The Broadband Quadrifilar Helical Antenna

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The quadrifilar helical antenna (QHA) has become increasingly popular in satellite based communication systems because of its ability to produce high gain and excellent circular polarization over wide beam angles. In this paper, the determinantal equation for the infinite tape QHA is reported, and used to analyze the QHA for its complete Brillouin, $(k-\beta)$, diagrams. We show that a QHA has four determinantal equations and four distinct $k-\beta$ diagrams. Each $k-\beta$ diagram is associated with a particular sequence mode, and each sequence mode is associated with a particular excitation. Of the four QHA sequence modes, we focus our attention on the two modes that produce circularly polarized radiated waves. Two basic radiation modes are exposed; a scanning mode and a fixed forward end-fire mode. These modes are similar in nature to Klock's (P. Klock: "A Study of Wave Propagation on Helices," Thesis, University of Illinois, March 1963.) unifilar modes. The effects of varying tape width, pitch angle and frequency are studied. A QHA model based on antenna array theory is developed, and used to investigate radiation patterns as well as operating bandwidth for each mode. One of the $\overline{k}-\beta$ diagrams for the QHA is shown below. The normalized wavenumber $\overline{k} = \frac{2\pi a}{cot\psi}k$, where a and ψ are the radius and pitch angle, respectively. Our first observation is that, for a given $\overline{k}$, it is possible to have two values of β. There are in fact many more β's for a given $\overline{k}$, but some have been ruled out because of their non-physical nature. Mode 1, labeled with $*$, is the so called scanning mode; Mode 2, labeled with o, is the fixed forward end-fire mode. These modes are very similar to those described by Klock.