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SHIELDING EFFECTIVENESS SIMULATION FOR THE ACCESS DOOR OF AN ANECHOIC CHAMBER

BY

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Abstract. This paper presents some aspects regarding the shielding effectiveness modeling in the access door area within an anechoic chamber. In order to model the shielding effectiveness of the anechoic chamber in the access door area, the CST Studio Suite® simulation software was used. Simulation of the access door shielding effectiveness was performed in the frequency range of 10 kHz ÷ 18 GHz. After analyzing the results given by the simulation, it was observed that the obtained values for the electromagnetic field (electrical field and magnetic field) oscillate around the limits specified in the reference standard EN 50147-1.

Keywords: anechoic chamber; Faraday cage; access door; shielding effectiveness; simulation.

1. Introduction

Anechoic chambers are metal enclosures that operate on the Faraday principle, and that are lined inside with materials with high absorption properties of electromagnetic waves (Fig. 1) (Frankonia web).

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The shielding effectiveness inside the anechoic chamber is considered a mandatory condition to be met in order to be able to use the chamber for electromagnetic compatibility (EMC) tests. Typically, anechoic chambers are used for pre-conformity and compliance measurements in accordance with in force standards. As is well known, the shielding effectiveness will suffer in those areas where the elements in the chamber are mounted (such as the access door) (Fig. 2) (Xiong *et al*., 2017).

The paper aims to estimate the reliability of the anechoic chamber by simulating the behaviour of the electric and magnetic field inside it. The simulation was performed using the specialized software for electromagnetic simulation CST Studio Suite®, a high-performance software package used for electromagnetic simulations (CST Studio Suite® web).

The main advantage of the simulation is that through this process one can estimate the operation mode in different situations of the object under simulation (Xiong *et al*., 2016). In order to perform a simulation, it is imperative to model the object that has to be simulated. This model must be designed so that it can perfectly mimic both the shape and properties of the real object (Munteanu and Kakerow, 2014).

In the paper the shielding effectiveness in the area of the access door in the anechoic chamber was simulated.

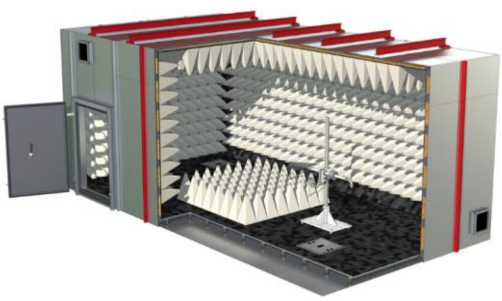


Fig. 1 – Anechoic chamber lined with radio-frequency absorbers.

Fig. 2 – Access door for an anechoic chamber.

2. Modeling the Anechoic Chamber

The anechoic chamber was simulated as a rectangular metal enclosure made of 0.3 mm thick steel. In accordance with in force standards and regulations concerning the construction of shielded enclosures (such as the Standard EN 50147-1 “Anechoic chambers - Part 1: Shied Attenuation Measurement”), the shielding effectiveness of an anechoic chamber is achieved without being lined with electromagnetic waves absorbing materials (Standard EN 50147-1).

In practice, the access door is a special structure designed to meet rigorous shielding conditions and ensure an optimal shielding effectiveness. In this simulation, the access door was modeled as a component of the enclosure, the two being coupled. The material characteristics used in the access door simulation were the same as for the enclosure’s material, both being considered to be made of the same material, namely: steel.

The properties of the material used in the performed simulation are specified in the legend of Fig. 3. These were accessed from the material library integrated in the CST Studio Suite® software.

CST Studio Suite® uses both the Furman SEY (secondary electron emission) and the Furman PDF (probability density function) models. The simulation was developed based on Secondary electron emission which is a specific feature applicable to any material that has the property of individualizing SEY (Fig. 4). The Furman’s PDF model is used to specify the probability of the random variable falling within a particular range of values, as opposed to taking on any one value (Carter and Maas, 1972).

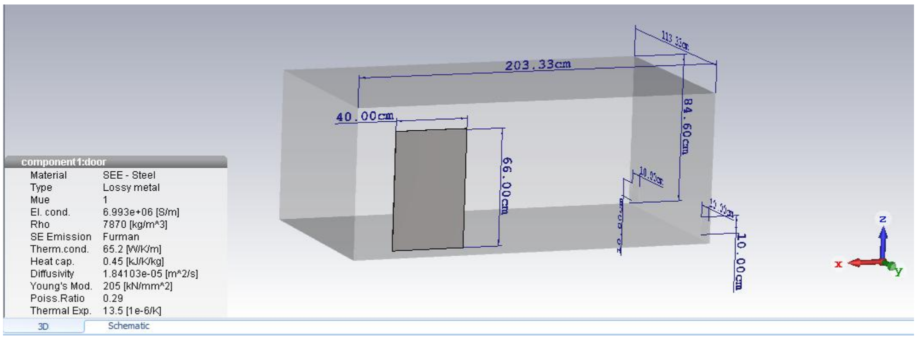
As a source of electromagnetic field, a linear polarized incident plane wave was used. The representation of the plane wave which is incident on the wall of the chamber in which the door is incorporated, is illustrated in Fig. 5. In the legend of Fig. 5, the field polarization specifications are presented.

Measurement of electromagnetic field values inside and outside the anechoic chamber was performed using field probes. They were placed as illustrated in Fig. 6. Four field probes were used: two for the electric field, and two for the magnetic field. To measure the simulated field near the access door, the field probes were placed as follows: two in the interior (one for the electric field, and one for the magnetic field), respectively two on the outside of the chamber (one for the electric field, and one for the magnetic field).

The next stage of modeling consisted in mesh network realization. Computing domain discretization was automatically generated for the entire volume under analysis. The network was built using triangular shaped elements. For this computational volume, a total of 1,073,088 tetrahedral shaped calculus cells were created (Fig. 7).

In order to simplify the model and reduce the time required to perform the simulations, the volume of the anechoic chamber was reduced to 1/4 of the model volume, since the volume of the enclosure shows symmetry after two planes of the coordinate system.

Modeling does not end with model designing and meshing. A very important step takes place afterwards and consists of its evaluation, verification and characterization. Verification ensures that the model has been designed in accordance with the requirements of the mathematical formulation of the problem, and validation assures that this formulation is a correct one, in line with reality.



component1:door	
Material	SEE - Steel
Type	Lossy metal
Mue	1
El. cond.	6.993e+06 [S/m]
Rho	7870 [kg/m^3]
SE Emission	Furman
Therm.cond.	65.2 [W/K/m]
Heat cap.	0.45 [kJ/K/kg]
Diffusivity	1.84103e-05 [m^2/s]
Young's Mod.	205 [kN/mm^2]
Poiss.Ratio	0.29
Thermal Exp.	13.5 [1e-6/K]

Fig. 3 – Anechoic chamber model.

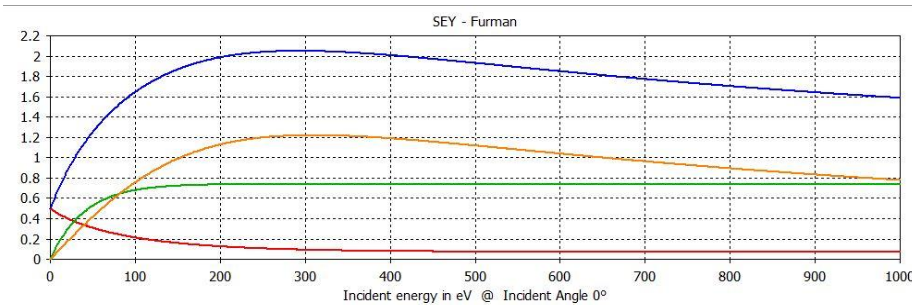
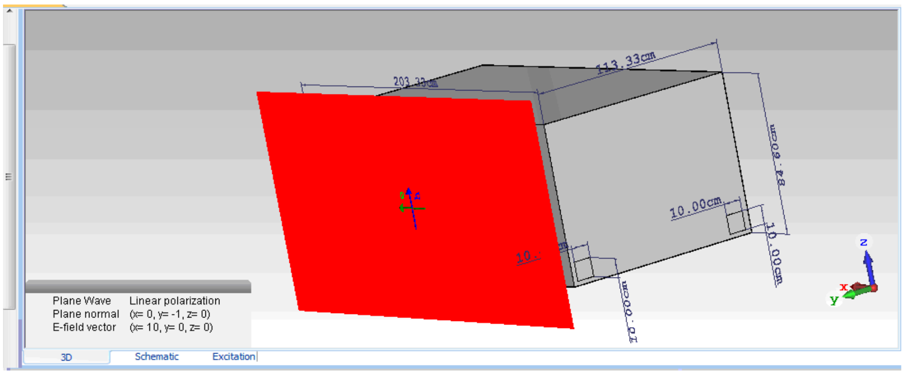
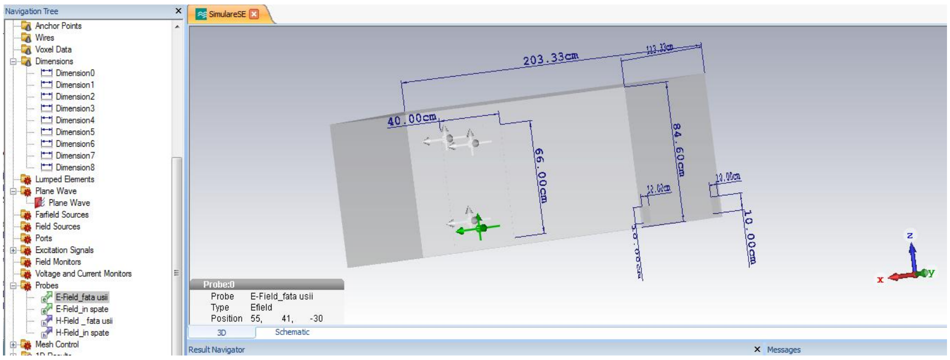


Fig. 4 – SEY - Furman.



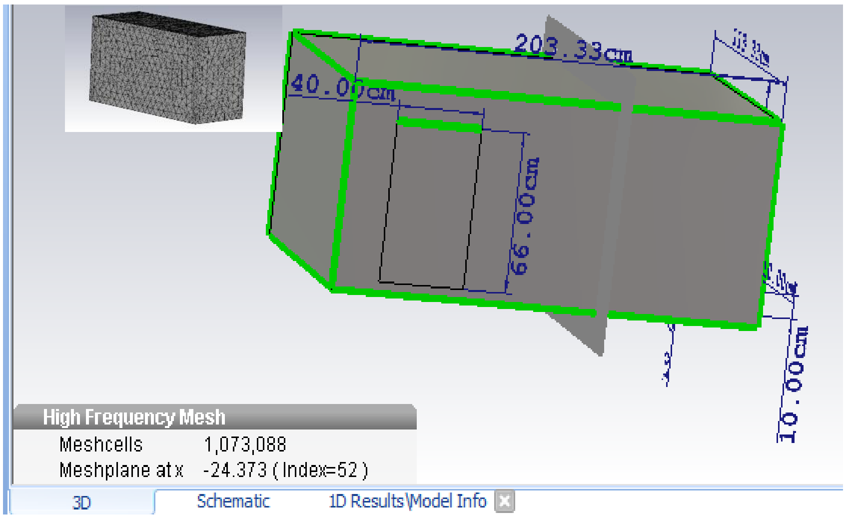
Plane Wave	Linear polarization
Plane normal	(x= 0, y= -1, z= 0)
E-field vector	(x= 10, y= 0, z= 0)

Fig. 5 – Plane wave. Field polarization.



Probe:0
Probe E-Field_fata usii
Type Efield
Position 55, 41, -30

Fig. 6 – Field probes layout.



High Frequency Mesh
Meshcells 1,073,088
Meshplane at x -24.373 (Index=52)

Fig. 7 – Meshing the anechoic chamber.

3. Simulation Results

Based on the above presented model, the simulation was performed and the results are presented selectively for certain frequencies in Tables 1 and 2. The simulation was performed in the frequency range of 10 kHz ÷ 18 GHz, with the step of 1%, the analysis being made in the frequency domain.

In the design and realization of the model were taken into account the standard requirements for the setup necessary for the calibration of a real enclosure, the sources used to simulate the electromagnetic field at the inside and outside being positioned in compliance with the specifications from the Standard EN 50147-1 (Fig. 8).

In Tables 1 and 2 the measured results near the access door (both in direct path and inside of the enclosure) for the electric field respectively, for the magnetic field, are presented. Based on these, the shielding effectiveness was calculated with Eqs. (1) and (2):

$$SE_E = 20\log(E_0/E_1) \tag{1}$$

$$SE_H = 20\log(H_0/H_1) \tag{2}$$

where: SE_E – shielding effectiveness in dB – electric field; SE_H – shielding effectiveness in dB – magnetic field; E_0 – electric field intensity measured in direct path; E_1 – electric field intensity measured inside the anechoic chamber; H_0 – magnetic field intensity measured in direct path; H_1 – magnetic field intensity measured inside the anechoic chamber.

The results presented in Tables 1 and 2 for the electric and magnetic field inside the chamber, have the constant value of 0.00001 because this is the minimum step used by the simulation software. This value for the electric field and for the magnetic field inside the enclosure is automatically returned by the solver analyzer. After simulation, the field value cannot be 0 because the mathematical algorithm on the basis of which the software is running would be misleading. It cannot divide at 0, which is why it adds to the 0 value the minimum incremental step.

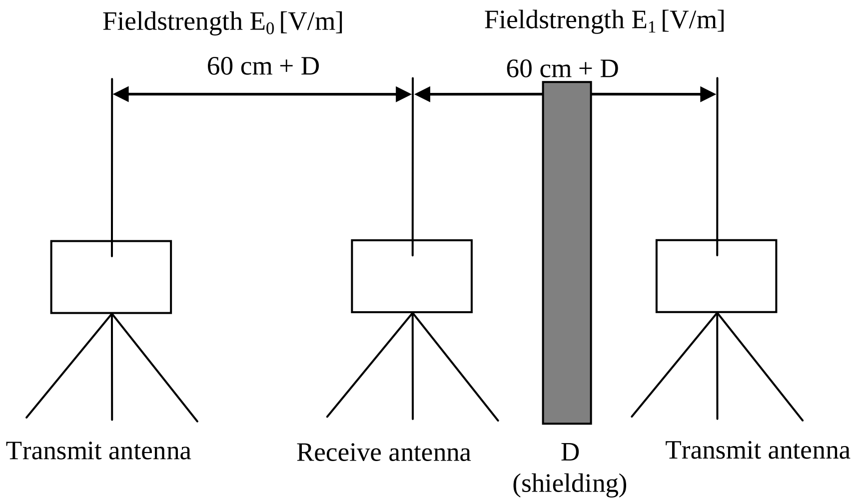


Fig. 8 – Field probes arrangement for shielding effectiveness simulation.

Table 1
Shielding Effectiveness Near the Access Door – Electric Field

Frequency [MHz]	Electric Field in Direct Path [V/m]	Electric Field Inside the Chamber [V/m]	Shielding Effectiveness [dB]
0.01	7.07	0.00001	116.99
0.1	7.26	0.00001	117.22
1	8.04	0.00001	118.11
10	10.97	0.00001	120.80
30	11.02	0.00001	120.84
100	12.54	0.000001	141.97
1000	14.45	0.000001	143.20
10000	14.14	0.00001	123.01
18000	13.28	0.00001	122.46

Table 2
Shielding Effectiveness Near the Access Door – Magnetic Field

Frequency [MHz]	Magnetic Field in Direct Path [A/m]	Magnetic Field Inside the Chamber [A/m]	Shielding Effectiveness [dB]
0.01	0.05	0.00001	73.98
0.1	0.06	0.00001	75.56
1	0.066	0.00001	76.39
10	0.072	0.00001	77.15
30	0.08	0.00001	78.06
100	0.069	0.000001	96.78
1000	0.07	0.000001	96.90
10000	0.07	0.00001	76.90
18000	0.07	0.00001	76.90

4. Simulation Results

Studies and researches on modeling and simulation of electromagnetic fields are imperative because they allow the estimation of the reliability of some equipment and the analysis of the effects caused by their electromagnetic interferences. The level of electromagnetic radiations and interferences has increased in recent years due to the constant evolution of devices and equipment that incorporate electrical and electronic circuits into their structure.

This paper aimed to illustrate an algorithm for designing a model for an anechoic chamber, model that can be simulated in order to estimate the shielding effectiveness for the enclosure.

In order to obtain the unique solution, one aimed to determine the local and instantaneous field sizes (electric - E and magnetic - H) in the space-time domain that was subjected to the analysis in terms of domain knowledge, domain material characteristics, spatial and temporal distribution of the field sources and other additional conditions (such as initial and boundary conditions).

The results obtained after the simulation was conducted were compared with the limits specified in the standard used for certification of shielded enclosures EN 50147-1 “Anechoic chambers – Part 1: Shied attenuation measurement,” thus validating the performed simulation.

The shielding effectiveness values calculated for the considered frequencies were satisfactory, with no significant variations in relation to the limits imposed by the EN 50147-1 Standard.

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⁂ *Frankonia Solutions®*, Anechoic Chamber Model FAC-3, web: https://frankonia-solutions.com/portfolio/fac-3-for-61000-4-22-testing.

⁂ *CST Studio Suite®*, https://www.cst.com/products/csts2.

SIMULAREA EFICACITĂȚII ECRANĂRII ÎN DREPTUL UȘII DE ACCES ÎNTR-O CAMERĂ ANECHOICĂ

(Rezumat)

Această lucrare prezintă câteva aspecte privind modelarea eficacității ecranării în zona ușii de acces într-o cameră anechoică. Pentru a modela eficacitatea de ecranare a camerei anechoice în zona ușii de acces, s-a folosit software-ul de simulare CST Studio Suite®. Simularea eficacității ecranării ușii de acces a fost efectuată în domeniul de frecvență de 10 kHz ÷ 18 GHz. După analizarea rezultatelor obținute prin simulare, s-a observat că valorile obținute pentru câmpul electromagnetic (câmp electric și câmp magnetic) oscilează în jurul limitelor specificate în standardul de referință EN 50147-1.