed to characterize the behavior of shielding materials against transient electromagnetic waves. The method was designed to simulate real-life situations of electronic circuits and systems and to supplement the IEC 801 group of standards in which only system testing is required and no characterization of materials is required.

The method was also designed to be easy to use and to yield readily interpretable results. For these reasons, a printed circuit board (PCB) was developed. The size of the PCB is that of a standard Eurocard (10 cm x 20 cm). When a transient occurs, the accompanying discharge current creates a strong magnetic field which can be detected by a loop antenna and induces a voltage in the loop. This induced voltage may disturb electronic circuits, for example, by falsely triggering logic circuits. However, logic circuits need at least 1 V to be triggered. On the other hand, analog circuits are sensitive at the level of mV.

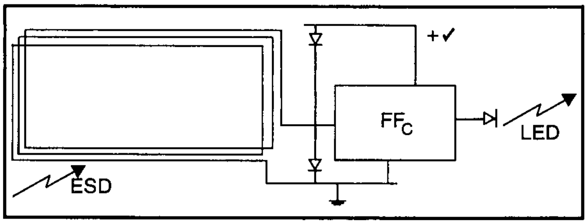

Figure 4. *Basic Circuit of Measuring System.*

In order to have an idea of the induced voltages, and also to create an easy-to-use system, eight loop antennas with a different number of turns were constructed. The number of turnings were in a series of 1, 2, 4, 8, 16, 32, 64, and 128 and each loop was connected to a flip-flop. In this way, each flip-

Number LEDs	Sensitivity (mV/cm^2)
1	0.125
2	0.25
3	0.5
4	1.0
5	2.0
6	4.0
7	8.0
8	16.0

Table 1. *Induced Voltages.*

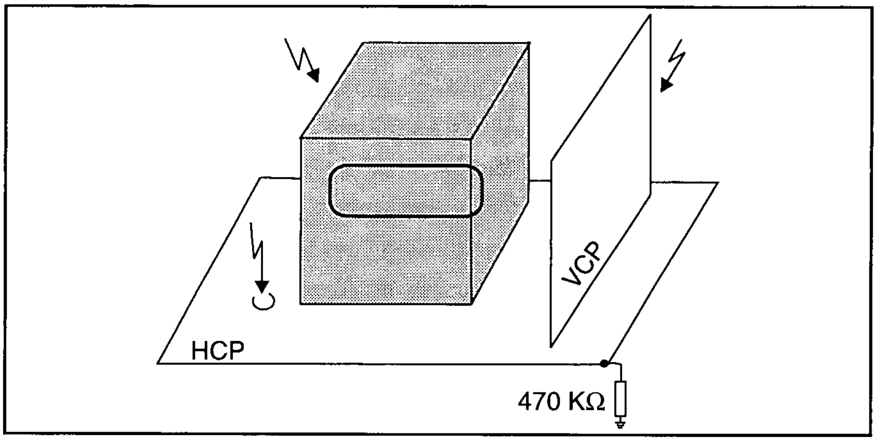

Figure 5. *Schematic Figure of ESD Test Setup.*

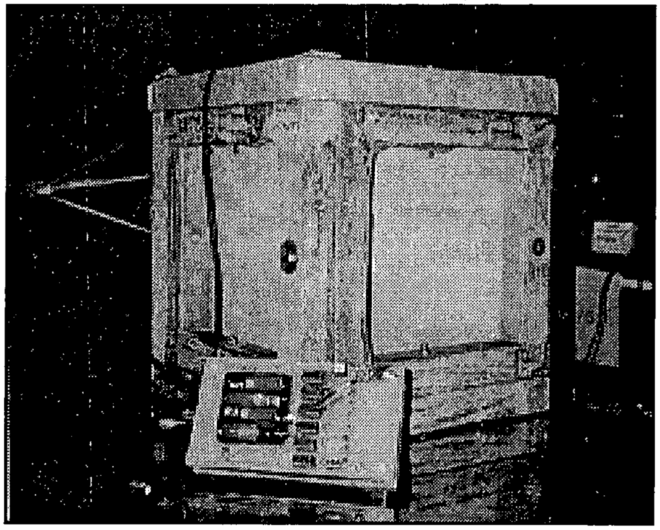

Figure 6. *PCB Under Test.*

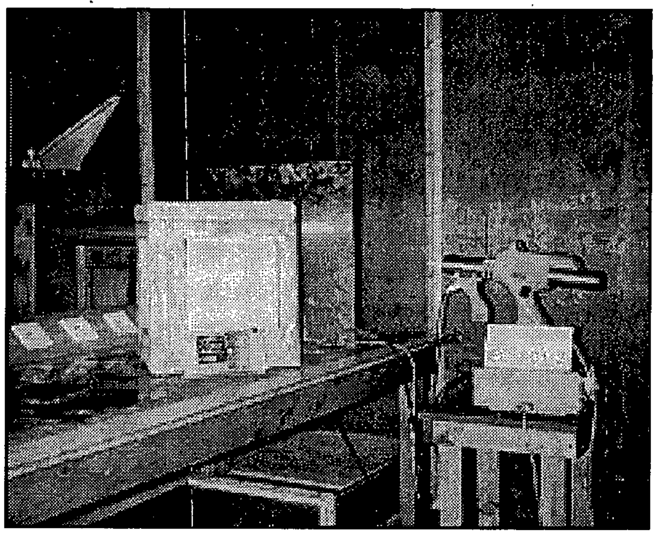

Figure 7. *ESD Test Setup.*

flop represents another sensitivity of the system. Each flip-flop drives an LED, so a "sensitivity thermometer" is obtained (Table 1). The basic idea is sketched in Figure 4.

In order to characterize the measuring system for further evaluation of the results, a triggering level for the logic circuits of about 2.5 V is estimated. This means that each triggered LED represents a loop where at least 2.5 V has been induced. For the case in which only one LED is triggered, only the very sensitive 128-turn loop generates the needed voltage level for triggering the flip-flop.

The loop surface area is 16 x 10 cm^2. For a case in which all eight LEDs are triggered, at least 2.5 V is induced in all loops, including the 1-turn loop. When only one LED is triggered, it may be calculated that about 20 mV/turn is induced. This represents a sensitivity of 0.125 mV/cm^2 surface loop area (Table 1).

ESD TESTING

IEC 801-2 ESD TESTING

The effect of an ESD discharge caused by people is simulated by the test setup described in the IEC 801-2 Standard. A small box of 30 x 30 x 30 cm^3 was constructed for the purpose of the ESD tests. Using a modular wooden frame, each side wall was formed by one panel. Each panel was covered by the metallized fabric, and the panels were screwed together. The contacting thickness was 4 cm at each edge. The PCB was placed inside the box. It should be noted that the PCB system is battery-operated (Figure 5). Figures 6 and 7 show the PCB and the ESD test setups. Both direct and indirect ESD discharge tests were performed with voltage levels of 25 kV.

MEASUREMENT RESULTS

No LEDs were triggered when the reference PCB was placed in the box and direct and indirect ESD discharge tests were conducted. This means that the shielding of the conductive material against the ESD transient discharge is such that less than 0.125 mV/cm^2 is induced in the receiving loops.

SURGE TESTING

IEC 801-5 SURGE TESTING

The effect of a lightning stroke discharge was also simulated using the test setups and the

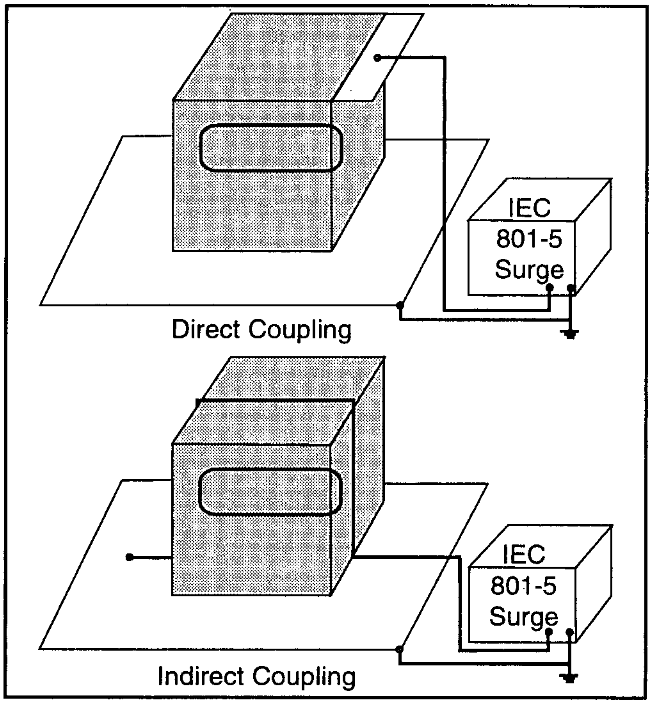

Figure 8. *Direct and Indirect Surge Testing of Boxes.*

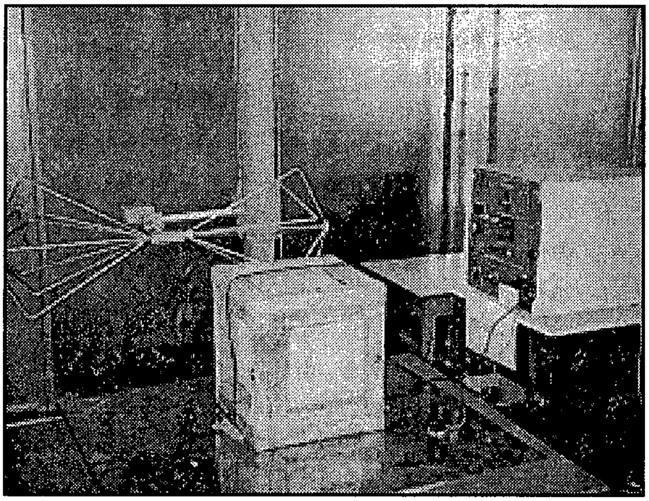

Figure 9. *Setup for Indirect Surge Testing.*

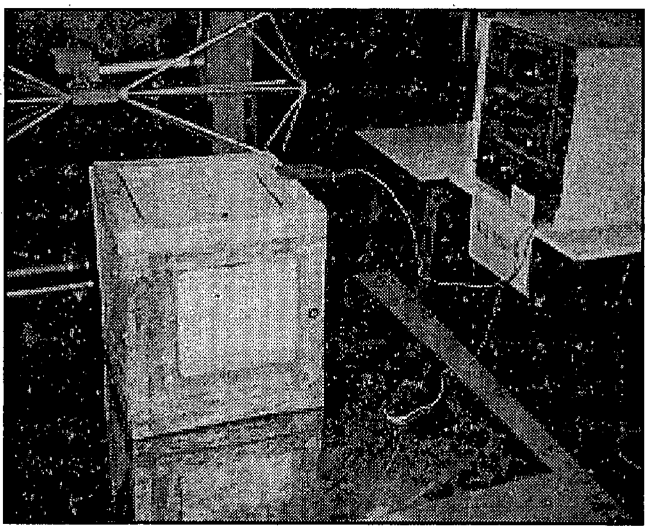

Figure 10. *Setup for Direct Testing.*

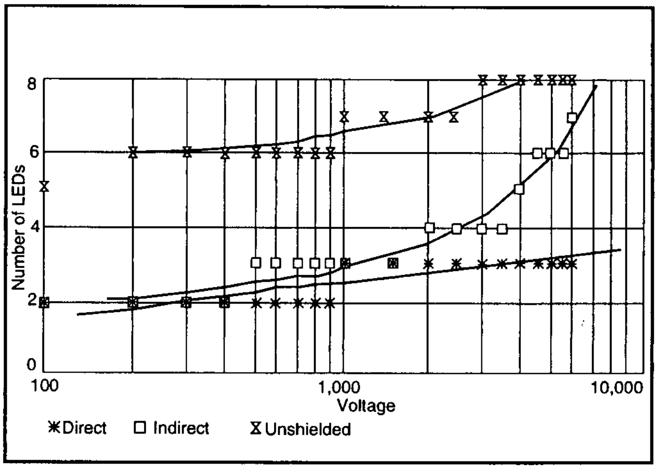

Figure 11. *Test Results.*

waveforms described in the IEC 801-5 Standard. Two types of measuring setups were constructed for surge testing the material. A small box of 30 x 30 x 30 cm^3 covered with the conductive material was used, and the reference PCB was placed inside. A direct and an indirect surge test was created by applying the surge pulse directly to the test box, and by coupling the surge pulse over a wire to the box. Both setups are shown in Figure 8. Figures 9 and 10 are photographs of the setups.

MEASUREMENT RESULTS

In accordance with the IEC 801-5 standard, conformal combined pulses — 1.2/50 µsec to 8/20 µsec — the pulse was changed from 100 V to 6 kV. For each test, the number of triggered LEDs was noted. They are given in Figure 11.

It may be concluded that for direct surge testing, a good ground connection at the same side as the application point of the surge pulse yields a very good result. The triggering of three LEDs is equivalent to a logic level triggering by the 32-turn loop or a loop surface area of about 5000 cm^2.

For indirect surge testing, the loops of the reference PCB are in parallel inside the loop created by the induction wire of the test setup. In this way, the loops of the reference PCB are oriented for maximum coupling to the surge induction loop. Thus, the indirect measuring results are worst-case values. It should also be noted that the unshielded box can only be operated for indirect application of transient pulses.

CONCLUSIONS

It may be concluded from the transient tests that the metallized fabric used as a shielding material for boxes and enclosures offers good protection against both ESD and surge discharges.

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REFERENCES

1. J. Catrysse, "The Use of Flectron Metallized Material for Shielding Against Electromagnetic Waves," Monsanto Internal Report, April 1992.

2. J. Catrysse, "A New Test Cell for the Characterization of Shielding Materials in the Far Field," 7th International Conference on EMC, IEE, York, 1990.

3. J. Catrysse, "Measuring Techniques for SE Values of Samples and Enclosures," IEE Colloquium on Screening of Connectors, Cables and Enclosures, London, January 17, 1992.

PROF. J. CATRYSSE *graduated as an electronics engineer from the University of Ghent in 1971, and started working as a research engineer at the HF laboratory of the University of Ghent. He joined the Katholieke Industriele Hogeschool in Oostende in 1974. He has been head of the electronics department since 1978 and a professor since 1983. Since 1983, he has been involved with EMC, especially with the characterization of filled conductive plastics for shielding purposes. Since 1990, he has been director of the EMC lab of the KIH.WV in Oostende, Belgium. FAX: (059) 70 42 15.*