Measurement of Electromagnetic Shielding Efficiency of Composite Materials

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Abstract. *This paper deals with the theoretical and practical aspects of the shielding efficiency measurements of construction materials. In this contribution is described the alternative test method of these measurements by using the measurement circular flange. There are also discussed the measured results and parameters of coaxial test flange. The measurement circular flange is described by measured scattering parameters in the frequency range from 9 kHz up to 1 GHz. The accuracy of the used shielding efficiency measurement method was checked by brass calibration ring. The whole measurement of shielding efficiency was controlled by the program from the personal computer. This program was created in the VEE Pro environment produced by © Agilent Technology.*

Keywords: Shielding Efficiency, Composite Materials, Scattering Parameters, Measuring Flange

1. Introduction

The measurement of the shielded, absorbing and EMC chambers or boxes are usually done by the setup which contains the transmitting and receiving antennas, test signal generator and test signal receiver. As the test signal receivers are usually used the EMC receivers or spectral analysers. The measurement itself runs by the following way. The receiver with the receiving antenna and also with essential cable is situated inside the chamber or tested box. The transmitter (signal generator) and transmitting antenna are placed at the outer side of the tested object. The location of the antennas is changed around the chamber or box. The worst case, when the shielding efficiency is lowest, is reliably identified by this positioning of antennas [1] and [2].

The problem could appear when it is necessary to measure the shielding effectiveness of the material from which will be the chamber or box constructed. Especially in the development stage is not possible to construct the whole chambers or boxes with the huge sizes for accurate measurements. This approach is very expensive and also time consuming.

The similar problem appears when it is necessary to know the shielding efficiency of the construction materials like bricks, plasterboard, concrete etc. This material could be also called as composite material, especially during its development stage. The construction of the chambers or boxes from these types of materials for the measurement setups mentioned above has the main problems with the door construction. The door of these chambers or boxes has usually the main influence on the whole shielding effectiveness, in the other words the doors always represent the weakest part of these chambers. But the construction of the doors from the concrete is really complicated, in same cases nearly impossible.

2. Subject and Methods

The alternative test method for the testing of shielding efficiency of shielding materials is discussed in [3]. The presented coaxial test apparatus is suitable for thin materials like plastic or metallic board, fabric material and so on. But this setup is not suitable for the construction materials (concrete, bricks etc.), because it is very complicated to produced the thin concrete plain with the maximal height around 1 mm. The modified test setup according to Fig. 1 was produced, after analyses of commonly available measurement solutions and setups. The Fig. 1 shows the technical drawing of the measurement coaxial flange. This flange was mainly designed for frequency range from 9 kHz up to 1 GHz. The shape and dimensions of the flange were calculated for the 50 Ω input and output impedances [4].

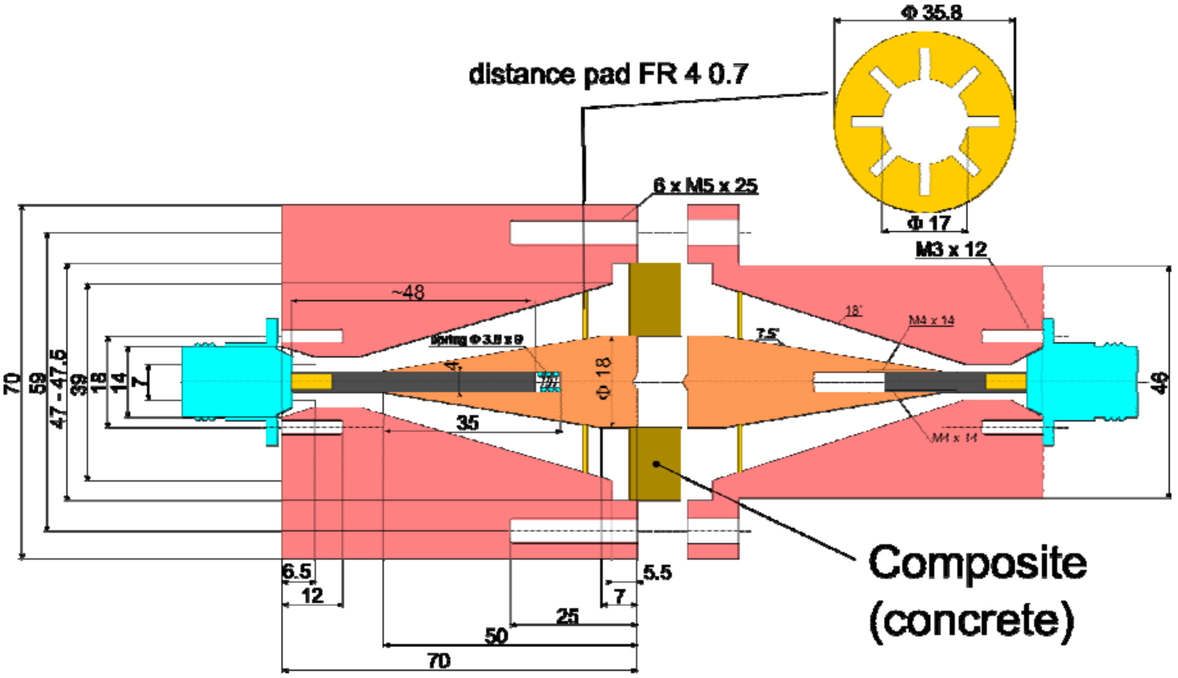

Fig. 1. Basic dimension drawing of the circular flange (dimensions are given in mm).

The design of the flange was done according to the basic mathematical relations [4]

$$Z_{\mathrm{m}} = \frac{60}{\sqrt{\varepsilon_{\mathrm{r}}}} \ln \frac{a_2}{a_1} \tag{1}$$

where

- Z_M is the characteristic impedance of the measurement system (50 Ω);
- ε_r is the relative permittivity (in this case is equal to 1, air);
- a_1, a_2 are the radius of the coaxial line (flange).

The transition from the N-type connector to the opposite end of the flange has the linear shape for both parts central and external. This shape was chosen for the better fabrication. The liner shape could be optimised for the better impedance matching especially at frequencies over 1 GHz. The central flange conductor is fabricated from the brass. The rest of the flange is made from the aluminium alloy. The flange is tightened by the torque wrench after the inserting the test composite by the same torque every time. This setup increases the accuracy of each measurement and also increasing the repeatability during the several measurement.

The measured scattering parameters of the flange itself are given in the Fig. 2. The S_{11} and S_{22} are in the whole range of interest under the -15 dB which refers about the good matching of the both test ports with the measuring system. The insertion losses in both directions (S_{21} and S_{12}) are in the whole measuring frequency range, under 1 dB. This data refers about the accurate design of the whole flange. The flange itself will have the insignificant influence on the total dynamic range of the whole measurement setup. The dynamic range will be mainly affected by the used measuring devices (generator and spectral analyser).

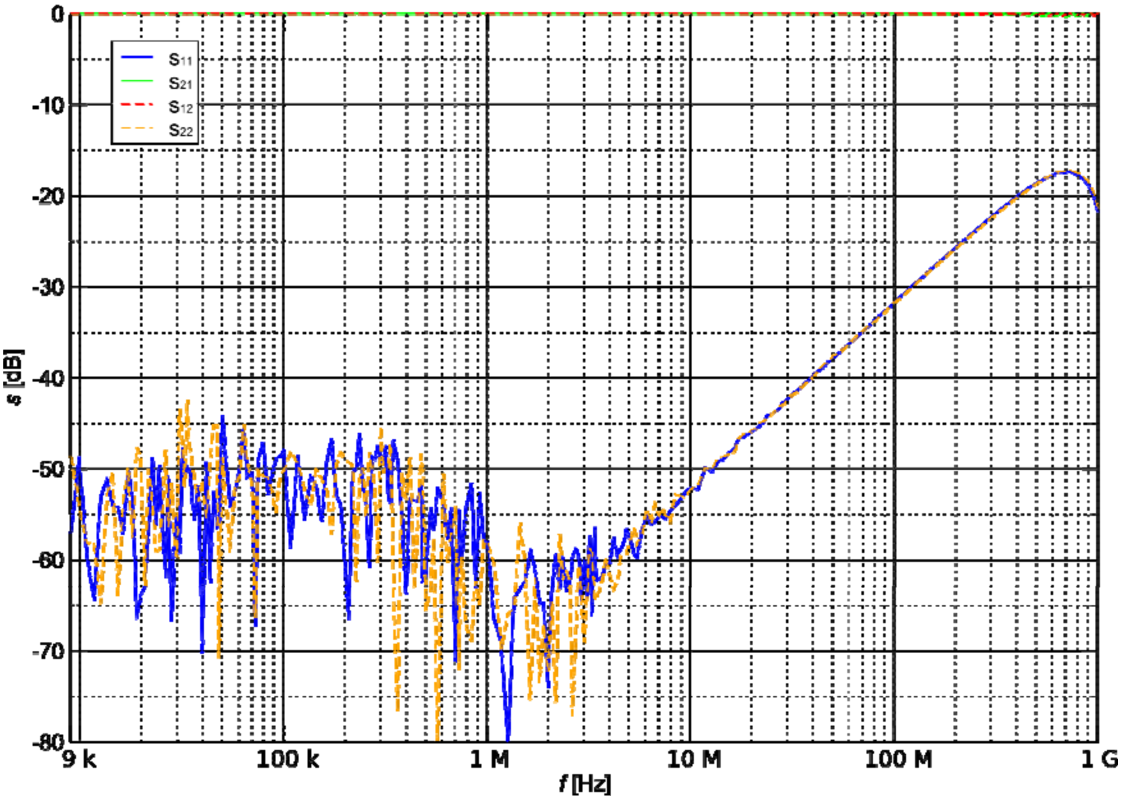

Fig. 2. Measured scattering parameters of the realised coaxial flange.

3. Results and Discusion

The measured scattering parameters refer about the accurate design of the coaxial flange. Several problems could appear during the prefabrication of the test sample concrete ring. This ring has to be produced with the high accuracy of its dimensions. The example of measured shielding efficiency of the composite concrete material is depicted in the Fig. 3. There is also shown the data which was measured with the brass disc. The shielding efficiency of the brass disc is the 115 dB at the kHz range and around 70 dB at the GHz range. The shielding efficiency of the composite concrete material is only several dB in the range from 100 MHz up to 1 GHz. The so low shielding efficiency of the concrete material is mainly caused by the small thickness of the material (only 8 mm).

4. Conclusions

The shielding efficiency of material is composed from several parts. The reflection loss, absorption loss and multiple path reflection losses are the main three parts of whole electromagnetic shielding. For the accurate classification of the shielding efficiency of composite concrete material will be necessary to measure each part of the whole electromagnetic shielding effectiveness. This measurement could be done by the vector network analyser. The dependency of the thickness of the material and shielding efficiency could be determined in the harmony with measured data. The future work will be focused on this problem and also on the composite concrete materials compound. There will be also tested the different thickness of the concrete samples.

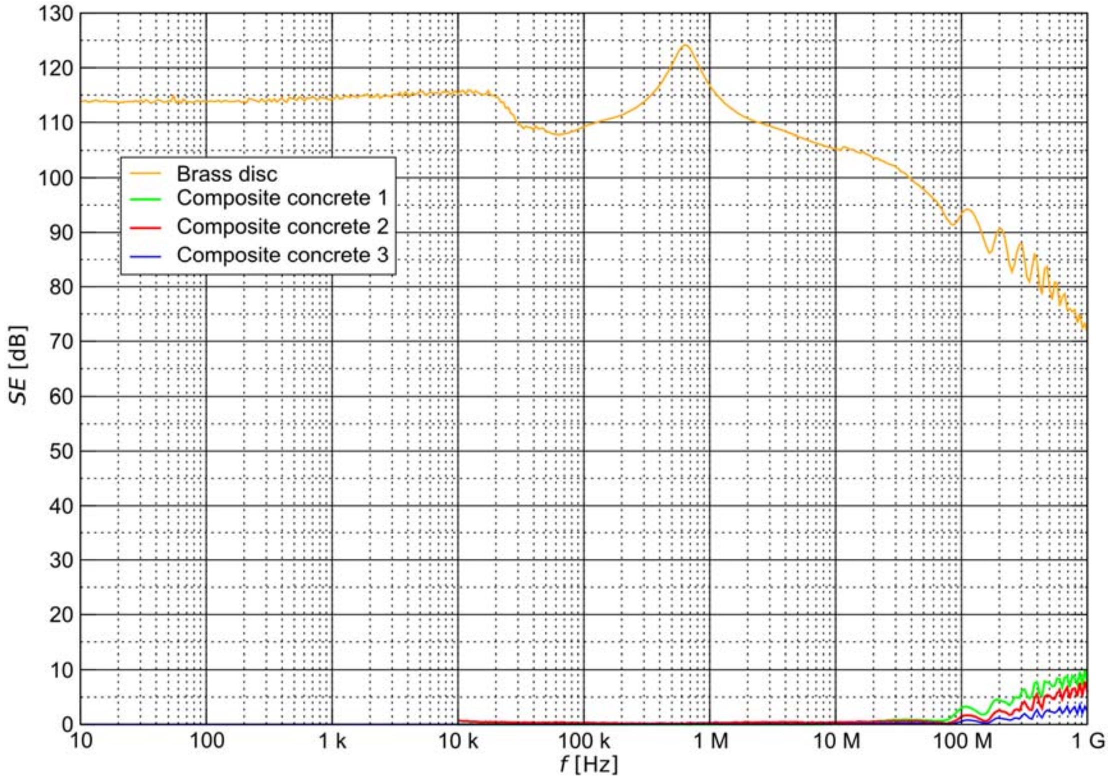

Fig. 3. Shielding efficiency of the brass calibration test disc and the composite concrete test sample.

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