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Electromagnetic Analysis for Vehicle Antenna Development Using Method of Auxiliary Sources

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Abstract – In paper [1] the electromagnetic analysis of large semi-open structures like vehicles was presented formulated as scattering problem, illuminated by a wide range of incident EM fields. The effect of resonances within the semi-open structure on the RCS, near fields and pattern of re-radiated fields had been shown. In this paper the interaction of the entire semi-open structure on the performance of an antenna is considered together with the investigation of near field distributions inside the cavity. The Method of Auxiliary Sources (MAS) [2] is utilized. For a simple geometry the results are compared to measurements.

Introduction. Antennas are often placed in environments where their interaction with surrounding objects affects the overall performance. In some cases the position of objects in the vicinity is not stabile, further the object may have very special frequency characteristics, which substantially effects on the performance of the antenna. This is especially true in automotive applications where the car's body, cavity of the car with its strong resonant properties as well as other components of the vehicle influence on performance of the antenna. Therefore, it is important to consider interaction of all of these parts with the antenna and to solve this complex electrodynamics problem together. In [3] the electromagnetic coupling effects on an antenna in a simple common conducting cavity are studied theoretically and experimentally. "Experimentally it is observed that at the resonant frequencies of the cavity the input resistance of the antenna attains values two or three orders of magnitude higher than that at frequencies away from resonance. It is shown via theoretical analysis that the input resistance of the antenna measured at resonant frequencies of the cavity is not merely the loss resistance desired in computing the antenna efficiency, but is actually the sum of the loss resistance of the antenna and the coupling resistance between the antenna and cavity. This coupling effect is demonstrated quantitatively by numerical computations for dipole

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and monopole antennas". So, it is a prime concern for antenna designers to consider mutual interaction and the impact on functionality of the antennas resonant properties with the cavity of the vehicle. MAS allow solving such distributed, complex problems and also easy calculating near field, which helps to follow to antenna energy flow. Besides, the numerical calculation of near fields inside vehicles has two main practical applications: a) To assess human exposure to RF and microwave fields; b) predict electromagnetic compatibility (EMC) and interference (EMI).

Results of investigation. Performed work consists of several parts. In the first part, it was build 3-D resonant object with cavity like the cub box with some apertures see fig. 1. The box was made of square sheet copper of 11 * 11 inches (27.9 cm * 27.9 cm) in size. The size of the big aperture is 24 cm * 24 cm, as shown in figure. The size of the small open narrow cut is 3 cm * 20 cm, as shown in figure. The wire as antenna for excitation is 20 cm long, and 5 cm away from the body of the box, with a radius of 1.0 mm. located inside the box opposite to the big aperture and was excited with a coaxial port from outside of the box. The S11 has been measured using an HP 8753 network analyzer in a pretty wide range of frequencies. The same system of the cavity was simulated on the computer and appropriate results of simulation and measurements are presented in the fig. 2. A good comparison of measurement to simulation based on MAS algorithm software has been achieved. After validate results of numerical simulations, in contrast to smooth geometry in [1], new type of geometry of the car, like jeep, was investigated. With a vehicle antenna (see fig.3.) for the frequencies ranging from 0.1-1.GHz. was investigated. A numerical study of EMC/EMI problems related to the resonance enhancement of the EM field inside vehicles, its possible influence on the passengers and on the inner sensitive electronic devices is given.

The calculated resonance characteristics – integrated radar cross-section (IRCS) were obtained in a wide frequency range. The high values of re-radiated field on some frequencies correspond to the resonances of the car cavities. Density and values of re-radiated and standing wave fields on such resonances sharply increase at high frequencies. Investigations of some particular cases have been performed allowing tracking the process of eigen-field forming inside the cavity. The formation and creation of new directional lobs in the pattern at the point of resonance frequency of the cavity – appearance of new spectral component in a far field is given. So, the MAS methodology allows determining and analyzes the basic characteristics of the 3D cavity – eigen-field and eigne-values and estimating efficiency of the antenna at the same time. In fig.4 and fig. 5. we present result of calculation of the radiation pattern and resonant near field in case of ka is equal 20, where k is wave number and a is the radius of the circumscribed sphere. Consideration of the conducted ground surface is taken in the constructed algorithm also.

Conclusion.

In this article the enhanced electromagnetic field at resonance frequencies inside the vehicle model was investigated. Some analyses done how could create an undesirable influence on the passengers' health as well as on the sensitive electronic systems inside the vehicle.

A software package, having user friendly GUI has been developed, allowing easily perform changes in geometries of the objects, to construct complicate distributed structures an easy way and to solve the problems and analyze similar electrodynamics properties.

Acknowledgment.

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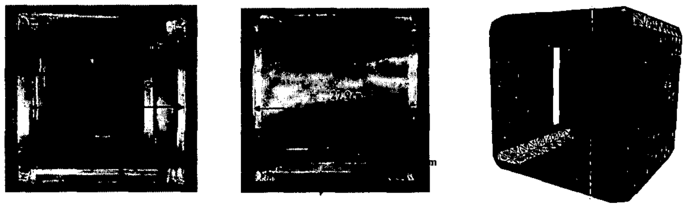
REFERENCES:

1. R. Zaridze, D. Kakulia, K. Tavzarashvili, G.Z. Chelidze, D. Pommerenke, K. Xiao. "Electromagnetic Analysis of the Large Semi Open Structures using Method of Auxiliary Sources". 2003 IEEE International Antennas and Propagation Symposium and USNC/CNC/URSI North American Radio Science Meeting, June 22-27, 2003, Columbus, OH, USA. IEEE Catalog #03CH37450C

2. R. Zaridze, G. Bit-Babik, K. Tavzarashvili, N. Uzunoglu, D. Economou. "Wave Field Singularity Aspects Large-Size Scatterers and Inverse Problems." IEEE Transactions on Antennas and Propagation, vol. 50, No. 1, January 2002, p. 50-58.

3. Y Huang, R. Narayanan, G. Kadambi, Electromagnetic Coupling Effects on the Cavity Measurement of Antenna Efficiency, IEEE Trans. on Antenna and Propagation, v.51, No.11, pp.3064-3071



a) b)

Fig. 1. a) Experimental model of the Open Cub; b) Computer model of the open Cub

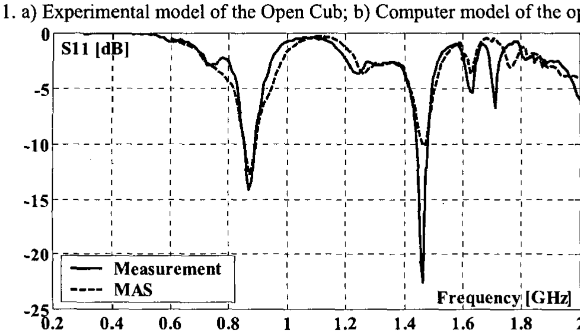
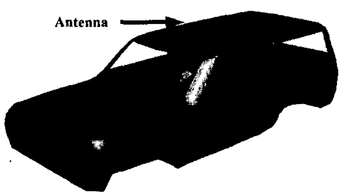


Fig.2. S11 of Open Cub



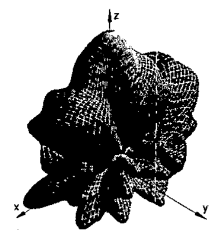


Fig. 3. The Simple Car model with Wire Antenna on Head.

Fig. 4. Radiation Pattern. ka = 20.

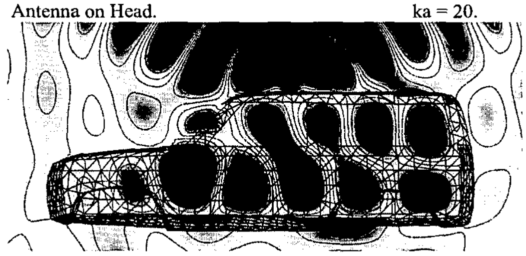


Fig.5 Ey Field Distribution in XOZ Slice. $ka = 20$.