ELECTROMAGNETIC SHIELDS ATTENUATION

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Key words: Electromagnetic field, Shield, attenuation, Microwave frequencies.

Shields are used to prevent unwanted electromagnetic fields and other electromagnetic disturbances from entering in an electromagnetic protected zone. In this paper the electromagnetic field attenuation of shields in microwave range is discussed. The method and instruments we used for attenuation measurements at frequencies in microwave range and experimental results obtained for different types of shields are presented.

1. INTRODUCTION

The electromagnetic radiation is an important source of interference on wanted signals from electric and electronic equipments.

Sources of electromagnetic radiation are:
- fixed radio, TV stations, radar;
- mobile emission stations used in telecommunication and technological processes;
- energy systems where the commutation is made with or without electric arc;
- lightning discharges, etc.

To neutralize the electromagnetic fields, in spaces in which these fields produce interferences on the wanted signal, transferred from the source to receiver, shields are used. Shields are structures made of materials which show, for the flux of a certain type of field, a conductivity large enough or which are able to create fields of reaction by influence or induction. The properties of the materials used on shields must counteract the electromagnetic field influences. More often, are used shields made of non-ferrous and ferromagnetic materials. Because of the wide implementation of computer and telecommunication technologies, electromagnetic shielding became of the most studied domains of Electromagnetic Compatibility (EMC).

The electromagnetic compatibility (EMC) represents the coexistence without conflicts of the electromagnetic energy emitters and receivers. In other words, the

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emitters transmit the information only at the desired receivers; the receivers react only at the signals from the selected emitters, and there is no mutual, unwanted perturbation (interference).

It is convenient to quantize the amplitude of the output signal $a_e$ toward the amplitude of the input signal $a_i$ with the logarithm of the two quantities ratio. Thus, the attenuation is defined as [1, 2]:

$$A[\text{dB}] = 20 \log \left( \frac{a_i}{a_e} \right).$$

(1)

In this paper, a characterization of a new magnetic composite material used as electromagnetic shield (homologated as EEM-01) at microwave frequencies in the range 1–18 GHz is accomplished by determining the attenuation. This material was intended for the use as electromagnetic shield at frequencies of the order of 1 MHz. The results obtained on the tests made at these frequencies were very good and presented in a previous paper (Jenica Neamțu, Liviu Giurgiu, Wilhelm Kappel, Teodora Malaeru, Eros Patroi, Gabriela Georgescu, Viorel Alecu, Characterization at microwave frequencies of magnetic composite and shields for electromagnetic protection, JOAM, 6, 3, pp. 979–982, 2004).

The magnetic composite material used contains pyrites ashes and have been obtained using a patented method: Patent RO, 2002-11-06, Method of preparation of magnetic composite materials with shielding properties, authors: Jenica Neamțu, Wilhelm Kappel.

2. EXPERIMENTAL SETUP AND PROCEDURE

The experimental setup used (Fig. 1) for determination of attenuation for shields at microwave frequencies (MW) is formed by GTEM (Gigahertz Transverse Electromagnetic) cell, spectrum analyzer, signal generator, horn antenna, and spectrum analyzer (table 1). The sample and the horn antenna are placed inside the GTEM cell.

<table>
<thead>
<tr>
<th>Table 1</th>
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<td>Equipments for determination of MW attenuation</td>
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<tr>
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The GTEM is a precision electromagnetic compatibility (EMC) test instrument primarily intended for use as an electromagnetic compatibility radiated immunity (RI) and radiated emissions (RE) test facility. The GTEM is a pyramidal tapered, dual-terminated section of 50 Ω transmission line. The cell is flared to create a test volume within which the equipment under test (EUT) is placed. At the input, a normal 50 Ω coaxial line is physically transformed to a rectangular cross section with an aspect ratio of 3:2 horizontal to vertical. The main technical characteristics of the used GTEM cell are:

♦ frequency range:
  – 9 kHz – 5 GHz, for RE tests
  – DC – 20 GHz, for RI tests
♦ maximum continuous working input power:
  – 250W, for RE tests
  – 400W, for RI tests
♦ input impedance: 50 Ω
♦ shielding effectiveness, from internal E-fields: 80 dB minimum, 10 kHz–1 GHz [3].

The signal generator is an electronic apparatus that provide signals with certain waveforms and with adjustable amplitude and frequency. The main characteristics of the signal generator used in our measurements are:

♦ frequency range: 250 kHz–40 GHz
♦ frequency resolution: 0.001Hz
♦ output power: –20 dBm–12 dBm
♦ modulation: AM, FM, ΦM, pulse and sweep
♦ internal function generator: sine, square, triangular, ramp and noise
♦ step sweep and ramp sweep (in frequency or power)
♦ possibility to connect to a computer by LAN or GPIB [4].

The horn antenna used in this case is a linearly polarized broadband antenna covering the frequency range of 1 GHz to 18 GHz. The Model 3115 was designed and built specifically for electromagnetic interference (EMI) measurements and specifications compliance testing. However it can also be used for antenna gain, pattern measurement, surveillance and other applications. The antenna is precision machined from aluminum with side plates of copperclad, tin-solder, epoxy fiberglass (G-10). Electrical specifications:

♦ frequency range: 1–18 GHz
♦ voltage standing wave ratio (VSWR): < 1.5:1
♦ maximum continuous power: 300 W
♦ peak power: 500 W
♦ impedance: 50 Ω [5].
The *spectrum analyzer* allows the graphical representation of the frequency spectrum of the received signal. The analysis results are displayed on a screen and can also be stored on a non-volatile memory. Those are the main characteristics of the spectrum analyzer used:

- frequency range: 100 Hz–26.5 GHz
- resolution: 0.1 dB
- accuracy: +/- 0.75 dB
- units of measurement: dBm, dBmV, dBµV, dBµA, A, V, W, and Hz
- maximum input power: 1 W
- logarithmic sweep
- built-in preamplifier
- data saving in its internal memory and/or on floppy disk
- possibility to connect to a computer by LAN or GPIB [6].

![Diagram of experimental setup](image)

**Fig. 1 – Experimental setup used for determination of attenuation.**

The signal from the signal generator is transmitted on sample by the tail of the GTEM cell (which act like a horn antenna) and is captured through the horn antenna and then transmitted at the spectrum analyzer.

The power level of the signal is measured, in dBm, with the spectrum analyzer (dBm represents the power level measured related to a reference power of 1 mW).

\[
p[dB] = 10 \log \left( \frac{p_x}{p_0} \right), \quad p_0 = \ln W. \quad (2)
\]

Measurements were made at different frequencies in the range 1–18 GHz with sample and without sample.

The attenuation, in dB, was calculated using the following relation:
where \( P_i \) is the power measured without the sample and \( P_m \) is the power measured with sample.

3. RESULTS AND DISCUSSION

Table 2 shows the attenuation obtained for the shield prepared from pyrites ashes.

Fig. 2 shows a graphical representation of the determined attenuation versus frequency.

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Attenuation (dB)</th>
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<tbody>
<tr>
<td>1</td>
<td>-0.75</td>
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<tr>
<td>2</td>
<td>2.47</td>
</tr>
<tr>
<td>3</td>
<td>1.01</td>
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<tr>
<td>4</td>
<td>1.79</td>
</tr>
<tr>
<td>5</td>
<td>0.89</td>
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<tr>
<td>6</td>
<td>5.33</td>
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<tr>
<td>7</td>
<td>3.38</td>
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<tr>
<td>8</td>
<td>4.97</td>
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<tr>
<td>9</td>
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<td>10</td>
<td>7.74</td>
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<tr>
<td>11</td>
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<td>13</td>
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<tr>
<td>14</td>
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<tr>
<td>15</td>
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<tr>
<td>16</td>
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<td>17</td>
<td>0.78</td>
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<tr>
<td>18</td>
<td>0.68</td>
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</table>

The tested magnetic composite material presents good attenuation values from 6 GHz to 16 GHz with the biggest values at 10 GHz and 15 GHz (7.74 dB, respectively 7.73 dB).

The attenuation values obtained at 1 GHz and after 17 GHz cannot be considered cogent because these are the limits of the sensitivity range of the horn antenna.
4. CONCLUSIONS

This magnetic composite material was first designed and tested for electromagnetic shielding at frequencies of the order of 1MHz. Considering the results obtained at these frequencies and those presented in this paper at frequencies between 1 and 18 GHz, we conclude that this magnetic composite material can be used as electromagnetic radiation absorber and shield in a wide frequency range.  

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REFERENCES