Method of Modal Parameters for the Wire Segments with Symmetrical Geometry and the Regge Method

S.V. Tkachenko, F. Middelstaedt , M. Raya and R. Vick
Otto-von-Guericke University, Magdeburg, Germany
e-mail: sergey.tkachenko@ovgu.de

Abstract— By earlier developed Method of Modal Parameters (MoMP) we have shown that for the single and double wire segments with symmetrical geometry the response functions for lumped voltage excitation can be calculated with good accuracy using only diagonal elements of corresponding infinite modal matrices. This gives a possibility to apply the Regge method early used for the circular wire.

Keywords- thin wires; helix; common mode; differential mode; Regge theory

I. INTRODUCTION

Analytical methods for calculating the effect of EM fields on thin wires - the Method of Modal Parameters (MoMP) was developed earlier [1]. In this method the system of exact Mixed Potential Integral Equations (MPIE), describing induced current and potential along the line, can be reduced to matrix equations with modal parameters: infinite matrixes of inductance and capacitance. These parameter matrixes are calculated by Fourier transformation of the kernels of the first and the second of MPIE, correspondingly. The solution of this system with further inverse Fourier transformation yields induced current and potentials. For the finite system of wires with symmetrical geometry - circular wire and its symmetrical combinations all modal parameter matrix become diagonal and the solution is reduced to a single sum. This gives a possibility to consider an excitation of such systems [3] by a lumped voltage source using so named Regge method.

II. RESULTS

In this work, we consider single and double finite wires with symmetrical geometry: straight wire, circular wire and helix wire, which are important for EMC practice. For such geometries corresponding MPIE systems are reduced to the separate uncoupled MPIE for differential and common current modes. For each mode we have solved these equations by the MoMP. Due to the fact, that the kernels of the MPIE for such systems of wires depend on the difference of arguments, during the calculation of corresponding matrix elements one can carried out a single integration instead of double one in the general case of arbitrary wires, which essentially reduce time of calculation. Moreover, we have found that to describe the current induced by a lumped voltage source in these thin symmetrical wires, it is sufficient to take into account only the diagonal terms of the corresponding matrices of modal parameters, i.e., the solution is approximately reduced to a single summation, as in the case of a circular wire (see Fig. 2). This circumstance gives a possibility to apply Regge method [2] for the summation of the series. In this method, the summation index m is considered as a complex variable and the Fourier series is represented as an integral

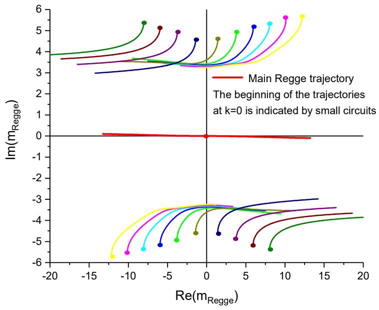

Figure 1. Regge trajectories $m_\alpha(k)$,for the differential current mode in straight wire pair, 0≤k≤4.1, a=1mm,L=10m and d=1m.

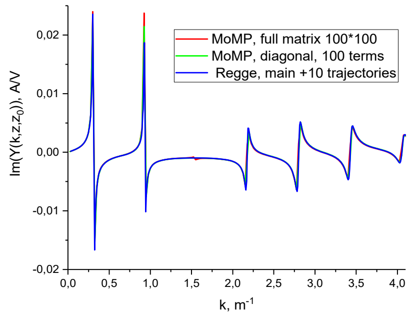

Figure 2. Comparison of the admittance functions obtained by the full matrix MoMP, the MoMP diagonal terms and by the Regge method. The source is at z_0=4m and receiver is at z=5 m

in the complex plane of the parameter m. The integral is defined by the zeros of the diagonal modal impedance per-unit length in the complex plane of the parameter m, which zeros define the so called Regge poles. The positions of the poles on the complex plane depend on the frequency and form so called Regge trajectories (see Fig.1). Our approach reduced summation over m, which require several hundred terms, to summation over Regges poles, which requires about ten terms (see Fig.2).

REFERENCES

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