EM Coupling to a Transmission Line Located Symmetrically inside a Cylinder

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***Abstract*—In this paper we outline an exact analytical solution for the current induced by an arbitrary exciting field in a loaded transmission line with symmetric geometry inside a cylindrical resonator.**

Keywords- cylindrical cavity, Green's function, transmission line

I. Introduction

Investigations of the coupling of high-frequency electromagnetic fields caused by intentional electromagnetic interferences to linear structures placed in cavity-like structures (racks, cases, housings, fuselage of aircraft, etc.) becomes an actual topic. Existing numerical methods (as MoM, TLM, etc.) allow considering specific cases only, but do not describe the general physical picture of interaction. Thus, the analytical description of the interaction of high-frequency fields with wire structures in cavities has become a topic of interest.

To solve this problem several methods can be offered. The approximate methods are based, as is usual in theoretical physics, on the use of small parameters. One group of such methods, Method of Small Antenna, uses the smallness of the dimension of the wiring structure in comparison to the wavelength [1]. Another small parameter that can be used to solve the coupling problem for long electrical objects inside a resonator is the thickness of the wire compared to other geometrical parameters of the problem (wavelength, height of the wire above ground, etc.) [2]. However, the approximate methods have some restrictions (dimension of the scatterer, accounting of a few resonator modes, etc.). It is of great interest to develop exact methods which can be used to check numerical codes, time – domain calculations using numerical inverse Fourier transforms, statistical investigations, etc. As usual in theoretical physics, an exact solution for the system "transmission line in resonator" can be found for systems with high symmetry, when the wire and cavity have the same symmetry. In our paper [3] a thin loaded wire inside a rectangular resonator was considered. The wire is led parallely to four walls of the resonator and connects two opposite ones. This system allows an exact analytical solution by spatial Fourier transformation for any kind of excitation. This method [3] is quite general and can be applied to symmetrical wires inside right cylinders of general form. The most practical case is the right circular cylinder, which has many practical applications in EMC, e.g., for electronic equipment in aircraft or other aerial vehicles.

II. Description of Obtained Results

In this paper we consider a wire, which is lead parallely to the cylindrical axis and connects both caps of the cylinder. Due to the same (transfer) symmetry of the wire and cavity in the z-direction, this configuration allows an exact analytical solution by a Fourier transformation for every kind of excitation (distributed, lumped) and with arbitrary loads. To do that a hybrid representation of the cylindrical cavity Green's function was used. Moreover, during the investigation of the exact equations for the induced current, one can separate the term, which corresponds to the transmission line approximation (TL) and then evaluate the effects of different resonances.

It was shown, that the analytical method demonstrates an excellent agreement of the results with those obtained by direct numerical calculations (PROTHEUS). At the same time, the TL approximation yields wrong results near cylinder resonances (see Fig.1).

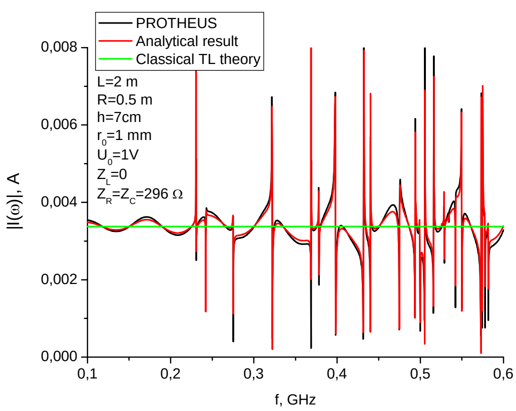

Figure 1: Current at the right matched terminal (Z_R=Z_C=296 Ω) induced in the symmetrical wire inside the cylinder by a lumped source U_0=1V at the left terminal. The length of the cylinder L=2m, the radius R=0.5 m, the distance between wire and wall of the cylinder h=7 cm.

References

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