Studying Oscillations Caused by a Current Surge via Evolutionary Approach to Electromagnetics

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This study is related with the problem of protection of electronic systems from the current and voltage surges. Various natural phenomena like lightning, electrostatic discharge, breakdown effects in appliances, switching, can be the reason for such surges. The surges, inevitably accompanied by onset of electromagnetic waveforms, are able to entail dangerous failure of microwave appliances, navigation and defense systems, communication networks, modern medical equipments, computers, and so on. Furthermore, nowadays it is also possible to develop effective ultra-wide band pulse generators in a very small volume which can be used as a tool for electromagnetic terrorism. The classical time-harmonic field approach meet essential difficulties in solving these problems.

In this tutorial lecture, a layout of the *evolutionary approach to electromagnetics (EAE)* will be presented. Recently, the *EAE* was recognized as an alternative to the classical time-harmonic field method [1]. To begin with, we discuss the layout of the *EAE* and consider then which class of new problems that can cover, which are inaccessible to the time-harmonic analysis. The layout is organized as follows.

1) Statement of the problem involves the following positions. (i) Maxwell's equations **with time derivative** and a given **time-dependent external force.** (ii) **Causality principle.** (iii) **Initial conditions.** (iv) The boundary conditions. (v) Finite energy condition, which specifies the space of solutions.
2) (i) Introduction of a six-component "electromagnetic" vector. (ii) Extraction of a self-adjoint operator from Maxwell's equations. (ii) Derivation of the operator eigenvalue equation.
3) Modal Basis problem for a cylindrical cavity involves the following positions. (i) Definition of two subspaces of the solenoidal TE and TM normalized modal fields. (ii) Definition of **two subspaces** of the **irrotational** normalized modal fields of the "electric" and "magnetic" kinds. (iii) Completeness of the Modal Basis by the Weyl Theorem.
4) (i) Projecting the fields sought for onto the basis yields the modal field expansion with the time-dependent amplitudes yet to be known. (ii) Projecting Maxwell's equations and the initial conditions yields the Cauchy problems for the modal amplitudes. (iii) Analytical and graphical examples for the solenoidal and the irrotaional modes.
5) Extensions of the EAE are possible in the following directions: (i) Maxwell's equations **with time derivative** can be supplemented with the **motion equation** for the **Lorentz** dispersive media. (ii) Maxwell's equations **with time derivative** can be supplemented with **motion equation** for the **Debye** dispersive media. (iii) Maxwell's equations **with time derivative** can be supplemented with **motion equation** corresponding to **dynamic Ohm's law.**

Implementation of the EAE for the cavity problem is given in the following publications [2]-[6].

References

[1] O. A. Tretyakov, F. Erden, "Evolutionary Approach to Electromagnetics as an Alternative to the Time-Harmonic Field Method," 2012 IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting, July 8-14, 2012, Chicago, IL, USA, IEEE Catalog Number: CFP12APS-CDR, ISBN: 978-1-4673-0460-3; ISSN: 1522-3965, http://bit.ly/TFzLj7.

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[6] F. Erden, O. A. Tretyakov, "Analytical Approach for Studying a Time-Domain Cavity Problem," 2014 IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting, July 6-11, 2014, Memphis, TN, USA, 978-1-4799-3540-6/14.

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