COMPUTATIONAL INVESTIGATION OF RADIATION FROM CONDUCTING BOXES WITH ARBITRARY APERTURES

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1 INTRODUCTION

The importance of obtaining relevant design information about a system before actually building a system is well known. In this work, an application of the electromagnetic simulation to obtain electromagnetic compatibility (EMC) and interference (EMI) information during the design phase of electronic system enclosures is reported. For this purpose, full-wave electromagnetic characterization of various packages has been performed using a rigorous, accurate, and efficient electromagnetic analysis program. The computational technique is outlined in Section 2.

The dimensions of the conducting enclosure are chosen to mimic the size of a lap-top computer. Radiation from such electronic equipment is classified as unintentional and measures are taken to suppress the radiation. Reducing the source intensity and shielding the sources are the two most common ways of suppressing the radiation. Shielding is usually accomplished by placing the electronic equipment in conducting boxes. However, various apertures inevitably exist on the enclosure for ventilation and input/output (I/O) purposes, which degrade the shielding quality.

Several different configurations of apertures on a conducting enclosure of dimensions 30 cm $\times$ 20 cm $\times$ 5 cm (reminiscent of a lap-top computer box) are considered to investigate their effects in the overall radiation from the system box as shown in Fig. 1. Although the number, the shapes and the locations of the apertures are different, the total area of the apertures is exactly 24 cm^2 for each configuration. Some representative results are presented in Section 3. The simulations are carried out in the frequency range of 500 MHz to 3000 MHz, considering the clock frequencies (and their leading harmonics) of common processors available nowadays.

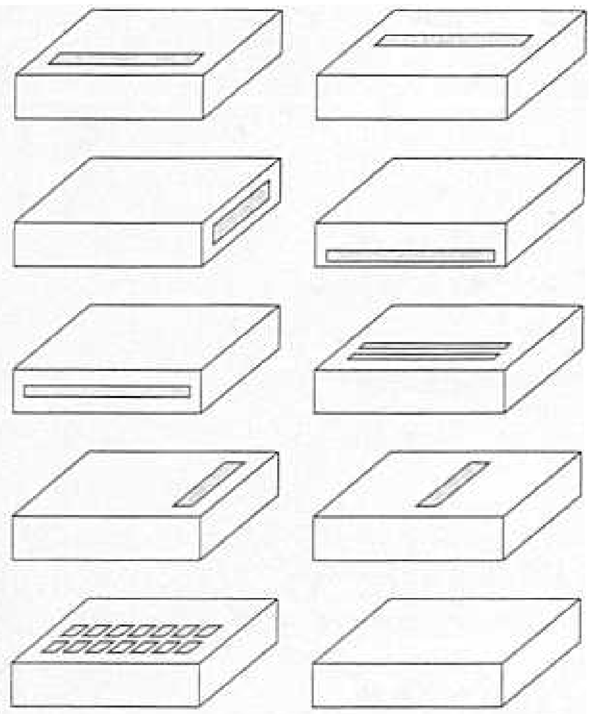
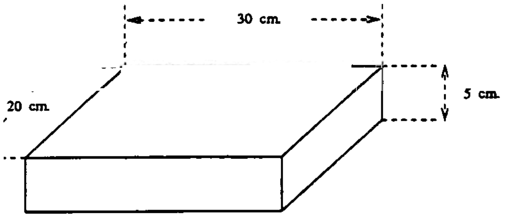


Figure 1: Various configurations of apertures on sample system enclosure.

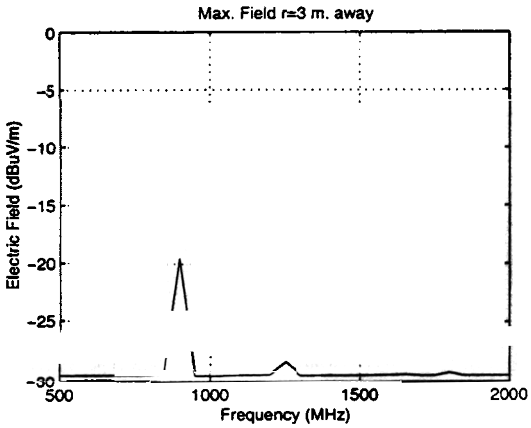
2 COMPUTATIONAL TECHNIQUE

The total area of the sample lap-top computer bc becomes 17 λ^2 at 3000 MHz and about 100 solı tions are required to sample the frequency range ‹ 500 MHz to 3000 MHz at every 25 MHz. Repea ing these computations for each different box coı figuration becomes a daunting task with tradition: integral-equation solvers. In this work, the fast mu tipole method (FMM) [1–6] is used for the comput:

tion of the radiation fields. The FMM employed here uses diagonalized translation operators for the three-dimensional Helmholtz equation. [2] The FMM is an iterative solution technique that requires $O(N^{1.5})$ operations per iteration as opposed to the matrix-vector multiplication being an $O(N^2)$ operation per iteration and the direct solution having $O(N^3)$ computational complexity. It is this efficiency of the FMM that allows us to solve hundreds of relatively large problems with limited computational resources. The FMM has been mostly used for scattering problems. We have placed a dipole source in the boxes and adapted the FMM to compute the radiation fields.



(a)

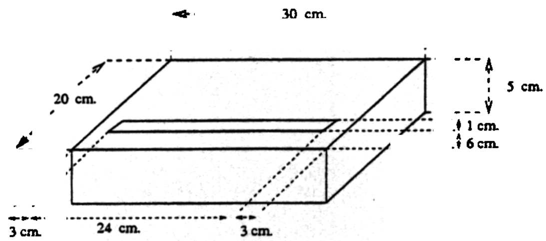


(b)

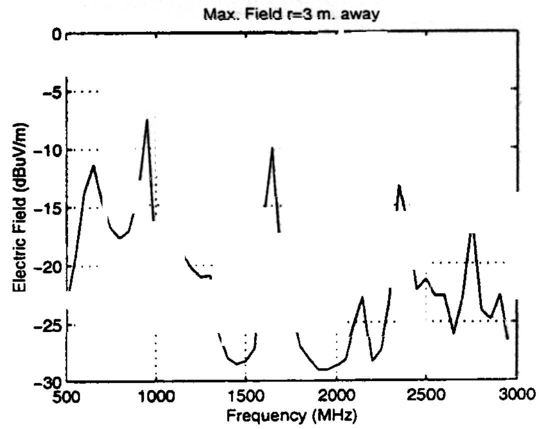
Figure 2: (a) A rectangular box with no apertures. (b) Maximum radiated field on a 3 meter sphere.

3 RESULTS

The radiation results presented in this section show the maximum value of the electric field on a spherical surface 3 meters away from the conducting boxes over a frequency range of 500 MHz to 3000 MHz. Figure 2(a) shows a closed box with no apertures punched on it. Ideally, the radiation from such a box should be zero. However, the computational results will indicate a small amount of radiation, as seen in Fig. 2(b), due to the approximate nature of the way the boundary conditions are satisfied on the conducting walls of the box. This low level of radiation can be called "numerical leakage" and constitutes the reference level against which other radiation results should be compared. Figures 3(b) and 4(b) show the radiation plots for the boxes with one large apertures each, as illustrated in Figs. 3(a) and 4(a), respectively. Clearly, the radiation levels for these two examples are significantly higher than that of Fig. 2. Figure 5(a) shows a different aperture configuration, where there are several smaller apertures and the total area of the apertures is equal to the area of the single large apertures shown in Figs. 3(a) and 4(a). The radiation plot for this configuration is shown in Fig. 5(b), where the radiation level is seen to be lower compared to Figs. 3(b) and 4(b). This suggests a simple way to suppress the radiation without compromising the area of ventilation and I/O opening.



(a)



(b)

Figure 3: (a) Laptop computer model with one big aperture. (b) Maximum radiated field on a 3 meter sphere.

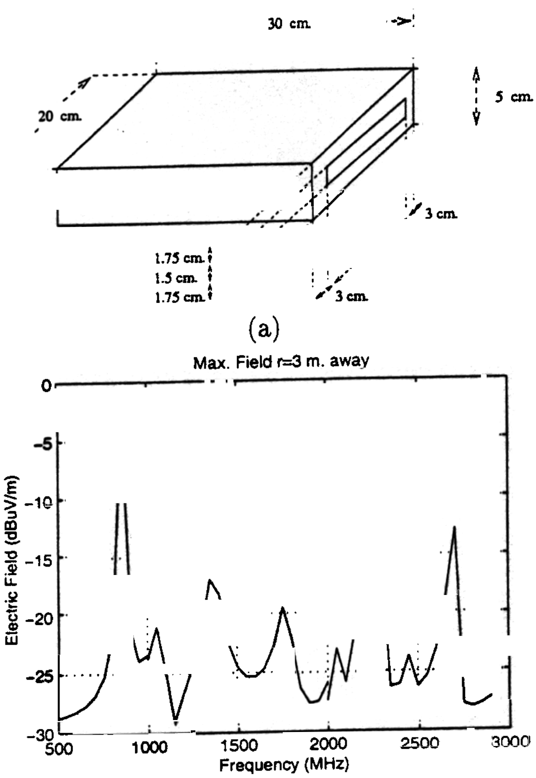


Figure 4: (a) Laptop computer model with one big aperture. (b) Maximum radiated field on a 3 meter sphere.

References

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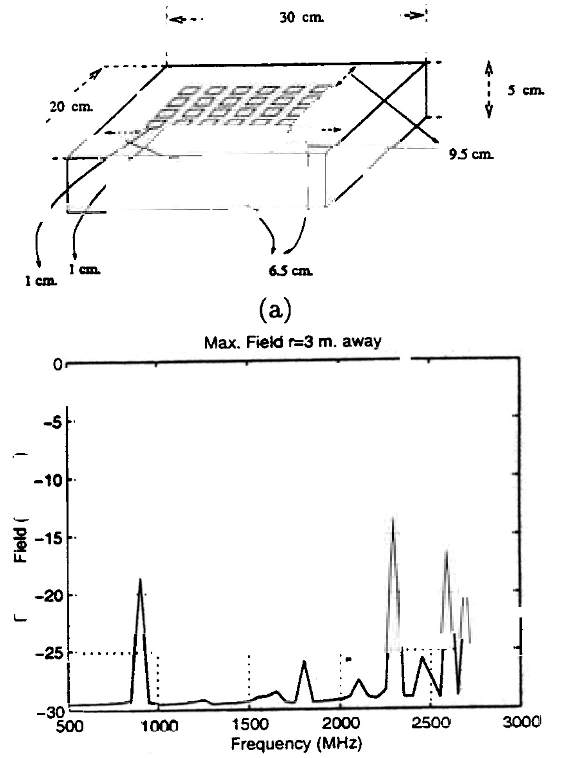

Figure 5: (a) Laptop computer model with several small apertures. (b) Maximum radiated field on a 3 meter sphere.