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Characterization of Shielding Material based on Tempreature vs Reflectivity to Control EMI

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Abstract

The reflection loss of an electromagnetic wave from a material is important parameter in the design of electromagnetic shielding techniques. May the designed circuit can show inefficiency because of the radiation interference from the external sources. In this paper mainly discussed about one of the compatibility techniques, shielding by the conductive materials. The shielding ability of the conductive material can be analyzed in terms of reflectivity for a single shielding conductive material. Conductors are best reflectors for electromagnetic waves, when ever electromagnetic waves incident on it. The reflectivity of these conductive materials can depends on the temperature. Based on the properties of the conductor as the temperature changes the conductivity of the conductor can changes, by it the reflectivity of the material can also changes. The analysis can be made for reflectivity of a conductive material with respective to the temperature at particular frequency. The thickness of the conductive material not considered here. The variation of reflectivity for different conductive materials at 10 MHz frequency can be analyzed. As the temperature increases the reflectivity of the material can be decreases in small percent. The best reflectivity can be achieved at low temperature to control EMI

Keywords: Compatibility, Shielding,Variation, Reflectivity

INTRODUCTION

Electromagnetic shielding is of prime concern in the design of any circuit in order to avoid electromagnetic interference from external sources. A good conducting enclosure of the circuit would stop electromagnetic interference from external sources. The reflectivity of the different conductive materials can be analyzed by considering the incident of electromagnetic wave at the interface of free space and conductor for various temperatures. As the frequency changes the reflectivity conductive material will changes but here the complete concentration is about change in reflectivity based on temperature for an fixed frequency. For change in temperature the conductivity of the conductor changes as the conductivity of the conductor changes, the reflectivity also changes. so to explain these analysis for different conductor materials can be selected like copper, aluminium, titanium, iron. Initially the variation of conductivity of these materials can be analyzed and then the variation of reflectivity can be observed. As the temperature increases the reflectivity will decreases because the reflection loss increases.

EXPERIMENT

Resistivity of the conductor with temperature

In general, electrical resistivity of metals increases with temperature, while the resistivity of intrinsic semiconductors decreases with increasing temperature. In both cases, electron–photon interactions can play a key role. At high temperatures, the resistance of a metal increases linearly with temperature. As the temperature of a metal is reduced, the temperature dependence of resistivity follows a power law function of temperature. Mathematically the temperature dependence of the resistivity ‘ρ’ of a metal is given in the equation [1].

Temperature Coefficient of Resistivity

As noted above, electrical conductivity values (and resistivity values) are typically reported at 20^{o}C. This is done because the conductivity and resistivity of material is temperature dependant. The conductivity of most materials decreases as temperature increases. Alternately, the resistivity of most material increases with increasing temperature. The amount of change is material dependant but has been established for many elements and engineering materials. The reason that resistivity increases with increasing temperature is that the number of imperfection in the atomic lattice structure increases with temperature and this hampers electron movement. These imperfections include dislocations, vacancies, interstitial defects and impurity atoms. Additionally, above absolute zero, even the lattice atoms participate in the interference of directional electron movement as they are not always found at their ideal lattice sites. Thermal energy causes the atoms to vibrate about their equilibrium positions. At any moment in time many individual lattice atoms will be away from their perfect lattice sites and this interferes with electron movement. When the temperature coefficient is known, an adjusted resistivity value can be computed using the following formula:

$R_1 = R_2 * [1 + a * (T_1 – T_2)]$ (1)

Where: R_1 = resistivity value adjusted to T_1

R_2 = resistivity value known or measured at temperature T_2

a = Temperature Coefficient

T_1 = Temperature at which resistivity value needs to be known

T_2 = Temperature at which known or measured value was obtained

Table 1: Resistivity of a few metallic elements

Metallic element	Resistivity (20^0c)
copper	1.72×10^{-8}
Aluminum	2.82×10^{-8}
nickel	6.99×10^{-8}
iron	1.0×10^{-7}
Tungsten	5.60×10^{-8}

Table 2: Temperature coefficient for a few metallic elements

Material	Temperature Coefficient (/°C)
Nickel	0.0059
Iron	0.0060
Molybdenum	0.0046
Tungsten	0.0044
Aluminum	0.0043
Copper	0.0040
Silver	0.0038
Platinum	0.0038
Gold	0.0037
Zinc	0.0038

Reflection Loss

The reflection at the interface between two media is related to the difference in characteristic impedance between the media as shown in the fig.1. The intensity of the transmitted wave from a medium with impedance Z_1 to a medium with impedance Z_2 is

$$E_1 = \frac{2Z_2}{Z_1+Z_2} E_0$$

and $$H_1 = \frac{2Z_1}{Z_1+Z_2} H_0$$

E_0 (H_0) is the intensity of the incident wave and, E_1(H_1) is the intensity of the transmitted wave. When a wave passes through a shield, it encounters a boundary, as shown in Fig. 1.

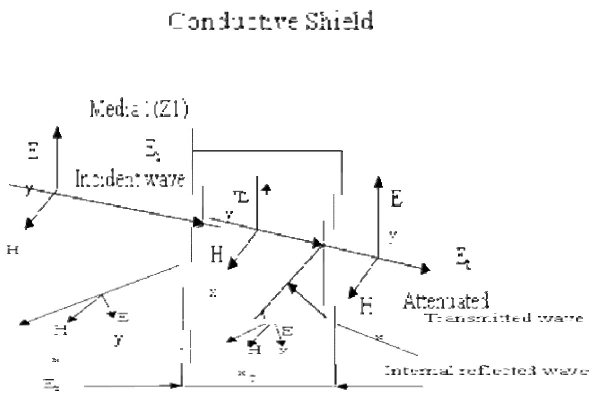

Figure 1: Representation of shielding mechanisms for plane waves

The second boundary is between a medium with impedance Z_2 and a medium with impedance Z_1. The transmitted wave, E_1 (H_1) through this boundary is given by

$$E_t = \frac{2Z_1}{Z_1+Z_2} E_1$$

and

$$H_t = \frac{2Z_2}{Z_1+Z_2} H_1$$

Substituting the wave impedance Z_W for Z_1, and the shield impedance Z_S for Z_2 the reflection loss for either the E or H field can be written as

$$R = 20\log \frac{|Z_W|}{4|Z_S|} (dB) \quad (dB)$$

Where Z_W = impedance of wave prior to entering the shield,

Z_S = impedance of the shield.

In the case of a plane wave (far field), the wave impedance Z_W equals the characteristic impedance of free space Z_0 (377Ω), then the equation becomes

$$R = 20\log \frac{94.25}{|Z_S|} (dB) \quad (dB)$$

And rearranging the above equation gives

$$R = 168 - 10\log\left(\frac{\mu_r f}{\sigma_r}\right)(dB)$$

Conductivity of material can be considered as inverse of the resistivity. Here the frequency of the operation considered at 1MHz, and the mobility of the conductor can be taken as unity.

RESULTS

The reflectivity of the different materials like copper, aluminum, titanium, iron, nickel can be observed with respect to the temperature, and the range of the temperature can be taken in between 20^0c to 50^0c at constant frequency. From fig (1) to fig (6) shown the relation between reflectivity to that of temperature. From the figures we can analyze that as the temperature increases the reflectivity decreases

<u>Reflectivity of single conductive shield V's temperature for copper material</u>

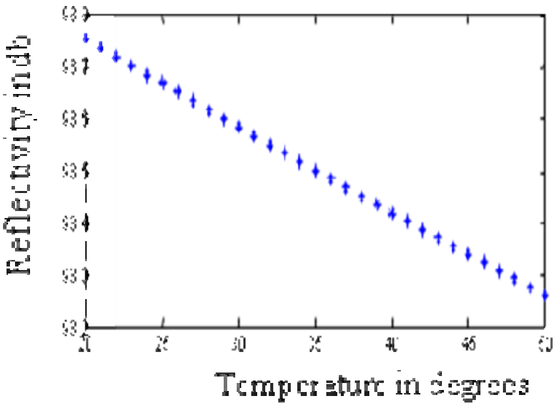

Figure 2: Variation of reflectivity with respect to the temperature for copper shield

<u>Reflectivity of single conductive shield V's temperature for aluminium material</u>

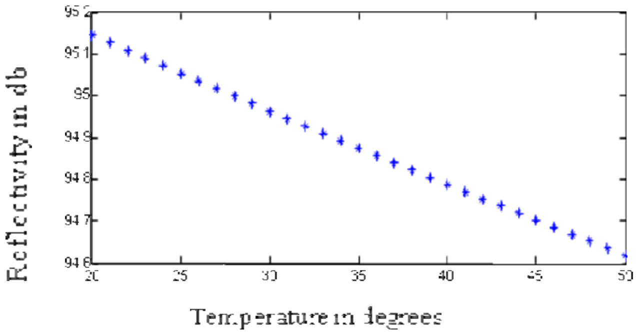

Figure 3: Variation of reflectivity with respect to the temperature for aluminium shield

<u>Reflectivity of single conductive shield V's temperature for Nickel material</u>

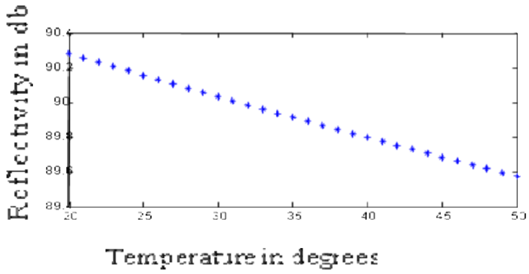

Figure 4: Variation of reflectivity with respect to the temperature for nickel shield

<u>Reflectivity of single conductive shield V's temperature for Tungsten material</u>

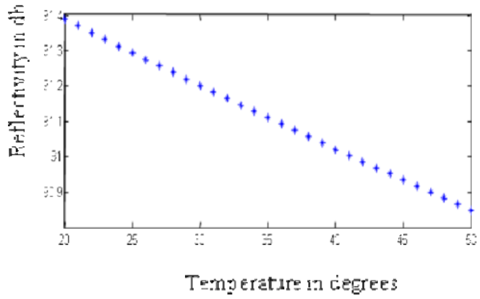

Figure 5: Variation of reflectivity with respect to the temperature for tungsten shield

<u>Reflectivity of single conductive shield V's temperature for iron material</u>

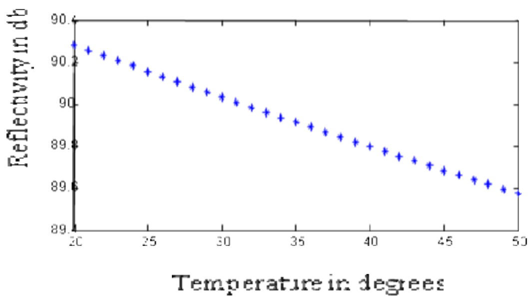

Figure 6: Variation of reflectivity with respect to the temperature for iron shield

CONCLUSION

From the figures it can be concluded that the reflectivity of the conductive materials can be decreases with increases temperature. Figure-2 shows the variation of reflectivity with respect to the temperature for copper shield, the variation of the temperature can be taken in between 50^0c to 20^0c for these the variation in the reflectivity can be observed from

98.28 to 98.78. Figure-3 shows variation in the reflectivity can be varied from 94.61 to 95.18 for aluminum,Figure-4 shows variation in the reflectivity can be varied from 89.51 to 95.18 for nickel, Figure-4 shows variation in the reflectivity can be varied from 89.58 to 90.3, Figure-5 shows variation in the reflectivity can be varied from 90.71 to 91.4, Figure-6 shows variation in the reflectivity can be varied from 102.7 to 103.42 for iron material. At low temperature the shield can reflects maximum incident signal, so the shield at Low Temperature can provides good shielding for the designed circuit which is enclosed by it. The best reflectivity can be achieved at low temperature to control EMI

FUTURE SCOPE

Variation of reflectivity with respect to the temperature for different materials are analyzed. As the Future Work one can analyze for the best material to be used for shielding from the absorption parameter. Reflection and Absorption are independent from each other, but when they combine together, they produce the overall shielding with true effectiveness.

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