MEASUREMENT OF A SHIELDING EFFECTIVENESS OF RELATIVELY SMALL METALLIC ENCLOSURES

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Abstract
Paper presents several results of the study and experimental verification of a shielding effectiveness of relatively small metallic enclosures, which operate above the first resonance. There is no standard for measurement and therefore different aspects of measurement and methodology are discussed. Relative size, volume, quality factor of the enclosure, position, radiator type, reciprocity etc. are discussed.

Keywords
shielding effectiveness, measurement, enclosure

Introduction
If a shielding effectiveness more then 100 dB is requested, modular cabins or chambers are essential. Methodology of shielding effectiveness (SE) measurement of small metallic shielding enclosures with dimension less then 2 m is not standardized yet. Due to small dimensions (due to possible resonances) the measurement is complicated and it is difficult to compare the results of measurement in different testing laboratories. But there is lot of other problems to be discussed. The definition of "small" enclosure is necessary express in relative dimensions compare to the wavelength. Historical methodology for shielded rooms testing - it is USA standard MIL-STD 285 (1956 [1]) and based on it, it is only IEEE 299 [2]. SE in dB is given by the difference between reference measurement of received signal and measurement with the shielding effect of enclosure (transmitted power through the wall of the enclosure under the test).
Reference measurement can be done

- following the IEEE 299 – measurement in free space close to the measured chamber with the same distance of the antenna
- following the MIL-STD 285 and [3] with the same arrangement but with the fully opened door of the shielded room (enclosure)

Problems to be solved
For a small enclosure there are problems, which have strong influence on measurement results – e.g.:

- where to put the reference? (see Fig.2) (outside or inside + to open „door" of the enclosure?)
- what is the measurement distance and measurement (set up) geometry (arrangement)? [4], [6]
- what is the influence of different objects inside the enclosure on resonances and results of SE (1)
- where to put „generator" – inside the enclosure or to illuminate it from the outside? [5], [6]
- where and how to search the maximum of radiation which strongly depends on frequency (see Fig.1), shape of the enclosure, geometry, arrangement etc.?
- how to describe the problem? - dimensions in wavelengths, resonant frequencies, Q factor etc. should be mentioned.
- can we use the reciprocity theorem when working in the "near field" of the "radiator", where the wave impedance (given by the E and H field cross components) is not constant? [5], [6]
- what antenna (radiator) to use? (see Fig.2).

Resonance frequency of the enclosure can be simply described by

$$f_n = \frac{c \cdot k_n}{2\pi\sqrt{\varepsilon_{r,ef}\,\mu_{r,ef}}}, \quad c = 3 \cdot 10^8 \text{ m/s}, \tag{1}$$

where $\varepsilon_{r,ef}$, $\mu_{r,ef}$ are relative effective permittivity and permeability k_n are wave number given by the geometry of enclosure (resonator is filled by the objects partly)

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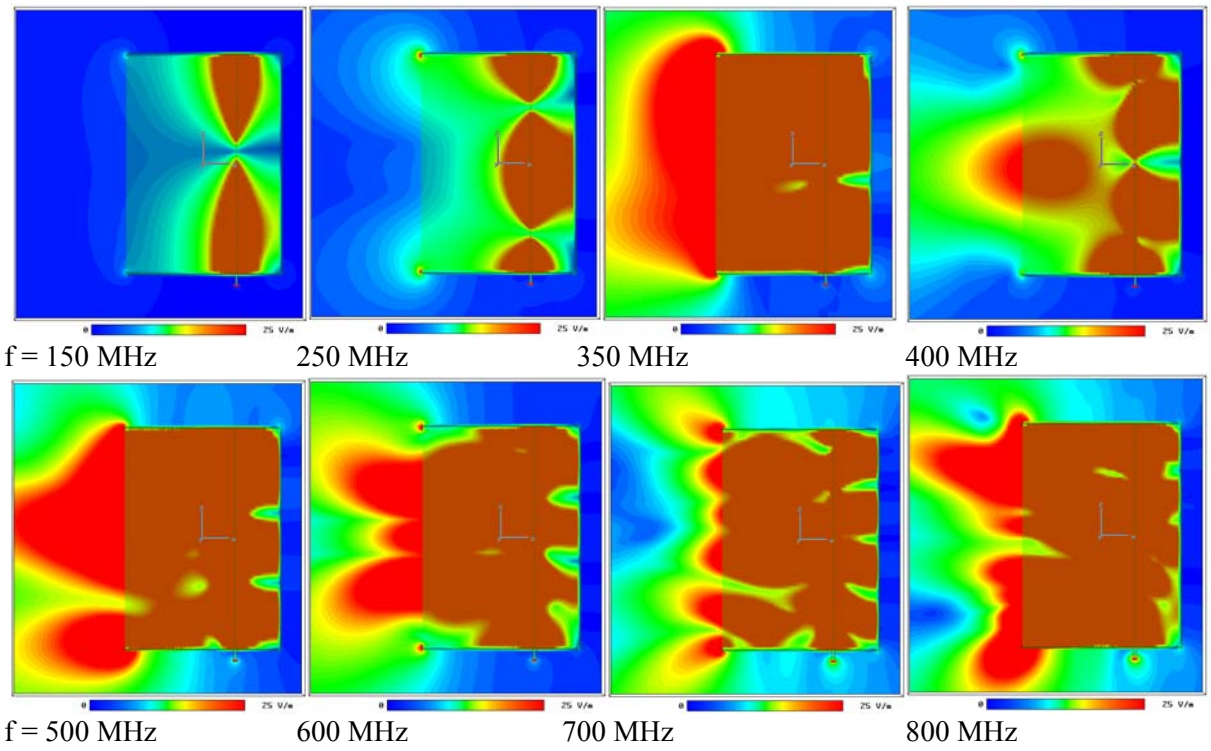

Fig.1 Distribution of relative intensity of electromagnetic field (electrical intensity) close to the "open door" of the shielded enclosure at different frequencies (enclosure - dimensions of 1200mm x 600mm x 600mm, E field scale 0 - 25 V/m, radiator is a wire antenna at the position of the red dot = connector close to the lower right corner at the bottom of the enclosure).

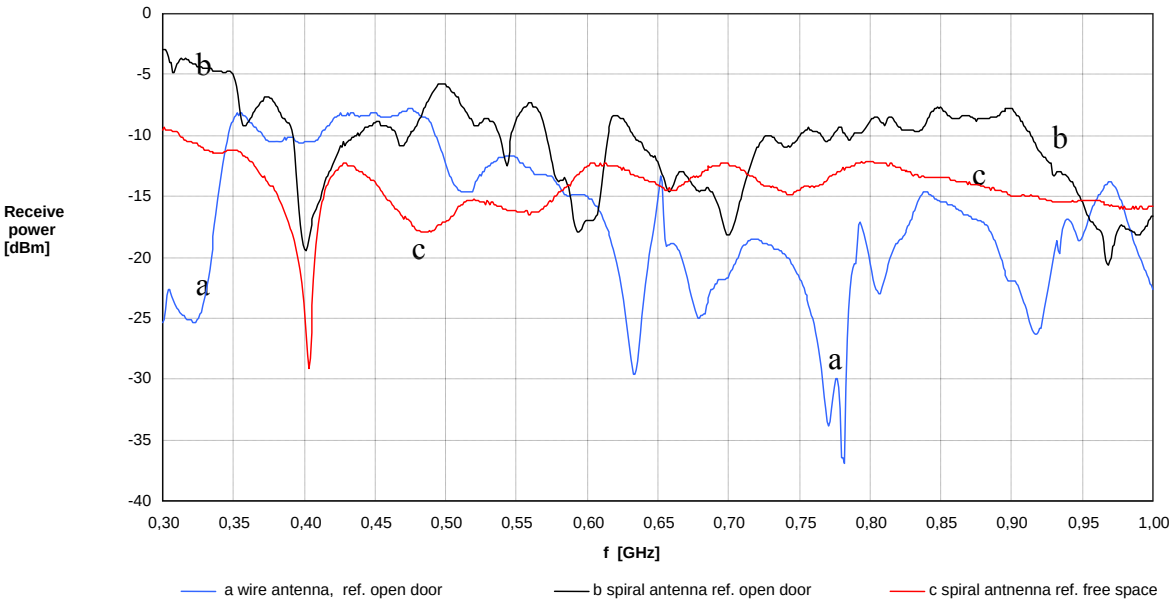

Fig. 2 Received power during the reference measurement, transmitter was placed inside the tested enclosure and 3 different reference radiators (antennas) and their positions were tested (wire, spiral antenna inside the enclosure, spiral antenna outside the enclosure)

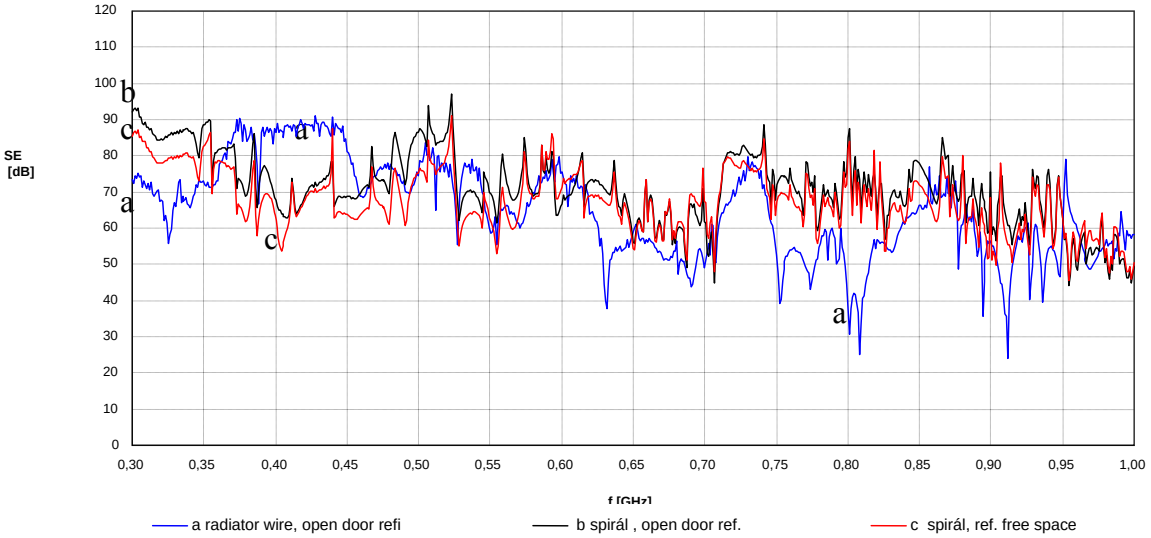

Fig. 3 Shielding effectiveness of the tested enclosure measured against 3 different references a,b,c - transmitter (radiator) is inside of the enclosure.

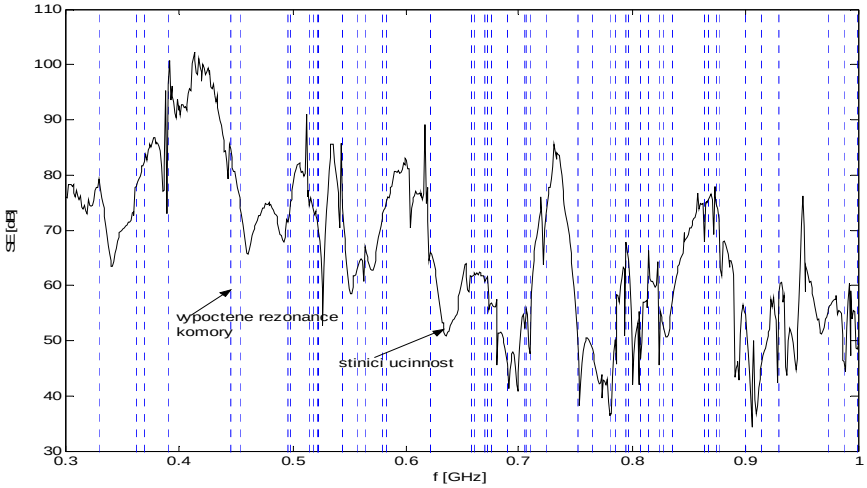

Fig. 4 Shielding effectiveness (SE) level of the enclosure and resonant frequencies of the enclosure.

Fig. 5 Arrangement of the measurement and its geometry (set up), transmitter (spiral antenna) is inside the enclosure, receive antenna – double ridged horn antenna is outside of it (antenna and EMC laboratory CTU in Prague)


Fig. 6 Radiators – wire and spiral antenna inside the enclosure (antenna and EMC laboratory CTU in Prague)

Conclusion

Different aspects of measurement of shielding effectiveness of relatively small enclosures were studied from [3], [4], [5]. Dimension in wavelengths, resonant frequencies, Q factor calculations were mentioned. Based on it, basic rules for measurement procedure were prepared at the Department of Electromagnetic Field, Czech Technical University in Prague (CTU). More theoretical aspects, global approach, testing results, and recommendation are described in [6]. Testing measurements to evaluate the designed methodology above the first resonance of the enclosures were performed at the EMC laboratory CTU in Prague. Research and results at the frequency below the first resonance were conducted at the Department of Radioengineering, Brno University of Technology [7].

Reference

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