

Improve Shielding Effectiveness with Suitable Designing Apertures for Air Conditions in Antenna and EMC Laboratory

Kasra Pahlavan

Department of Telecommunication Engineering Shahre Rey Branch, Islamic Azad University, Tehran, Iran
email: p.kasra@gmail.com

M.R. Moniri

Department of Telecommunication Engineering Shahre Rey Branch, Islamic Azad University, Tehran, Iran
email: mr_moniri_h@yahoo.com

Abstract - This paper presents the electromagnetic interference shielding impact due to air vent holes on electronic systems chassis. In designing and building EMC labs one of the important factors is S.E (shielding effectiveness), if this parameter improves shielding performance of enclosure will be better and leakage of energy will reduce. If the vent hole size become larger much more air can come to the room and electronic instruments become cooler, but on the other hand with growing of the size of the vent holes, shielding effectiveness will be lower and unwanted signals will come to the room easier and this signals can disturb our systems and damage result of our tests. So the main purpose of this paper is presenting a way to improve shielding performance of air vents.[1]

Keywords - Electromagnetic Compatibility (EMC), Shielding Effectiveness, Air Vents, Air Conditions in EMC Rooms, Shielding of Antenna and EMC Labs

I - INTRODUCTION

This paper contains two parts. First part explain shortly about the reference paper and the methods of that research and the results, and the second presents a new way for designing vents to improve shielding effectiveness. The tests are simulated in CST STUDIO software.

We can define the shielding effectiveness as the ratio of incident and transmitted electric and magnetic fields. In the simulations, the transmitted fields correspond to the observed field levels when a metal screen is added between a radiating source and set of monitoring points. Incident fields are determined by examining the field levels at the same points when no metal screen is present. The shielding effectiveness (S.E) is depending on several factors like the surface geometry of the aperture (length and width), depth, shape of aperture and total number of apertures.[2],[4]

$$SE_E = 20 \log_{10} \left| \frac{\hat{E}^{inc}}{\hat{E}^{tran}} \right| \quad (1)$$

$$SE_M = 20 \log_{10} \left| \frac{\hat{H}^{inc}}{\hat{H}^{tran}} \right| \quad (2)$$

The formula 1 shows electric shielding effectiveness and formula 2 shows magnetic shielding effectiveness. $E^{incident}$ shows the amount of electric field that radiate to the aperture and $E^{transmitted}$ shows the amount of electric field that transmit from the aperture.

In the reference paper the apertures are considered as squares and then presented a practical analysis of shielding effectiveness of vent holes on a system chassis while

investigating the impact of aperture size, hole to hole proximity distance and hole depth on shielding performance.

But in this paper the apertures have been considered as circles and then the tests has been done again and then the results have been compared.

II - THEORETICAL ANALYSIS

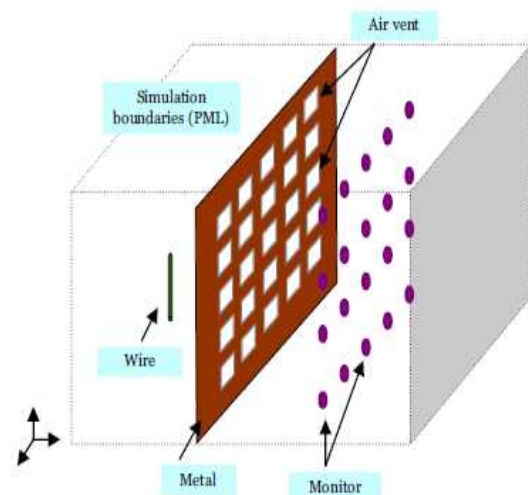


Fig.1- Representation of Vent holes model showing radiating element and monitor points.[1]

In this part at first two important questions will be asked and then the answer will be explained.

1-Why circles are better than squares?

2-How can number of vents and arrangement of them influence shielding effectiveness?

As has been shown in Fig 1 the basic model developed for this investigation consists of a metal screen of variable thickness spanning along the entire height and width of the simulation environment, essentially splitting it into two sections. On the left side, a thin wire antenna is used as source to illuminate metal screen. Multiple observation points are placed to the right of the metal screen at a minimum distance equal to one wavelength of the lowest simulation frequency of interest (3GHz). The size of the metal panel is kept constant at 200mm×200mm and the panel made of aluminum.

In the reference paper the arrangement of the vent holes varies as 15x15, 25x25 and 29x29 but in this paper it has

been used just 15x15 vent holes arrangement and then the vent holes has been changed to circles. In both square and circle holes the separation between the holes is 1 mm and the test has done with three thicknesses 1mm, 3mm and 7 mm. One of the important targets in this paper is keeping constant the air flow that passes from the aperture, So the holes and metal area in circle model and square model must be same and because the area of a square is bigger than a circle with the same diameter as the squares side, the arrangement of circles in circle model is difference and the number of circles is more than squares. The simulation boundaries are defined as Perfectly Matched Layers (PML).

This situation allow the incident signal to quickly reach steady-state.

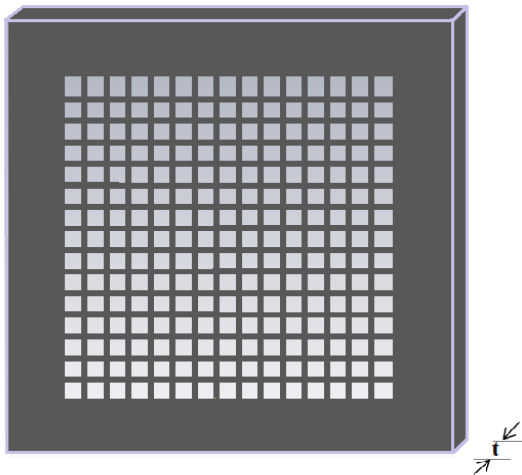


Fig.2 Arrangement of vent holes in reference paper

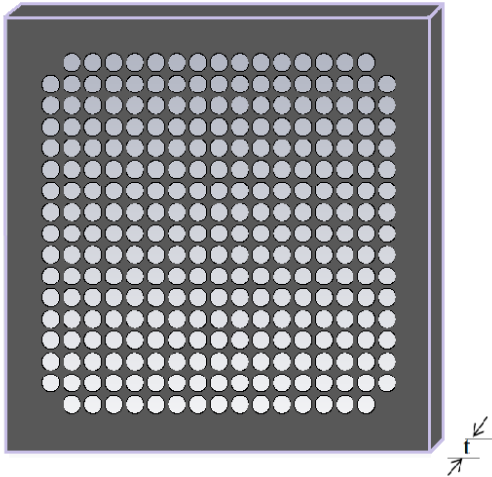


Fig.3-Arrangement of testing vent holes (the area of holes and metal is the same as square vent holes panel)

In the metal panel there are two sections, the metal and vent holes. When the wave that propagate from the wire antenna radiates to the panel there are two different behaviors, some through the metal panel and some amount of it pass through the vent holes. The vent holes act as wave guide and the wave attenuates during passing from

the wave guide. So we have two different attenuations and the shielding effectiveness's.

In the metal section:[2]

$$SE = R + A + B \quad (3)$$

$$A = 20 \left(\frac{t}{\sigma} \right) \log(e) \text{ dB} \quad (4)$$

$$R = 20 \log \frac{|Z_w|}{4|Z_s|} \text{ dB} \quad (5)$$

$$B = 20 \log(1 - e^{-2t/\delta}) \text{ dB} \quad (6)$$

In square vent holes:[3]

$$SE = 20 \log \alpha_{mn} L \quad (7)$$

$$\alpha_{mn} = w \sqrt{\mu_0 \epsilon_0} \sqrt{\left(\frac{f_c}{f} \right)^2 - 1} \quad (8)$$

$$f_c = \frac{v_0}{2d} \sqrt{m^2 + n^2} \quad (9)$$

And in circle vent holes:

$$SE = 20 \log \alpha_{mn} L \quad (8)$$

$$\alpha_{mn} = \frac{R_s}{a\eta \sqrt{1 - \left(\frac{f_c}{f} \right)^2}} \left[\left(\frac{f_c}{f} \right)^2 + \frac{m^2}{(x'_{mn})^2 - m^2} \right] \quad (9)$$

$$R_s = \sqrt{\frac{w\mu}{2\sigma}} \quad (10)$$

$$f_c = \frac{x'_{mn}}{2\pi a \sqrt{\mu_0 \epsilon_0}} \quad (11)$$

The consequent of shielding effectiveness in metal parts and vent holes can result the total shielding effectiveness of the panel.

III – SIMULATION RESULTS

This test has been simulated in CST STUDIO 2013 and the results has been compared in the diagrams.

Shielding performance

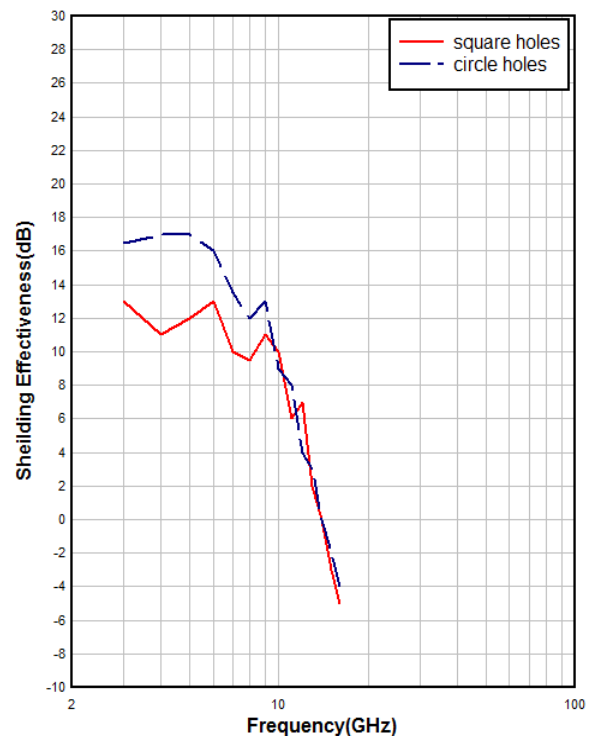


Fig.4 – simulated shielding performance for case with thickness of 1 mm

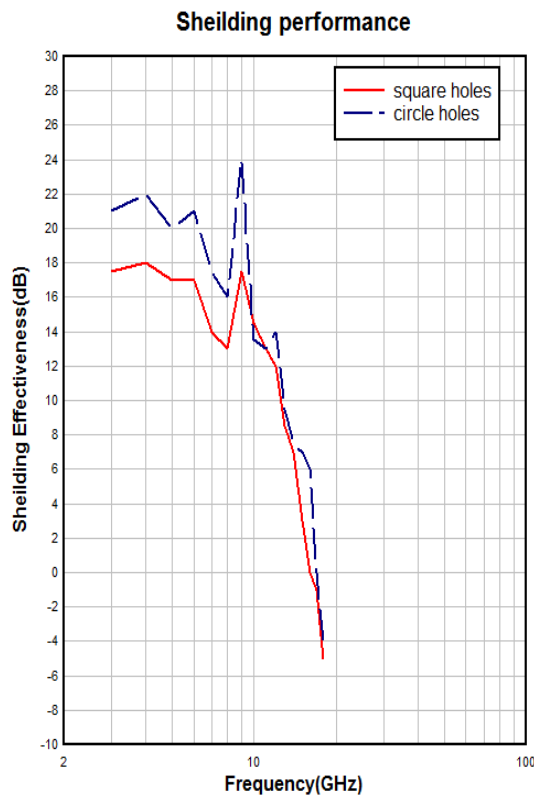


Fig.5 - simulated shielding performance for case with thickness of 3 mm

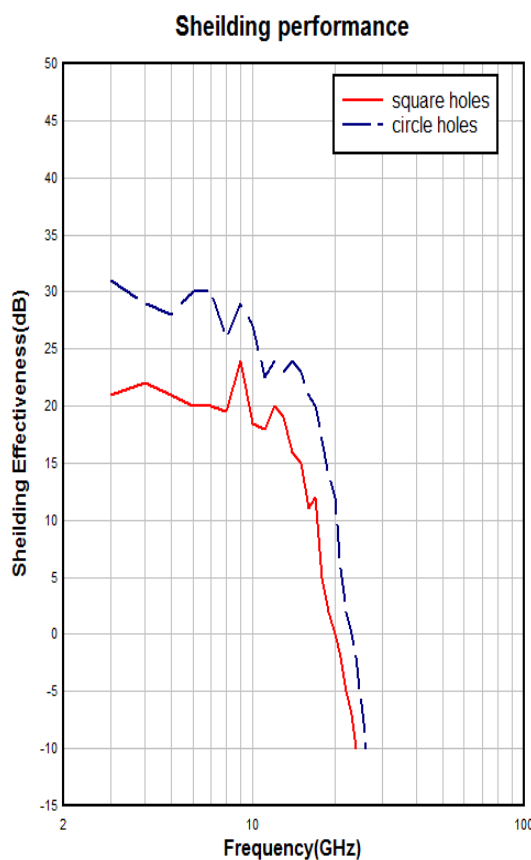


Fig.6 - simulated shielding performance for case with thickness of 7 mm

Fig.4,5 and 6 compare the shielding effectiveness in square vent holes and circle vent holes with thickness of 1,3 and 7 millimeters. When the thickness of vents increases the vents change to waveguide and because of the attenuation properties and cut off frequency in waveguides transmission of electric and magnetic fields inside and outside of the laboratory reduces, so increasing the thickness of the aperture can cause better shielding effectiveness, also attenuation in circle holes is very lower than square holes, and so using circle vent holes with larger thickness is good way to achieving better shielding performance.

IV – CONCLUSION

A detailed computational simulation of vent holes shielding effectiveness was presented. In the simulation the impact of shapes of the vent holes and hole depth was investigated. Finally it has been shown that using circle vent holes with larger thickness can cause better shielding performance.

On one hand in industry building circle holes is easier than square holes. For example the holes created by Diller and no mold would be needed and at the other hand circles vents cause better shielding performance so using circle vents in air conditions in EMC labs and Antenna rooms is an effective way.

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AUTHORS PROFILE



Kasra Pahlavan

Department of Telecommunication Engineering
Shahre Rey Branch, Islamic Azad University,
Tehran, Iran
email: p.kasra@gmail.com

M.R. Moniri

Department of Telecommunication Engineering
Shahre Rey Branch, Islamic Azad University, Tehran, Iran
email: mr_moniri_h@yahoo.com