Seminar on

A Critical Look at the Characteristic Mode Analysis for the Design and Pattern Synthesis of Antennas mounted on Complex Platforms

by

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Abstract

In this work, we take a critical look at two practical antenna problems: (i) designing an antenna to provide the performance specified by the user; (ii) synthesizing the radiation pattern of a plurality of antennas mounted on a complex platform.

Despite its long history, and countless publications on antenna analysis and design that have flooded the literature over several decades, practical design of antennas to meet the specifications desired by the user remains a challenging task when the antenna is to operate in a complex environment, also specified by the user, e.g., a UAV, an army vehicle, the topside of a ship, or the ubiquitous mobile phone. The problem becomes even more challenging when a plurality of antennas share the platform and their composite radiation pattern is specified. Recently, the Characteristic Mode Analysis (CMA) has been proposed as an attractive approach for addressing the problems mentioned above. The first step in the CMA analysis is to solve an eigenvalue equation, derived from the MoM matrix, to derive the characteristic modes (CMs) that are the eigenmodes of the above equation, together with the corresponding eigenvalues, which serve to determine the importance of these modes at a given operating frequency. The designer then attempts to select one or more these modes to attempt to meet the user specifications, which typically include the return loss, bandwidth, desired pattern, polarization characteristics of the antenna, etc. There is one important missing link that is encountered when following this CMA-based process, however. A majority of these antenna characteristics squarely depend upon the exciter of the platform; and yet, the CM's being source-free solutions do not include any information on the excitation. We show in this paper that despite the claims to the contrary in the existing literature, the correct way to excite a CM is not always to place a source at a location where the CM current distribution is maximum; furthermore, a concentrated source, e.g., a probe feed, a dipole (or monopole), or a PIFA, frequently used to excite a platform of the type mentioned above, cannot launch a CM, except for the trivial case of thin wires, and then too only approximately.

Given this background, we propose a modification of the classical CMA, in which we deal directly with 'source-based' characteristic functions, called CBs (characteristic bases), derived directly from the original MoM equation, $Z\,I = V$, as opposed to the source-free eigenvalue (modal) equation $X\,I = \lambda\,R\,I$, which is a derivative of the MoM equation used to construct the CMs. The paper then goes on to present several practical examples of antenna design based on the CB approach, including: (i) CP antenna with wide S_{11} and AR bandwidths; (ii) multiple MPAs on a PEC ground plane; (iii) a multi-element GPS antenna system for interference suppression; and (iv) a top-loaded monopole mounted on the topside of a ship. Difficulties encountered in designing these antennas using the traditional CM approach are pointed out to support of the argument that the CB approach should be favored over the CM approach for these practical antenna design problems.

Biography

Raj Mittra is a Professor in the Department of Electrical Engineering & Computer Science department of the University of Central Florida in Orlando, FL., where he is the Director of the Electromagnetic Communication Laboratory. Prior to joining the University of Central Florida, he worked at Penn State as a Professor in the Electrical and Computer Engineering from 1996 through June, 2015. He was a Professor in the Electrical and Computer Engineering at the University of Illinois in Urbana Champaign from 1957 through 1996, when he moved to the Penn State University. Currently, he also holds the position of Hi-Ci Professor at King Abdulaziz University in Saudi Arabia. He is a Life Fellow of the IEEE, a Past-President of AP-S, and he has served as the Editor of the Transactions of the Antennas and Propagation Society. He won the Guggenheim Fellowship Award in 1965, the IEEE Centennial Medal in 1984, and the IEEE Millennium medal in 2000. Other honors include the IEEE/AP-S Distinguished Achievement Award in 2002, the Chen-To Tai Education Award in 2004 and the IEEE Electromagnetics Award in 2006, and the IEEE James H. Mulligan Award in 2011.

Recently he founded the e-Journal FERMAT (www.e-fermat.org) and has been serving as the co-editor-in-chief of the same. Dr. Mittra is a Principal Scientist and President of RM Associates, a consulting company founded in 1980, which provides services to industrial and governmental organizations, both in the U.S. and abroad.

***** ALL ARE WELCOME *****

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