Design of OmniDirectional Electrically Small Vee-shaped Antenna Using Characteristic Modes

Khaled A. Obeidat, Bryan D. Raines, and Roberto G. Rojas
ElectroScience Laboratory, Dept. Electrical and Computer Eng.
The Ohio State University,
1320 Kinnear Rd., Columbus, OH 43212, USA
obeidatk@ece.osu.edu, rainesb@ece.osu.edu, rojas-teran.1@osu.edu

Center-fed Vee Antennas usually radiate a beam that is generated by the first current mode as shown in Figure 1. However, there are applications with conformal antennas where the goal is to excite an electric dipole-type pattern (ommidirectional) with its null along the vertical axis. This implies that Mode 2 of this antenna needs to be excited. To achieve the desired pattern and polarization, the antenna should be excited at two locations with two out of phase sources such that each source is located on one of the arms. The Theory of Characteristic Modes (CM) will be used to analyze the antenna modes and consequently synthesis the required current by proper excitation of the required current modes. Another important restriction with this antenna is that it is considered to be electrically small but it must operate in a frequency range that is as wide as possible. Recall that electrically small antennas are narrowband.

The theory of CM was explored first by Garbacz and Turpin (R. J. Garbacz and R. H. Turpin, AP-19, pp. 348-358, May 1971) and later by Harrington, et al. (R.F. Harrington and J.R. Mautz, AP-21, 2, 188-199, 1973). The CM of the antenna can be used to express the total current as a superposition of orthogonal current modes which depend on the shape and size of the Antenna and are independent of the feeding. Using CM theory the first dominant three modes on the Vee wire antenna are shown in Figure 1. Mode 2 is the desired mode because each arm has the same current magnitude but with opposite direction. Thus two out of phase sources at each arm must be used to eliminate the even modes (modes 1 and 3) and excite the dominant odd mode (mode 2).

Several geometries of the Vee-antenna will be presented to identify the configurations that can achieve the largest frequency of operation. For electrically small antennas, matching networks are usually necessary; however, some antennas can be easier to match than others. This issue will also be discussed.

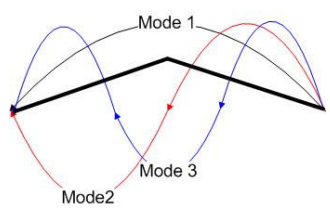

Figure 1: Vee Antenna's first three dominant modes