Mesure d' Impedance
de surface
Efficacite de Blindage de Structuers

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Developed by:

Roland SCHURIG

Sandeep GOPALA KRISHNAN

Prerana SHAMSUNDAR PUNJABI

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Executive Summary

Electromagnetic Interference shielding refers to reflection and / or adsorption of electromagnetic radiation by a material, which thereby acts as a shield against penetration of the radiation through the shield. The main ways to improve shielding is by either reflection mechanism or absorption mechanism.

Metals are the most common material used of EMI shielding. The losses whether due to reflections, absorption or multiple reflections, are commonly expressed in dB. The sum of all losses is the shielding effectiveness (in dB). The absorption loss is equal to the thickness of the shield.

Electromagnetic radiation at high frequencies penetrates only the near surface region of an electric conductor. This is known as skin effect. The electric field of a plane wave penetrating a conductor. The depth at which the field drops is called the skin depth. Hence the skin depth decreases with the increasing frequency and with increasing conductivity or permeability.

Shielding effectiveness (SE): The ratio of the signal received (from a transmitter) without the shield, to the signal received inside the shield; the insertion loss when the shield is placed between the transmitting antenna and the receiving antenna

In this assignment we will test and verify the shielding effect of different materials. Additional test have been performed to confirm the reciprocity and other properties.

1 Mode Operatoire

1.1 Référence de la mesure

a. Equivalent electric circuit

We have one emitter (can be assimilated to a generator), one collector. So the equivalent electric circuit is

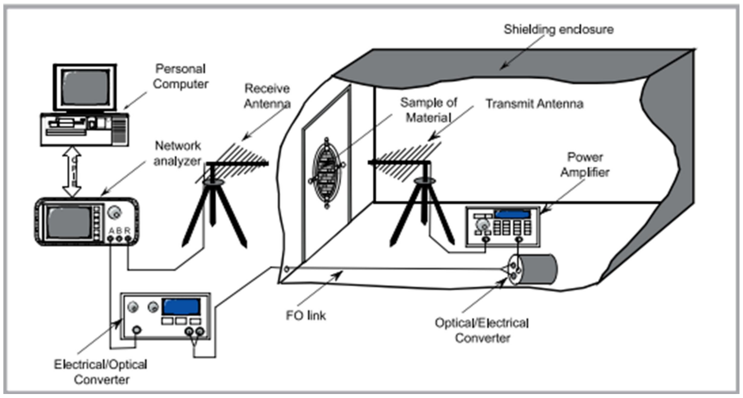

FIGURE 1: SIMULATION

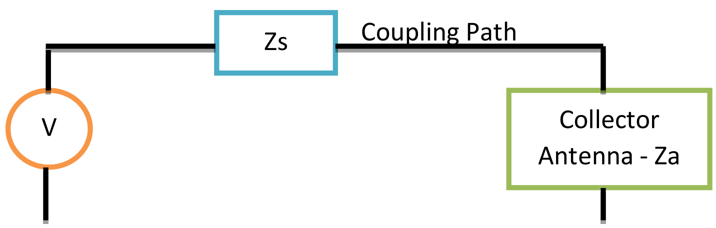

FIGURE 2: ELECTRIC CIRCUIT

b. The need to perform the average on several curves according to the measurement method employed

With higher frequency, higher will be the transmission, but we can also notice that at a certain frequency, the transmission will be optimum after which it decrease with increasing frequencies. To tune the system with respect to optimum frequency and distance between the two antennas there is a need to perform at test on several curves.

c. Reciprocity - we invert the roles: The emitter becomes the receiver and the receiver becomes the emitter

We observe on the following figure the results:

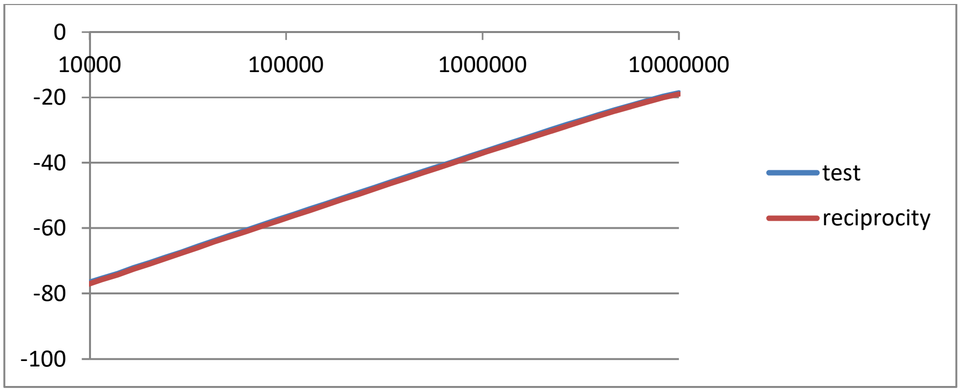

FIGURE 3: RECIPROCITY TEST

We observe that since the two antennas are placed apart at an optimum distance (D = 2 * Radius of the emitter). The circuit has the property of being reciprocal.

1.2 Mesure en presence du matériau

a. Influence of the position of the material between the two spirals

We observe on the following figure that the position of the material between the spirals has no incidence on our test

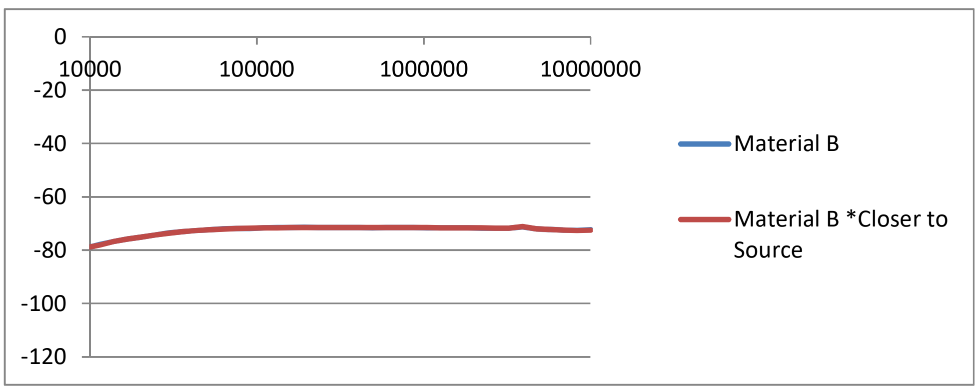

FIGURE 4: THE DISTANCE EFFECT

b. For the first material, the frequency band used is from 1 kHz to 10 MHz

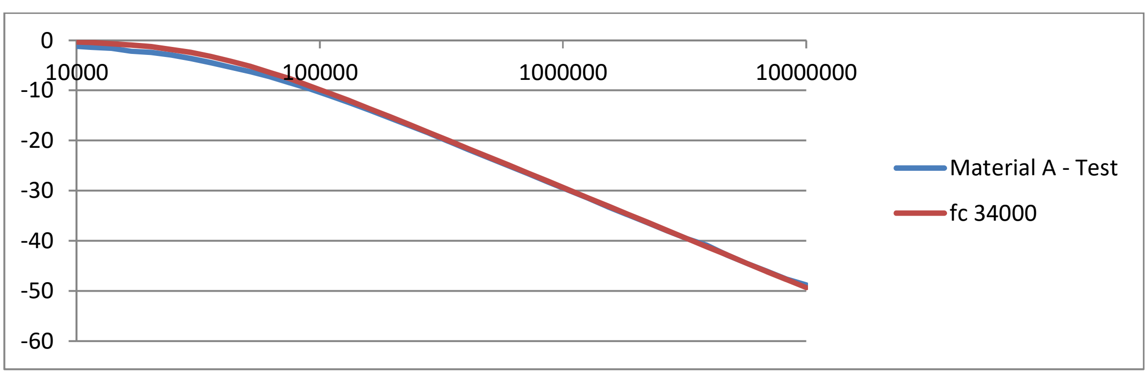

FIGURE 5: FREQUENCY RANGE TEST ON MATERIAL - A

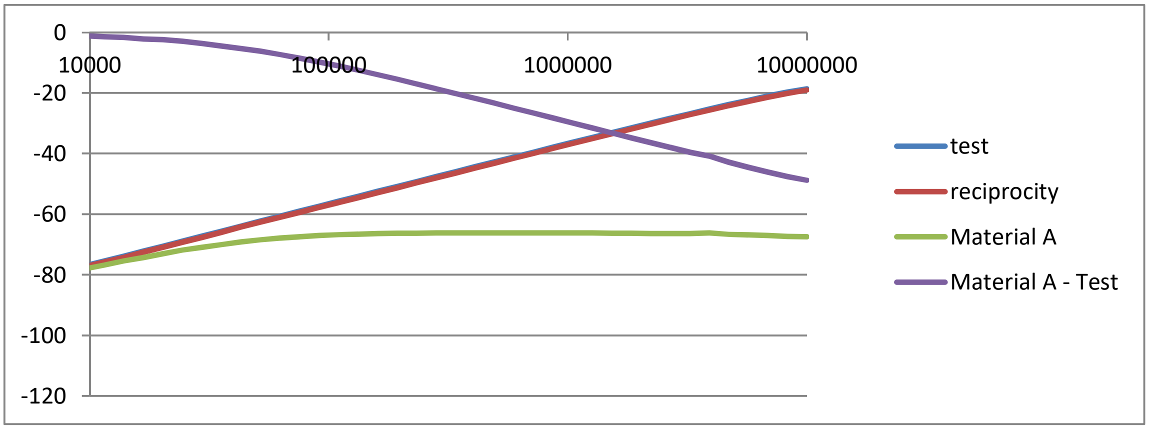

FIGURE 6: RECIPROCITY TEST ON MATERIAL A

In this case, we observe that the cutoff frequency of material A is close to 34 kHz

c. In order to determine its surface impedance, we apply the following formula:

$$Z_s = \frac{f_c}{10^7}$$

We find $Z_s=3.4*10^{-3}$ Siemens

2 Analyse des echantillons

2.1 Cas de la feuille d'aluminium

a. Thickness of the aluminum sheet

$$d = \frac{1}{\sigma_{as} Z_s}$$

The aluminum sheet is 10^{-6}m = 1µm thick.

2.2 Cas des empilements de feuilles d'aluminium

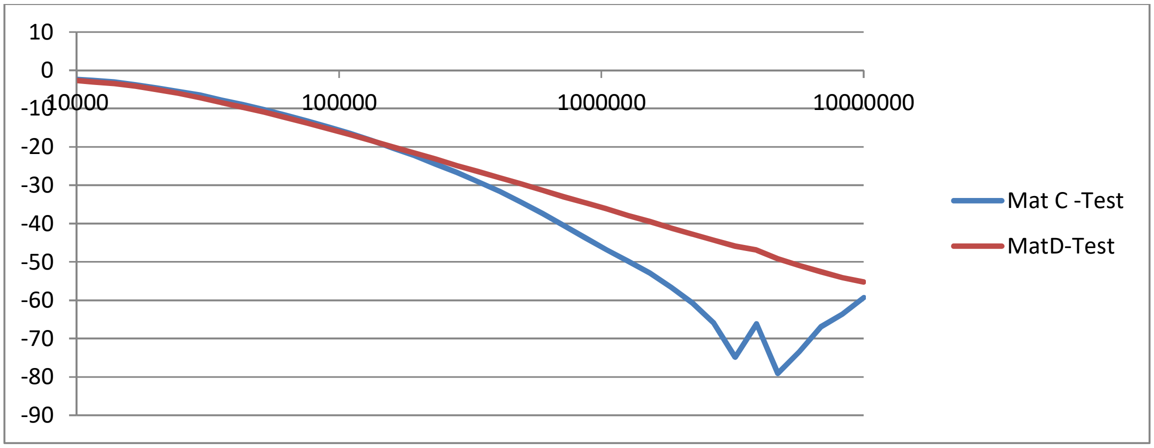

FIGURE 7: COMPARISION BETWEEN SINGLE SHEET AND DOUBLE SHEET OF ALU

a. For material C (2 sheets of ALU distant of 10 mm)

We find a surface impedance of

$$17*10^3/10^7= 17 *10^{-4} \text{ Siemens}$$

b. For material D (2 sheets of ALU distant of 1.7 mm)

We find a surface impedance of

$$16,5*10^3/10^7= 16,5*10^{-4} \text{ Siemens}$$

c. For material E (99% of ALU sheet)

We find a surface impedance of

$$26,8*10^3/10^7= 26,8 *10^{-4} \text{ Siemens}$$

When the distance between the two sheets is greater (Material C) it acts as a 2'nd order filter and has better We see that when more the distance between the 2 sheets is greater, the more we have a diminution of the cutoff frequency. This results in better shielding effect and insulation.

2.3 Empilement de plaques de composites de Carbone

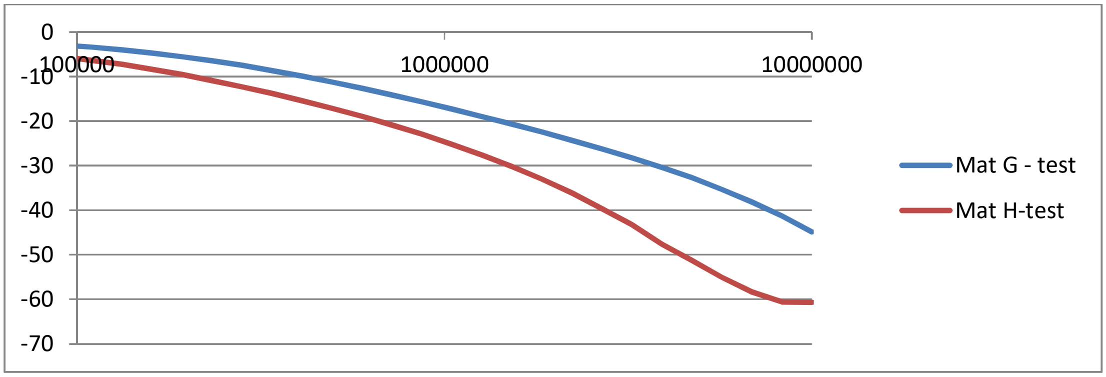

FIGURE 8: COMPARISION BETWEEN SINGLE SHEET AND DOUBLE SHEET OF CARBON MATERIAL

a. Surface impedance of 1 sheet Carbon

$$14 * 10^3 / 10^7 = 14 * 10^{-3} \text{ Siemens}$$

b. Surface impedance of 2 sheet Carbon

$$72 * 10^4 / 10^7 = 72 * 10^{-4} \text{ Siemens}$$

c. The influence of the thickness of a material on the shield's performance

In general the absorption performance can be made better either by increasing the thickness of the shield of by using a metal with higher permeability. At higher frequencies where both absorption and reflective losses increases, higher electric conductive materials provide better shielding effect.

Additionally, due to the thickness of the material very good attenuation is achieved. The system acts as multiple 1'st order systems ("n+1" 1'st order systems)

d. The frequency at which the experimental curve does not follow a first order filter

At very high frequencies since the system is an open loop system there is a coupling between the 2 materials and this will cause a stop in the shielding effect.

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

Where: δ = skin depth (mm)

ω = angular (radian) frequency

μ = material permeability (4π x 10-7 H/m)

σ = material conductivity (5.82 x 107 mho/m for Cu)

f = frequency (hertz)

Frequency	Skin Depth (mm)
60 Hz	8.52
100 Hz	6.59
1 kHz	2.086
10 kHz	6.597
100 kHz	0.2086
1 MHz	65.971*10^-6
10 MHz	20.86*10^-6
100 MHz	6.5971*10^-6
1 GHz	2.086*10^-6

Where the cut-off-frequency is Fc -140000 Hz.

3 Effet de la geometrie

Impact of the size of the emitter while keeping the same size for the receiver. This part was not completed due to shortage of time.

4 Legend:

Material A: 1 sheet ALU

Material B: 1 other type sheet ALU

Material C: 2 sheet ALU, separated

Material D: 1 sheet ALU, not separated

Material E: 1 sheet ALU, 99% of ALU

Material F: 1 sheet Titanium

Material G: 1 sheet Carbon

Material H: 2 sheet Carbon

Material I: 1 carbon meshed sheet (using A350)

Material J: 1 honeycomb (using Helicopter)

5 Conclusion

This project is a good opportunity to apply the advices and the lessons taught. The session gave us a unique exposure in the shielding effectiveness of different materials used.