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Prediction of Shielding Effectiveness of Cables used for Automobile Sector: Technical Note

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ABSTRACT:

The automotive industry is gearing for a drastic shift towards the electric vehicles and also leaping for the autonomous vehicles. The functional performance of such autonomous vehicles must be properly ensured. One such kind of disturbance to the proper functioning of the vehicle is Electromagnetic Interference due to presence of various electrical systems. The operating frequency range is increasing due to latest advancement in automobile industry. The future working frequency is going to be 74GHz which falls under extremely high frequency range. So it is inevitable to analyse the electromagnetic interference and emission caused by such futuristic models. The electromagnetic field effect is dependent on the shielding effectiveness. The Electromagnetic Shielding Effectiveness (EMSE) varies with numerous parameters like the type of material, shape of material, size of material etc. The work deals with the modelling of cable and study on shielding effectiveness of the cables used in automotive. The same has to be evaluated with standards test procedures and validated.

KEYWORDS:

Electromagnetic Interference; Shielding effectiveness; Automotive; Cables

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1. Introduction

Automotive systems are associated with lot of conductors routed through confined spaces within the body of the vehicle. Apart from the electrical components and systems a lot more sensors and electronic components include Antilock braking systems, rear cameras for reverse, self-parking facilities, IR sensors, LIDAR systems, wireless connectivity, etc. may lead to an alarming and unpredictable increase in the radiated noise which may even lead to the total system failure. The radiated Electromagnetic Interference (EMI) may corrupt the data signals adjacent to the electrical wire. This leads to the importance of study of electromagnetic interference and its compatibility. Fig. 1 shows the clear picture of various sources, paths, victims of EMI.

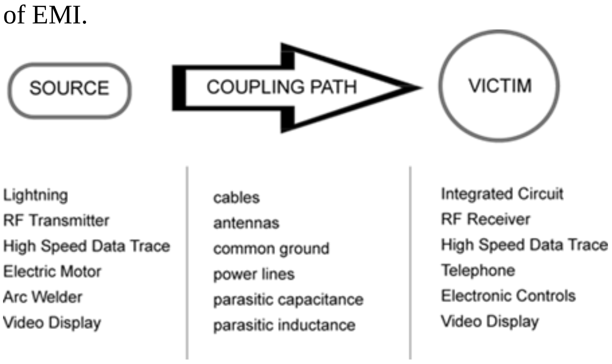

Fig. 1: Electromagnetic interference

Among the sources mentioned RF transmitter, electrical wires around the car body and high speed data trace can be source of since the wires are bunched and routed to various components throughout the automotive system the path of EMI is through radiation and the victim will be the data transmission wires for sensors and other electronic components. There are various EMI control techniques like shielding, grounding, short routing, twisted pairs etc. Electromagnetic compatibility can be achieved through proper shielding EMI and threat to the automotive system functioning.

2. Shielding effectiveness

Electromagnetic shielding is a process by which a material can able to reduce the transmission of electromagnetic radiation that affects the human or equipment [1]. Electromagnetic interference energy emits through the apertures, cables or wires. These apertures on the enclosure walls could be for ventilation purposes and the wire a part of the electrical or electronics equipment's communication line, power cable, signal line, etc. Various studies have been done based on so many factors that affect the shielding enclosures [7]. When an electromagnetic wave propagates through a material, some part of the wave is reflected and remaining gets transmitted through the material. The quality of shielding effectiveness (SE) can be measured with shielding co-efficient K_S, absorption co-efficient A and reflection co-efficient R using [2],

$$SE = Ks + A + R \tag{1}$$

Shielding co-efficient K_S is determined by the intensity of electric field strength E, possibly based on the intensity of the magnetic field H using [6]:

$$K_s = \frac{E_2}{E_1} \quad (2)$$

$$K_s = \frac{H_2}{H_1} \quad (3)$$

Frequency range also has an effect on the shielding effectiveness. According to [3-4] for the frequency range of 50 Hz to 20 MHz, SE is determined by the relation,

$$\mathrm{SE} = 20\log\frac{|\mathrm{H_1}|}{|\mathrm{H_2}|} = 20\log\frac{|\mathrm{V_1}|}{|\mathrm{V_2}|} \quad (4)$$

For the frequency range of 20 MHz to 100 GHz SE is determined by the relation,

$$\mathrm{SE} = 20\log\frac{|\mathrm{E_1}|}{|\mathrm{E_2}|} = 20\log\frac{|\mathrm{P_1}|}{|\mathrm{P_2}|} \quad (5)$$

Where E_1 and H_1 are the electric field intensity and magnetic field intensity at any point in the space where there are no shielding material, E_2 and H_2 are in the same place. V_2 is voltage reading within the enclosure, V_1 is voltage reading in the absence of the enclosure and P_2 is power detected within the enclosure, P_1 is power detected in absence of the enclosure.

According to [5] the E-field and H-field are related by the wave impedance using,

$$Z = \frac{|\mathrm{E_t}|}{|\mathrm{H_t}|} \quad (6)$$

Where E_t and H_t are total electric field intensity and total magnetic field intensity. The characteristics impedance is given by,

$$Z_0 = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}} \quad (7)$$

Where ω is the angular frequency, μ is the permeability, ε is the permittivity and σ is the conductivity of the medium. The SE for electric and magnetic fields can be given by,

$$SE = 20\,log\,\frac{|E_{inc}|}{|E_{tran}|} \quad (8)$$

$$SE = 20\,log\,\frac{|H_{inc}|}{|H_{tran}|} \quad (9)$$

Where E_{inc}, H_{inc} are the intensity of electric and magnetic field of the incident wave and E_{tran}, H_{tran} are the intensity of transmitted wave.

3. Objectives and formulation

The primary objective of this study is to predict the radiated emission due to the interference between electrical signal and data signal at higher operating frequencies. The SE is a measure of radiated emission. A sample automotive cable is taken for the analysis and its total radiated emission, SE in dB are analysed.

4. Cable modelling

A single turn cable of length 50cm is modelled along with a PCB with single trace as shown in Fig. 2 operating in the range of 30 MHz to 1 GHz frequency with a step size of 10 MHz. The analysis is done with 3D electromagnetic modelling software.

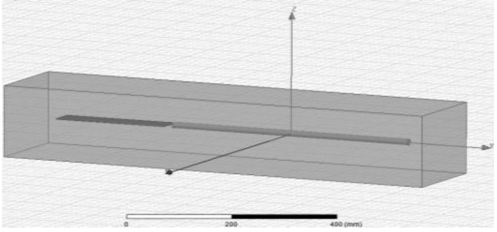

Fig. 2: Automotive cable model

5. Results and discussions

Fig. 3 shows the SE against the electromagnetic field in dB in the frequency range of 1 MHz to 1 GHz. There is a wide range of SE up to 18 dB. Fig. 4 shows SE in terms of Y-parameter. Table 1 shows the data values for S-parameter in dB. Fig. 5 gives the SE against electromagnetic field in terms of Z parameter which ranges between 15 dB to 60 dB. Fig. 6 shows the wide spectrum range between +20 dB and -70 dB in the frequency range of 1 MHz to 1 GHz. Fig. 7 shows the variation of radiated emission in 3D polar plot in mV. The change in the SE values gives the interference level in the mentioned frequency range. Fig. 8 shows the variation of radiated emission in dB. The variations in the emission values differ drastically even in the range 1 MHz to 1 GHz. It gets worse when the operating frequency range is in multiples of GHz.

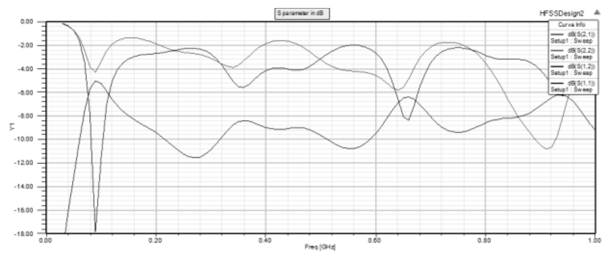

Fig. 3: SE in terms of S-parameter

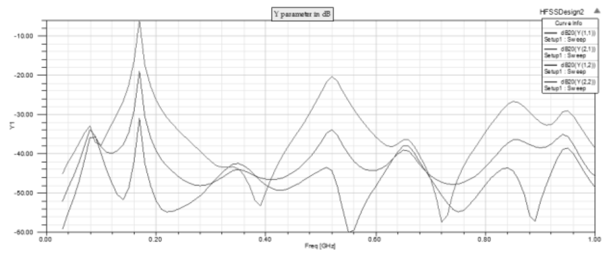

Fig. 4: SE in terms of Y-parameter

Table 1: SE data values in dB

Freq. [GH]	dB(S(1,1))	dB(S(1,2))	dB(S(2,2))
0.1	-11.45552	-5.251883	-3.400493
0.2	-2.706327	-9.424639	-1.906548
0.3	-2.751223	-10.86445	-3.117265
0.4	-4.154299	-8.981298	-1.881475
0.5	-3.140869	-9.663352	-3.265793
0.6	-2.674869	-9.50605	-4.594013
0.7	-3.494778	-8.099926	-2.14562
0.8	-2.875698	-8.591758	-3.523628
0.9	-4.115357	-7.12397	-10.49414
1	-2.892809	-9.25253	-2.30374

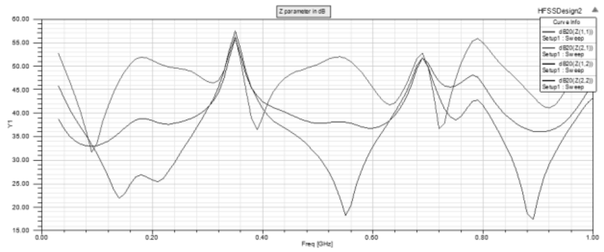

Fig. 5: SE in terms of Z parameter

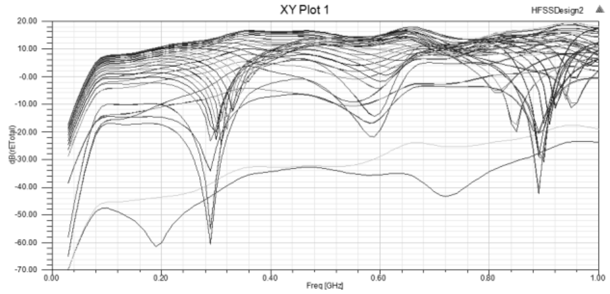

Fig. 6: Total radiated emission in dB

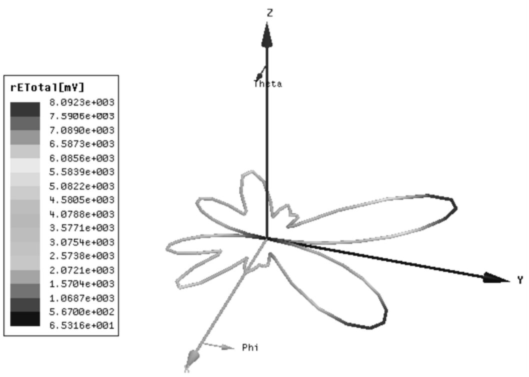

Fig. 7: Total radiated emission in mV

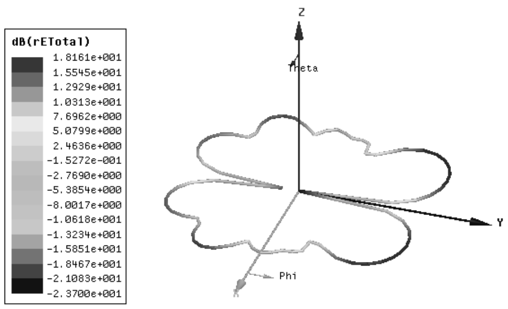

Fig. 8: Total radiated emission in dB

6. Conclusion

The shielding effectiveness against the electromagnetic radiation in automotive is a vital arena to ensure the proper functioning and good performance of the autonomous vehicles with Automatic Driver Assistance Systems (ADAS). The simulated results of the cable model clearly give us the effect of EMI with a frequency range of 1 MHz to 1GHz. As a future scope of this simulation, an automotive cable is to be tested and simulation results shall be validated with standard test procedures.

REFERENCES:

[1] A. Das and V.K. Kothari. 2009. Effect of various parameters on electromagnetic shielding effectiveness of textile fabrics, *Indian J. Fibre and Textile Research*, 34, 144-148.

[2] *IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures*. 2006. EMC Society, New York, 39.

[3] F. Paulis, M.H. Nisanci, A. Orlandi, M.Y. Koledintseve and J.L. Drewniak. 2014. Design of homogeneous and composite materials from shielding effectiveness specifications, *IEEE Trans. Electromagnetic Compatibility*, 56(2), 343-351. https://doi.org/10.1109/TEMC.2013.2280463.

[4] Possible effects of Electromagnetic Fields (EMF) on Human Health. 2007. *Scientific Committee on Emerging and Newly Identified Health Risks*.

[5] H.W. Ott. 2009. *Electromagnetic Compatibility Engg.*, John Wiley & Sons. https://doi.org/10.-1002/9780470508510.

[6] T. Nishimura, T. Nakamura, L. Quan, N. Amemiya, and Y. Itoh. 2014. Potential for torque density maximization of HTS induction/synchronous motor by use of superconducting reluctance torque, *IEEE Trans. Applied Superconductivity*, 24(3), 1-4. https://doi.org/10.1109/TASC.2013.2283238.

[7] S. Bhuvaneswari and S. Manivannan. 2015. Shielding effectiveness of enclosures - A Review, *Int. J. Applied Engg. Research*, 10(68), 428-430.