Study on Computer Generated Electromagnetic Interferences on Video Data Processing

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Abstract

This paper presents a review of Computer Generated Electromagnetic Interference (CGEI) on Video Data Processing and the radiated emission of EMF on Video Data Processing unit either a CRT or LCD, LED. For data processing, processor requires data transmission in parallel and this parallel transmission, sometimes signals, cause interference with each other. Due to this interference, we lose some signals or data and this lost of signals is known as eavesdropping.

To overcome EMF interface or eavesdropping, we use EMF interference shielding methodologies reducing the electromagnetic interference by using electromagnetic interference shielding effectiveness.

Keywords: CGEMI, EMI, VDP LVDS, EMR Carbon nano-fiber composite, electromagnetic interference, reinforced polymer

Introduction

For data transmission from a main unit in a data processing system to peripheral unit requires parallel data input. This is normally done via cable system comprising leads for number of data bits and for control signals and different voltage levels. For example information is to be presented as an image on the display unit either LCD or CRT. The main unit typically comprises a data processor, a memory unit, an application program which is executed with the aid of processor and intermediate storage memory in the form of an image memory for temporary storage of the information which is to be presented on the display units and I/O unit for parallel input and output data.

A display unit of standard type additionally comprises a presentation panel, a number of drive circuits for LCD segments included in the panel, a control unit which, by means of the drive circuits, controls the data output to the presentation panel and an I/O unit which corresponds to control unit and is located in the main unit. The main unit and the display unit are coupled

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Author is grateful to the anonymous referees for comments and suggestions for improving the text and contents of the paper. Author alone is responsible for any errors/mistakes still remaining in the paper.

together with a cable normally comprising eight data leads for transmission of an 8 – bit data word, a number of voltage leads for supply voltage, different voltage levels and earth-ing and number of control signal leads for transmission of control signals such as clock signal, resetting signal, register selector, read / write signal, enable signal etc.

All the above operations are done by electronic device. It is well known that electronic equipment produces electromagnetic fields which cause interface on television (display Unit) reception. An interface is not the only problem caused by electromagnetic radiation. It is possible in some cases to obtain information, the signals are picked up and the received signals are decoded, especially in the case of digital equipment. This possibility constitutes a problem because remote reconstruction of signals inside the equipment may enable reconstruction of the data.

This problem is not a new one; defense specialists have been aware of it for the last 30 years. Video Data processing unit or Video display unit are being devised in which screen eavesdropping can be prevented and Electromagnetic effects can reduced. Equipment designed for defense purpose is four to five times more expensive than that for general purpose.

It was considered very difficult to reconstruct hidden data in the radiation field and it was therefore believed that eavesdropping on the digital equipment could only be performed by professionals with the access to very sophisticated detection and decoding equipments. Video Data Processing (VDP) unit requires medium and low level protection against eavesdropping.

In Video Data processing unit it can be easily recognized that the field radiated by such digital equipment will consist of two parts:

- Narrowband harmonics of the digital clock signals.
- Broadband harmonics of the various random digital signals such as the video signal.

The video signal is amplified from Transistor - Transistor Logic units (TTL) several hundred volts before it is fed into the cathode ray tube (CRT). The EM Radiation (EMR) originating from the video signal is the major component of the broadband field generated by the Video Display Unit. Each radiated harmonic video signals shows a resemblance to a broadcast TV signals.

The signal received by the Video display unit (TV) receiver does not control synchronization on the TV screen while receiving radiation from a video display unit will be moving over the screen in both the horizontal and vertical directions unless the synchronization frequencies in the video display unit and the TV receiver are the same. The picture received on display unit may not be very stable and therefore not very readable. The quality of reception can be improved by externally generating the necessary synchronization signals and feeding them into the display unit receiver. With this extension to the normal TV receiver almost any type or make of video display unit can be eavesdropped on and it generates a sufficiently high radiation level. The extension can be designed and constructed by any electronic amateur within a few days.

The aim of the measurement set up is to check the reconstruct ability of information displayed on the display unit by means of radiation receiver. Since various sources of radiation occur, this reconstruct ability is not determined only by the radiation level produced. Therefore a normal receiver should be used as a measuring instrument. The measuring distance from the unit or terminal under test will be in that case the variable which determines the stringency of testing. The information on the screen is required not to be reconstruction able on the normal display receiver.

EMI Shielding

Given the rapid development in commercial, military, scientific electronic devices and communication instruments, there has been an increase in number of developing materials that could shield against electromagnetic radiation to prevent interference. The current material options that provide effective shielding effectiveness are metals, metal powder, metal-fiber filled plastic polyacrylonitrile (PAN), Nickel Coated Reinforced Polymers (NCRP), aluminum structures, coatings nickels and copper metalized fabrics and more recently, nano-reinforced polymers composites. Typical limitation found with materials used for shielding to prevent EMI are associated with corrosion susceptibility, lengthy processing times, high equipment cost for production, difficulty of material utilization to build articles with complicated geometries, limited service life when using conductive layers due to peeling and wear and high reinforcement concentration. NCRP like carbon nanofiber, carbon nanotube and nanowire reinforced polymer matrices seem to overcome some of these limitations because they are lightweight materials with design flexibility, corrosion resistance and suitable for mass production through conventional plastic manufacturing technologies such as extrusion and injection molding.

Measuring Electromagnetic interference shielding effects at a broad frequency range for newly developed materials is crucial to determine their properties and potential applications. Shielding effectiveness is defined for incident waves that are in transverse electromagnetic mode (TEM) i.e. similar to plane waves caused by a distant source.

In a coaxial cable a transverse electromagnetic mode (TEM) is present. Meaning the magnetic (H) and electric (E) field vectors are both perpendicular to the direction of current propagation. New Nano engineered and Nano reinforced materials are relatively expensive, hence the specimen size required for testing its properties should be as small as possible. Currently there are numerous ways to conduct testing for shielding effects that depends on the type of materials being used and their application. Researchers can make use of several existing standards available to characterize Shielding Effectiveness (SE) of materials such as:

- ASTM D4935-99
- ASTM ES7 – 83
- MIL-STD-188-125A,
- IEEE-STD-299-1991
- MIL STD-461C
- MIL-STD-462

It has been reported that using the ASTM D4935-99 standard coaxial holder to measure Shielding Effectiveness is convenient because relatively small specimens are required for testing in comparison with military standards, which require 6 cm square sample size. However because of their limited dynamic range and relatively large specimen dimensions, these standards may also be impractical and inadequate for testing some newly developed nano-reinforced materials. It is noticed that the ASTM - D4935-99 standard tester and the required specimen are relatively large.

Shielding effectiveness can be obtained from the transmission measurements of the load and the reference specimen and it equals the transmission of the reference (dB) minus the transmission of the load (dB) specimens, as indicated in equation (1). The reference and load specimens need to be of the same material and thickness. Therefore it is imperative that Shielding Effectiveness testing be performed using both the reference and load specimens.

The purpose of any shielding effectiveness (SE) test is to determine the insertion loss (IL), caused due to introduction of a material between the source and signal analyzer. SE is determined by measuring the electric field strength levels with both reference ER and Load EL specimens, this is without and with the shielding martial respectively

$$SE = 20\log10\,(ER/EL) = (dB)R - (dB)L \qquad \ldots(1)$$

And it can also be determined by measuring power

$$SE = 10\log10\,(PR/PL) \qquad \ldots(2)$$

The SE coaxial tester impedance of 50 Ω throughout its length matches the impedance of the signal analyzer, cables, connectors and attenuators. This impedance was achieved by choosing the diameters "D" and "d" to compute the characteristic impedance, Z_0 of a coaxial line

$$Z_0 = (\eta_0 / 2\pi\ \eta\varepsilon_r)\ \text{in}\ (D/d) \qquad \ldots(3)$$

Where η_0 is free space wave impedance approximately which is equal to 377 Ω, D is the inner diameter of the outer conductor, "d" is the diameter of the inner conductor and ε_r is the real part of the relative permittivity of the dielectric material between conductors, which for air is equal to 1. Applying the previous equation to the coaxial holder and having air as the dielectric material, it is determined that the impedance of the holder is only a function of its dimensions "D" and "d"

$$Z_0 = 60\ \text{in}\ (D/d) \qquad \ldots(4)$$

The upper frequency limit for pure transverse electric mode (TEM) operation is the cutoff frequency fc of the first higher order mode. This can be computed using following equations

$$fc = (n/\pi)\,(2c / D+d) \qquad \ldots(5)$$

where, n is a positive integer and equal to 1 for the principal mode and c is the speed of light equal to 3 x 108 m/s . Also for the new SE tester the following dimensions were chosen to match the dimensions of female N – type connectors of 10 dB, 50 Ω attenuators

$$D = 7.32\ mm; \qquad d = 3.18\ mm \qquad \ldots(6)$$

Therefore it was determined that the characteristic impedance of the tester is 50 Ω with a theoretical cutoff frequency of 18.2GHz.

According to the ASTM- D 4935-99 standard, an electrically thin material must have a thickness tm less then 0.01 times the electrical wavelength, λ, of the signal transmitted through the specimen being tested i.e., the electrical wavelength of the speed of light divided by the frequency of the signal. If a material is not electrically thin, measurements of shielding effectiveness (SE) should be performed throughout the frequency range of interest? Electrically thin materials that are isotopic and whose electrical properties are independent of the frequency might require SE measurements at only few frequencies since their EMI SE characteristics are independent of the frequency (10). Also it is known that the transition between near field and far field occurs at about the $\lambda/(2\pi)$ from a dipole source.

Table 1 shows the maximum thickness of a specimen to be considered electrically thin at the specified frequencies. Tests with coaxial SE testers are in the far - field region because the distance between the source and the receiver is more than a quarter of the wavelength of the highest frequency used in the tests. If needed, near field SE can be determined from far – field data for electrically thin materials [Lozano, K., Files, B. and Rodriguez, F., 1999] with the newly developed simple EMI SE tester. A specimen that is .165 mm thick or less will be considered a thin material at frequencies up to 18.2 GHz.

Table 1: Electrically Thin Material, Wavelength and near to far field transition

Sr. No.	Frequency f (10) GHz	Maximum thickness to be an electrically thin material, t_m (mm) mm	Wavelength λ(mm)	Near to far field transition (mm)
1	1	3.000	300.0	47.75
2	5	0.600	60.0	9.55
3	13.5	0.222	22.2	3.54
4	18.2	0.165	16.5	2.62

EMI Shielding Effectiveness Device

The new electromagnetic interference Shielding Effectiveness device consists of two identical flanged parts that are clamped together to hold the outer part of testing specimen of two concentric rods that hold the circular central part of the reference specimen. The fanged conductors are attached using four nylon bolts and have SE tester showing the 10dB attenuation attached to it. The flanged parts have threaded ends designed to couple standard N-type connectors, like the ones of the attenuators and cables.

Manufacturing of the tester was performed using alloy 360 brass rods. The manufacturing process of this new EMI Shielding Effectiveness tester was much simpler than the ASTM D-4935-99 standard device. Its dynamic range is much higher, it is lighter, less costly and easier to manipulate by the researcher.

Shielding effectiveness can be obtained from the transmission measurements of the load and the reference specimen and it equal the transmission of the reference (dB) minus the transmission of the load (dB) specimens, as indicated in (1). The reference and load specimens need to be of the same material and thickness. Therefore it is imperative that Shielding Effectiveness testing be performed using both the reference and load specimens. Several reporters consider using air as the load specimens. Several reporters consider using air as the reference materials. However doing so yields an insertion loss of 0 dB for reference; therefore the SE of the sample is the negative of the transmission of the load specimen. As a consequence, this practice does not provide accurate results for absolute SE measurements.

Using newly developed SE tester, the transmission readings without material between the flanges. It can be observed that reading of – 20dB and 0 dB were obtained with and without attenuator, respectively, indicating good performance of the SE tester with an expected impedance match of 50 Ω. The results indicate proper operation up to ≈ 1 GHz, which closely corresponds to the expected resonance frequency for a radial transmission line mode in the space between the flanges. Consequently, the newly developed simple EMI – SE tester seems to perform satisfactorily up to 11 GHz.

A Commercial conductive gold film, AGHT-4, with thickness of 0.18 mm, with 4.5 Ohms/ Square surface resistively was used to calibrate the SE tester. This is in the case of a sample with thickness t, conductivity σ, and complex permeability μ.

In the case of a single thin film alone with sheet resistance RA, the thickness of the film and any supporting substrate is insignificant compared to the wavelength, t can be sent to zero and the equation is reduced as follows:

$$SE = -20 \log 10 [2 RA \eta 0 / 2 RA \eta 0 + \eta 2 0] \quad \cdots (7)$$

In the case of gold film with a value of RA equal to 4.5 Ω /square used for the calibration, a value of 32.6 dB SE is theatrically expected, computed by using equation (7). The EMI SE specification of the AGHT-4 film is according to the manufacturer. Therefore acceptable EMI SE values were obtained with the new SE tester using an AGHT – 4 films for calibration. It should be noted that is up to 1.5 GHz for the SE value of 32 dB.

Experiment

Different samples were prepared to further elucidate the potential of the developed tester. The following list presents the materials that were prepared and tested to determine their EMI –SE

a) Low–density polyethylene (LDPE) sheet with thickness of 1.5 mm
b) Mylar (PET) with thickness of 0.18 mm
c) Aluminum foil with thickness of 0.015mm
d) 15% weight VGVNF liquid crystal polymer (LCP) sheet with thickness of 1.25 mm

In the case of the LDPE sample, pellets with a density of 948 Kg/ m3 and a melting temperature of 135 degree Centigrade were provided by Chevron Phillips Chemical Company. The pellets were hot pressed using a hydraulic press into sheets of 1.5 mm thickness. Commercial Mylar and aluminum foil were used with the provided thickness.

Results

The shielding effectiveness of a low density polyethylene (LDPE) sheet (t = 1.5 mm) is taken. It can be observed that the reference reading is much lower than the - 20 dB attenuation generated by the two attenuators, which indicates that assuming 0 dB for the reference reading generates incorrect results. For example assuming 0 dB for the reference reading, a SE of -30 dB would be reported, which is incorrect value because it is known that the SE of LDPE is ≈ 0dB since it is transparent to electromagnetic interference.

The electromagnetic Interference Shielding Effectiveness of aluminum foil resulted in about 40 dB. An Aluminum plate was tested along but its SE was out of the operating range of VNA and thus measurement became meaningless. The reason for this is that the resistivity of aluminum plate is RA = 2.85 x 10 -8 ohms / Square and yields a SE of 196 dB.

The Shielding Effectiveness of a Liquid Crystal Polymer (LCP) composite with a concentration of 15% weight of vapor grown carbon nanofibers (VGCNF). The thickness of the VGCNF / LCP was 1.25 mm and the SE obtained is close to 30 dB, indicating a performance similar to the aluminum foil. This nanotechnology material has good EMI Shielding Effectiveness properties which potentially make it suitable for EMI applications.

The transmission of the reference sample readings are critical when experimentally obtaining Shielding Effectiveness value, Reference sample reading for the materials tested. Reference sample readings have a strong dependence on thickness and conductivity. The non conductive LDPE with a thickness of 1.5 mm has a smaller reference value as compared to non conductive PET with a thickness of 0.18 mm. Likewise in the case of the aluminum plate which has smaller reference value when compared to aluminum foil. However an exception occurs with the 15% weight nanofiber reinforced liquid Crystalline Polymer (LCP). This sample has a surface resistivity of 410 Ω /Sq and a thickness of 1.25 mm. The surface resistivity of the AGHT -4 is 4.3 Ω /Sq with a thickness of 0.17 mm. Given the thickness and resistivity value of the VGCNF/LCP sample, a lower reference value was expected, but VGCNF/LCP sample has a higher reference reading than the AGHT -4.

Only the air and aluminum foil have a reference reading of 0 dB. This observation summarizes the need to perform the reference sample test instead of assuming 0 dB for reference when measuring the SE of any materials. Several resonances effects are observed in the region of 2.2 GHz and 4.4 GHz which correspond to the total length of $\lambda / 2$ and λ for the flanged tester measured from the interfaces with the N- type connectors. This indicates that there is an impedance discontinuity at the interfaces of the connectors, which needs to be compensated for the future designs.

Future work consists on researching the EMI –SE characteristics of numerous nano-reinforced materials and developing an understanding of the SE mechanism involved in nano – reinforced materials.

Conclusion

The objective of this paper is to identify the electromagnetic effects on Video Data Processing at extremely low frequency electromagnetic fields and how to reduce the effect of the electromagnetic field on Video Data Processing especially of Parallel Processing / Distributed Processing by using shielding effectiveness.

With every real danger posed by EMI, the advantage of LVDS over the data transmission schemes may be useful information for anyone designing data interfaces. To reduce power, cost and a 400 mbps data rate make sure you add reduced emissions to the list of benefits associated with LVDS interface. Besides with the speed power, EMI befits. New composite EMI materials offer an excellent way to mitigate the EMI that will be an inevitable part of cellular stations that handle mixed data transmission. The use of new materials offers tremendous potential for dealing with EMI problems that will become ever more critical in an increasingly cellular world.

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