# Shielding Effectiveness of a Box with a Slot

Let us calculate the shielding effectiveness of a PEC box with a slot, excited with a plane wave incident in the direction perpendicular to the slot.

A rectangular metal enclosure with an aperture on one face can be modelled as a waveguide, shorted at the far end, with the aperture at the entrance to the waveguide. The model is quickly created with just a few plates in WIPL-D Pro (Fig. 1).

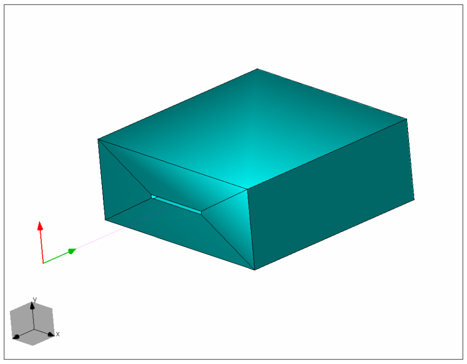

**Fig 1. Rectangular box with an aperture**

The electric field shielding effectiveness is calculated as the ratio of the impinging field to the field measured at some point within the waveguide, distant from the slot.

The theory assumes that a single $TE_{10}$ waveguide mode propagates from the aperture and normal to it. Higher order modes, and modes propagating in other directions may exist which will complicate the results, and introduce need for EM simulation in order to predict the shielding effectiveness. The box is taken to be empty. The results of EM simulation are in excellent agreement with results obtained by using intermediate level simulation tools from University of York, and easily obtainable by using their online calculator [1] .

The objective is to investigate the influence of changes in box and slot geometry as well as in position inside the box at which field is calculated on shielding effectiveness (Fig. 2).

For fixed dimensions of the box and of the aperture ($a$=30 cm, $b$=12 cm, $d$=30 cm, $l$=10 cm, $w$=0.5 cm), shielding effectiveness at various positions within the box (at the symmetry plane) is displayed in Figs 3 and 4. The shielding effectiveness is worst close to the slot while it increases as we move away from the slot. The subsidiary depthwise resonance shifts up in frequency as the probe moves towards the back. The principal resonance is due only to the box dimensions, so its frequency is unaffected.

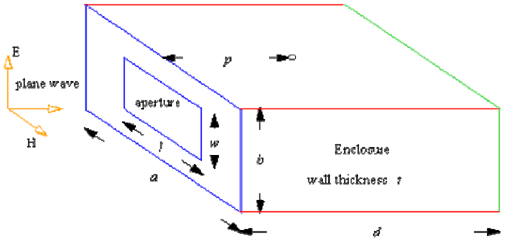

**Fig 2. Explanation of geometry of the box with a slot (taken from [1])**

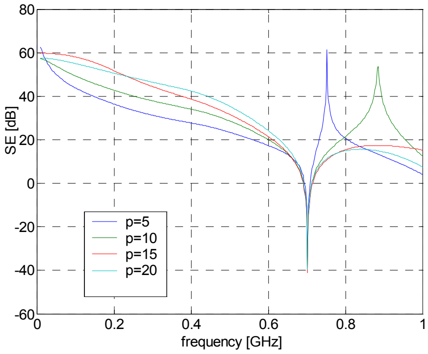

**Fig 3. Shielding effectiveness of electric field for *p* varying from 5 cm to 20 cm.**

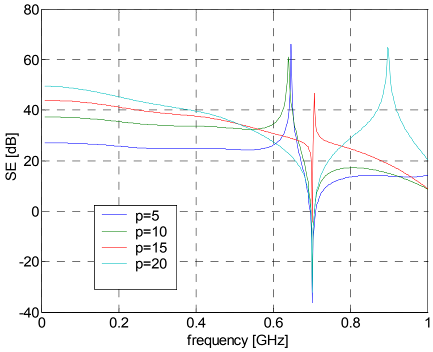

**Fig 4. Shielding effectiveness of magnetic field for *p* varying from 5 cm to 20 cm.**

If we fix everything except the width of the box ($a$), then for $b$=12 cm, $d$=30 cm, $l$=10 cm, $w$=0.5 cm and $p$=15 cm, and by varying $a$ from 20 cm to 40 cm, we get Figs 5 and 6. The principal resonance frequency shifts as we change the box size, as expected.

By fixing all parameters except the length of the slot to *a*=30 cm, *b*=12 cm, *d*=30 cm, *w*=0.5 cm and *p*=15 cm and varying *l* from 3 cm to 17 cm, we get Figs 7 and 8. Shielding effectiveness is directly related to the size of the slot, and it decreases as the slot grows.

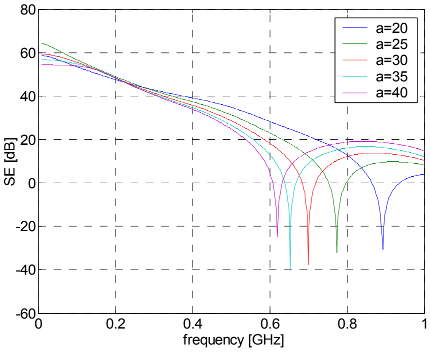

**Fig 5. Shielding effectiveness of electric field for box width *a* varying from 20 cm to 40 cm**

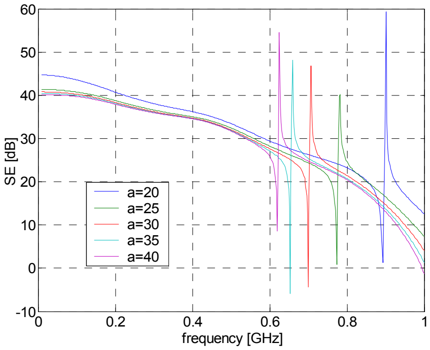

**Fig 6. Shielding effectiveness of magnetic field for box width *a* varying from 20 cm to 40 cm**

A closer look at the fields inside the box at several frequencies within the range from 700 MHz to 1.3 GHz was done in order to illustrate higher order modes that form. Fig. 9 shows near fields at different frequencies in case when the incident plane forms an angle of 75 degrees with the normal to the slot.

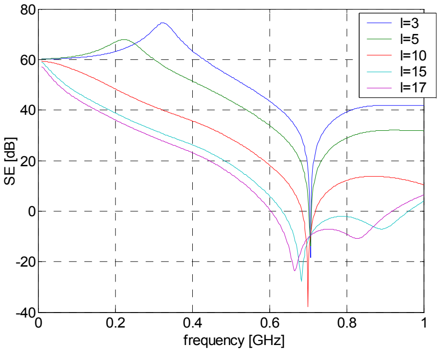

**Figure 7. Shielding effectiveness of electric field for *l* varying from 3 cm to 17 cm**

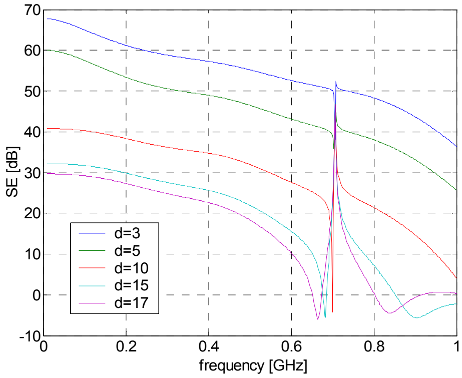

**Fig 8. Shielding effectiveness of magnetic field for *l* varying from 3 cm to 17 cm**

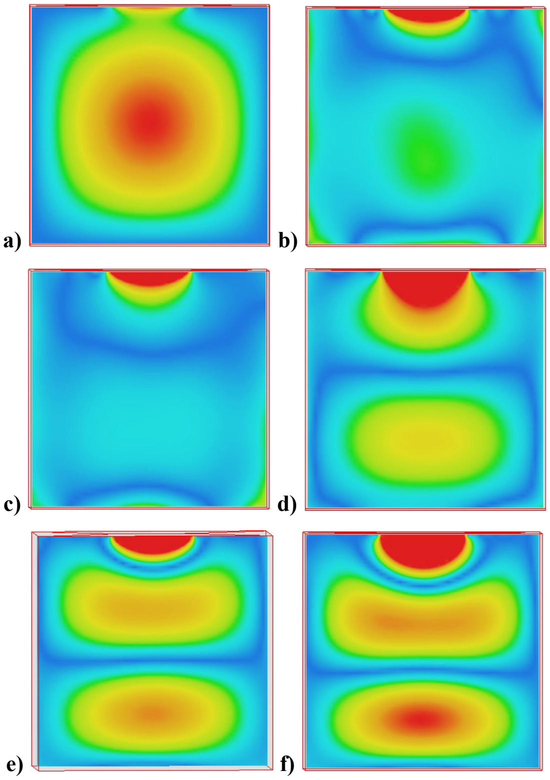

**Fig 9. Electric field amplitudes inside the box at: a) 700 MHz, b) 800 MHz, c) 900 MHz, d) 1 GHz, e) 1.2 GHz, and f) 1.3 GHz.**

All models used in this paper required around 750 unknowns (4.5 MB of RAM). In many examples, this can be further diminished using symmetry planes to about 200 unknowns. Simulation in **100 frequency points takes about 40 seconds** on a Intel Core2 Duo CPU with 2.66 GHz clock.

### References

[1] http://www.emc.york.ac.uk/examples/screening/screening.html