Electrical Shielding Effectiveness of PC Box; Effect of Polarization Angle and Aperture Dimension

I. B. Basyigit, A. Genc, B. Urul and S. Helhel

***Abstract*—**In this paper, the effects of an aperture shape and polarization angle have been investigated by means of measurement results. In the investigation, metallic computer box having same size of apertures were considered that there were 2mm metallic thickness. Measurements were conducted in the frequency range of 2.6 GHz to 9 GHz for all polarization of transmitting antenna with respect to longitudinal aperture orientation. It has been observed that electrical shielding effectiveness performance of hexagonal apertures is 10 dB better than elliptical apertures in this frequency range. Whereas elliptical aperture on empty case are performing better electrical shielding effectiveness than installed one up to 5.85 GHz, their performances merge at this point and beyond.

***Keywords*—**Shielding effectiveness, electromagnetic compatibility, metallic enclosures, cavity and polarization of electromagnetic waves.

I. Introduction

THE electromagnetic interference has become a serious problem with the usage of complex and nested electronic networks. Especially sensitive electronic equipment may sustain damage in electrical environment. Shielding is one of the major effective methods to reduce the emissions and improve the immunity of electronic equipment. Since increased data usage and ultra-high speed data transfer require electronic networks to be composed of high frequency operating components as microprocessors. Shielded enclosures and enclosure components usually have apertures for maintenance, cooling and ventilation that they have different pattern and size for control panels, heat dissipation airing, cable penetration and other purposes. These apertures decrease the shielding performance and the integrity of the shielded enclosures due to the electromagnetic energy leakage. Also the wired and dielectric structures have electromagnetic emission excitation characteristics. That's why it is significant to illuminate the shielding properties of enclosures. The general definition of the shielding effectiveness (SE) according to the IEEE Standard 299 (IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures) [1] is usually employed to quantify the efficiency of the shielding phenomenon. Generally, ESE can be identified in (1) is the ratio of electric field strengths with absence and presence of an enclosure, respectively.

$$ESE = 20\log\frac{E_a}{E_p} \quad \text{[dB]} \qquad (1)$$

There are plenty of equipment running in between 2 GHz and 9 GHz. The wireless USB operating in the frequency range of 3.1 GHz to 10.6 GHz has already been intended for short-range multimedia file transfers at about 480 Mbit/s data rate with low power consumption. UWB technology has been used for use in personal area networks (PAN) with the IEEE 802.15.3a standard. Body area network (BAN) applications operating in the frequency range of 7.25 – 8.5 GHz band has also been started to use. Microwave radiation is also used in electron paramagnetic resonance (EPR or ESR) spectroscopy, typically in the X-band region (9 GHz). High-speed multimedia radio is the implementation of wireless data networks over amateur radio frequencies using commercial off-the-shelf hardware such as 802.11 access points and D-Star equipment to increase the power and coverage of the 802.11 signal that system is running in the frequency range of 2.3 GHz, 3.4 GHz, and 5.8 GHz. High and ultra-high ultrasound waves for ultrasonic imaging have been started to be used in acoustic microscopy, with frequencies up to 4 GHz. MAN (Metropolitan area network) protocols like Wi-MAX (Worldwide Interoperability for Microwave Access) are based

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on standards such as IEEE802.16a/b/c/d/e/f that designed to operate between 2 and 11 GHz. Ultra-Wideband Sensing devices operating in the frequency range of 17 MHz and 8 GHz for medical applications have newly announced that they are almost available for commercially. UWB characteristics are available for short-range indoor applications [2-4] such a as PC units involved with low emission levels. Data rate can be exchanged for range by varying pulse energy per data bit due to the short duration of UWB pulses. High data rate at UWB may enable in wireless monitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for a personal computer, file transfers between cell-phone handsets and handheld devices such as portable media players. UWB systems are also used for real-time location; its precision capabilities and low power make it well-suited for radio frequency sensitive environments, such as hospitals. Slow progress in UWB standards, the cost of initial implementation and performance significantly lower than expected initially are several reasons for the limited use of UWB in consumer products which caused several UWB vendors to cease operations. UWB is also used in precision radar-imaging technology, accurate locating, and tracking [5]. An increased usage of UWB frequencies in wide range of commercial and military applications forced EMC test authorities to extend CISPR-16 EMC test range up to 6 GHz, and it can normally be expected that these test limits will be extended to frequencies including X-Band.

There are various numerical studies about shielding effectiveness [6-11]. For example, integral equation of electrical field is used to get solutions via the moment of method (MoM). Transmission line matrix (TLM), Finite difference time domain (FDTD), finite element methods (FED) are also the other numerical methods. In these methods, it is possible to meet differences in the solutions for special regions which depend on in spatial, frequency solution, computation time and precise simulation. The major problem of these methods is necessity of computer resources such as HDD space and RAM etc. Also computations take many hours/days to reach an acceptable solution. MoM technique requires many few tens of seconds for running per each frequency point on computers having high speed (3-4 GHz) and high capacity. [8] So, it takes 3-4 hours to produce data containing of nearly one thousand frequency points. Also different transformation codes on MoM take more time to get data. Widely used analytical formulation based on equivalent circuit method [12] gives allows calculating the shielding effectiveness of enclosures with rectangular aperture. The enclosure is considered as a short-circuited rectangular waveguide and the apertures are assumed as two shorted coplanar transmission lines. The ESE is calculated as a function of frequency, dimensions of enclosure and aperture, and probe position within the enclosure. This analytical calculation is much faster than other numerical methods as indicated above. Analytical methods do not require more capacity.

We have already investigated aperture size and some parameters of magnetic shielding effectiveness before [13, 14]. Most of the studies in literature are focused on 0.1 - 3 GHz frequency interval. In this paper, measurements conducted from 2.6 GHz to 9 GHz to suggest better shielding solutions in UWB usage as explained in the previous paragraph. Measurements were repeated for all polarization of transmitting antenna with respect to longitudinal aperture orientation.

Paper is organized as follows: Section II gives measurement campaign and its peripherals. Section III includes the measurement results of ESE on PC box according to versus frequency for different aperture shape and polarization angle. Section IV also contains the comparison and conclusion of results.

II. MEASUREMENT SET UP

SE measurements have been performed in a standard anechoic chamber at EMC Pre-Compliance Test Laboratory at Akdeniz University EMUMAM (Industrial Based Microwave and Medical Applications Research Center). The chamber is a 3 m standard anechoic chamber having a dimension of 4 m × 4 m × 8 m. Rohde-Schwarz (SMF-100A) signal generator operating between DC and 41 GHz and Agilent (E4405B-ESA-E Series) spectrum analyzer were used as radio equipment. Ultra-wide band microstrip and standard gain horn antenna were preferred for high frequency measurements. Both transmitting and receiving antennas were attached to dielectric rope at 30 cm above the wooden reference table for avoiding any electromagnetic interference. Measurement setup details are shown in Fig.1.

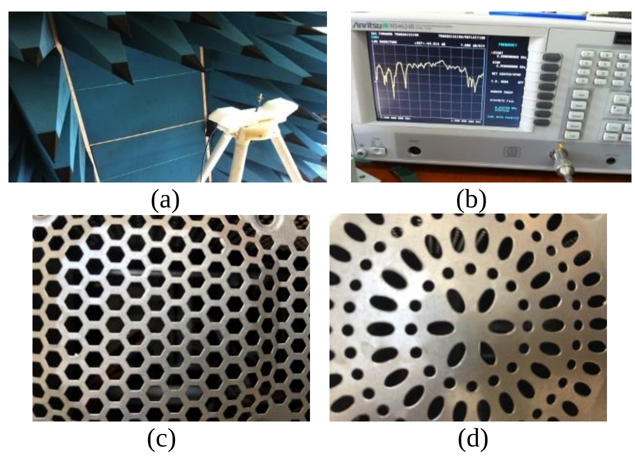

Fig. 1 Measurement Setup: (a) Reference measurement (Absence of PC box) (b) PC Box with hexagonal aperture (c) Measurements conducted by network analyzer (d) PC box with ellipsis aperture

Measurements have been carried out between 2.6 GHz - 9 GHz. 10 MHz measurement intervals was chosen for high frequency band of which 2.60 GHz - 9 GHz. Each measurement was repeated 20 times for each frequency and mean values were used to reduce measurement errors.

III. RESULTS

In Fig. 2, it has been observed that electrical shielding effectiveness performance of hexagonal apertures is 10 dB better than elliptical apertures in this frequency range for the polarization angle of 0º. Whereas elliptical aperture on empty case are performing better electrical shielding effectiveness than installed one up to 5.85 GHz, their performances merge at this point and beyond.

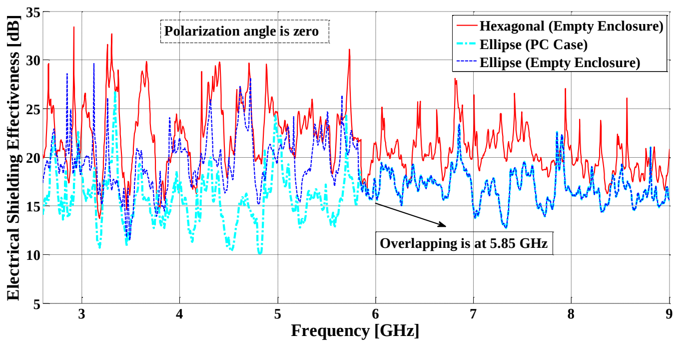

Fig. 2 ESE measurement of PC Box with polarization angle is zero

In Fig. 3, it has been observed that electrical shielding effectiveness performance of hexagonal apertures is slightly better than elliptical apertures in this frequency range for the polarization angle of 30º. Depending on the polarization angle variation, overlapping observed at 5.85 GHz and beyond between empts case and PC cases is not observed.

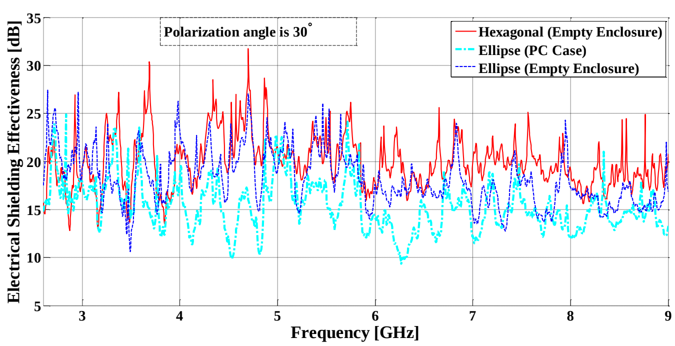

Fig. 3 ESE measurement of PC Box with polarization angle is 30°

In Fig.4, it has been observed that electrical shielding effectiveness performance of hexagonal apertures is slightly better than elliptical apertures at the begging of worked frequency range for the polarization angle of 60º. By then, their performances reverse that elliptical aperture starts to predict slightly better performance due to match between aperture dimensioning [15-16].

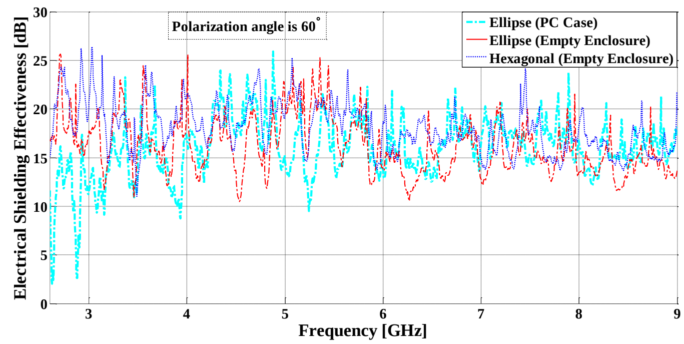

Fig. 4 ESE measurement of PC Box with polarization angle is 60°

In Fig.5, it has been observed that electrical shielding effectiveness performance of hexagonal apertures is predicting better ESE performance than elliptical apertures up to 6 GHz for the polarization angle of 90º. After that point, there is no clear dominance of any aperture type.

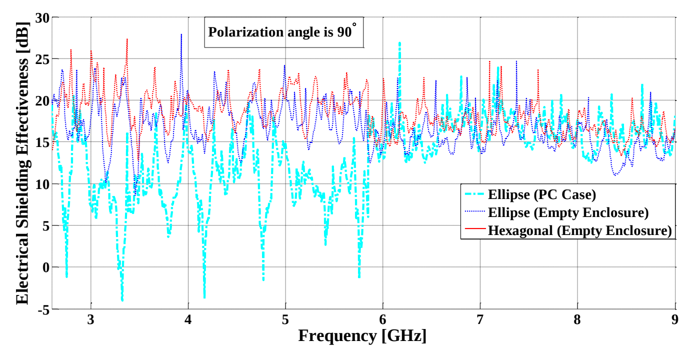

Fig. 5 ESE measurement of PC Box with polarization angle is 90°

IV. CONCLUSIONS

We have observed the variation of ESE performance of metallic enclosures having hexagonal and elliptic apertures on it with respect to polarization angle by measurement results. We have also beholden and compared both ESE performance variation of empty PC case and installed one. During this observation we modeled USB entrance of cases as elliptical apertures.

It has been seen that electrical shielding effectiveness performance of hexagonal apertures is 10 dB better than elliptical apertures in this frequency range. Whereas elliptical aperture on empty case are performing better electrical shielding effectiveness than installed one up to 5.85GHz, their performances merge at the point and beyond.

It has also been observed that polarization angle is one the dominant factor on ESE performance of metallic cases. These findings can be beneficially important for TEMPEST like secure applications.

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