# Electromagnetic Fields in and around an Enclosure for HEMP E1 Excitation

D. V. Giri
Pro-Tech, Wellesley, MA 02481, USA
Dept. of ECE, Univ. of New Mexico,
Albuquerque, NM USA
E-mail: Giri@DVGiri.com

F. M. Tesche
EMConsultant
Lakeville, CT , USA
E-mail: Fred@Tesche.com

***Abstract***— *In this paper, results of a numerical study of the shielding of a screen room is conducted and presented. Several movies illustrating the behavior of the transient E-field in and around the shielded room due to an incident HEMP-E1 pulse are produced and the global shielding behavior of the enclosure is summarized using cumulative probability distributions.*

Keywords- EM shielding, enclosures, numerical study, fields in enclosures

## I. INTRODUCTION

Shielding is an important consideration in the design of a system, which is to be protected against the unwanted effects of electromagnetic (EM) fields. via currents flowing on penetrating conductors. In general, these conductive penetrations arise from the telephone, communications, power, and other non- electrical conductors. In addition to these penetrations, there are several apertures (holes) in the facility enclosure (e.g., the entrances of the facility), and EM fields may penetrate the interior at these points. Finally, EM field diffusion through the facility walls and roof is a possibility. The above three fundamental ways by which external EM energy can penetrate facilities can be characterized by the acronym ***CAD*** as follows:
**C → Conductive penetrations A→ Aperture coupling, and D → Diffusive coupling.**

## II. ENCLOSURE GEOMETRY AND EXCITATION

In this section, we will be interested in the EM fields inside and outside the enclosure shown in Figure 1. We model the entry door into the facility and will illustrate the effects of EM fields passing into the door. The incident angles are represented by using the angles $\theta$ and $\phi$ in the spherical coordinate system. It should be noted that these angles specify the direction from which the incident field arrives.
A vertically polarized excitation field is considered here. Using the FDTD code , a model of the enclosure was developed. The enclosure was located in a computational grid of maximum dimensions (x, y, z) = (121, 121, 60), which yields a total of 5.27 million unknown E and H field components that must be determined in each time step. The mesh dimensions for this model were $\Delta x$ = 7.2 cm, $\Delta y$ = 8.8 cm and $\Delta z$ = 8 cm, and the resulting time step was $\Delta t$ = 0.14 ns. Typical computation times were on the order of 3 minutes for 500 time points.

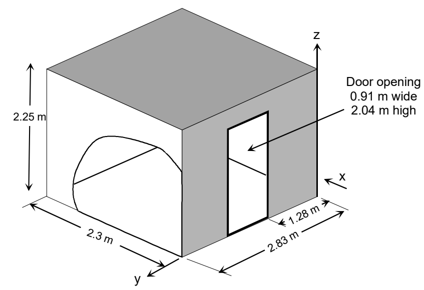


**Figure 1. Cut-away diagram of a shielded room, showing an empty interior**

We will assume that the incident field arises from a HEMP-E1 and has the form

$$E(t) := Eo\cdot\left[e^{-a\cdot(t-ts)} - e^{-b\cdot(t-ts)}\right]\cdot G\cdot\Phi(t-ts) \quad (1)$$

where the waveform parameters are $E_o$ = 60 (kV/m), G = 1.2 a = 3.75 x $10^7$ (1/s), b = 8.46 x $10^8$ (1/s).

For the case of $\theta = 90^o$ and $\phi = 180^o$. (Door open) Figure 2 presents a surface plot of the total E-field at a time *t* = 15.56 ns in a 4x5 meter section of the 1-meter-high plane for the facility. In this plot it is easy to see the outline of the shielded enclosure and the location of the front door. At this time, the incident HEMP field has already swept across the facility, and only a remnant of the waveform tail is evident at the far end (x = 4) of the plot.

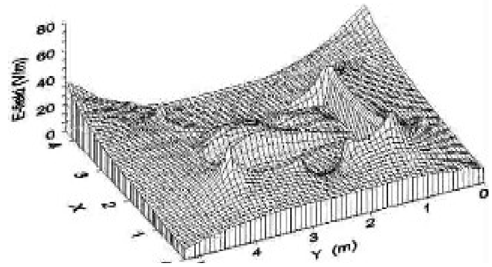


**Figure 2. Surface plot of the total E-field in a 4 x 5-meter plane at a height of 1-meter over the ground for the facility and HEMP E1 excitation, at a time *t* = 15.56 ns.**

Several such computations and cumulative probability distributions have been computed and will be presented.