CHARACTERISTICS OF A TRIPOLE ANTENNA OVER A LARGE GROUND PLANE

Edward K N Yung and C L Law
Department of Electronic Engineering
City Polytechnic of Hong Kong
Kowloon, Hong Kong

Ever since the WARC'77 Convention on direct broadcast satellite (DBS) systems was held in 1977, several experimental DBS systems have been successfully launched in various parts of the world. In the convention, it was recognized that for a commercially viable system, the EIRP of its satellite must be substantially increased from current standards. Thus, TV programs broadcasted directly from a satellite could be received by a low gain antenna at an ordinary household. Furthermore, circularly polarized waves were recommended for the broadcast in the K_u-band. Hitherto, most effort has been expended on the development of satellite bound antennas. Progress in the development of simple, small, robust, and low cost antennas for the reception of circularly polarized waves is slow. Study of a tapered helix as a feed in a S-band antenna has been reported [1]. Use of Archimedean spiral antennas has also been contemplated [2]. However, neither of them are sufficiently robust and low cost as a consumer product. In fact, an extremely robust and inexpensive antenna for circularly polarized waves is available but often overlooked. The said antenna is the tripole antenna [3]. On the one hand, the tripole antenna with a ground plane is a self-contained receiving antenna. On the other hand, it could be utilized as a feed in parabolic reflectors.

A tripole antenna is made of three identical wires of length h, and of radius a. These wires are connected together at a common point to form a symmetrical three-point-star as shown in Figure 1. For convenience, one of the wires is chosen as the reference wire. Thus, the other two wires are oriented at angles of ±120°, with respect to the reference. These wires are fed by three sources of equal amplitude placed at a point g from the center. Relative to the source on the reference wire, the phases of the other sources are ±120°. The tripole is placed parallel to and at a distance d above a large ground plane.

An integro-differential equation has been developed for finding the current distribution on the tripole antenna. As the wires are oriented at an angle of ±120° from one another, the couplings between them would be much stronger than orthogonal wires. To better account for the strong couplings, both of the magnetic vector potential and the electric scalar potential are used explicitly. Moreover, in order to evaluate the junction effects accurately, the equation is derived by enforcing that the tangential electric field is zero on the cylindrical surface of the wires.

In the present study, a tripole of a=1.25mm, h=50mm, g=18.75mm, and d=18.75mm, operating at 12GHz is chosen as the representative antenna. An electrically long (2λ) antenna is chosen because short tripoles are not practical in the K_u-band. For the representative tripole, the current distribution on the reference wire is sketched in Figure 2. The current distribution is similar to a simple dipole. It is observed that the slope of the current at the junction is always zero because there is no charge accumulation there.

The variation in the input admittances of the representative tripole with respect to the change in its driving point is plotted in Figure 3. In line with the results obtained in [4], the input admittance is extremely sensitive to the location of the driving point. On the other hand, if the driving point is fixed at g=18.75mm, the variation in the input admittance relative the length of the wire is sketched in Figure 4. It is anticipated that the above phenomena could be utilized to design a tripole with extendable wires and movable driving points such that impedance matching by consumers is possible.

The radiation patterns in both principal planes are identical because of the symmetry of the configuration. The directivity of a tripole with a ground plane is approximately 3dB better than that of a dipole. A tripole with its relatively wide beamwidth can be used as an inexpensive feed in a reflector antenna. Although a self-contained tripole may be good enough to pick up a telephone conversation in a satellite based mobile phone system, it is not adequate to receive a TV signal in a DBS system. To improve the overall gain of a tripole, parasitic elements must be added.

REFERENCES

1 V K Lakshmeesha, L Nicholas, V Mahadevan, and S Pal, "S-Band Shaped Beam Antenna For Indian Remote Sensing Satellite - IRS," IEEE AP-S Symposium, Vancouver, 1985, pp.629-632.

2 H Nakano, K Nogami, and J Yamauchi, "Numerical Analysis of Spiral Antenna Backed By A Reflector," IEEE AP-S Symposium, Vancouver, 1985, pp.237-276.

3 D Kajfez and M G Harrington, "Impedance Measurements on the Tripole Antenna," Proceedings of IEEE Region III Convention, Huntsville, Ala., Dec. 1969, p.404.

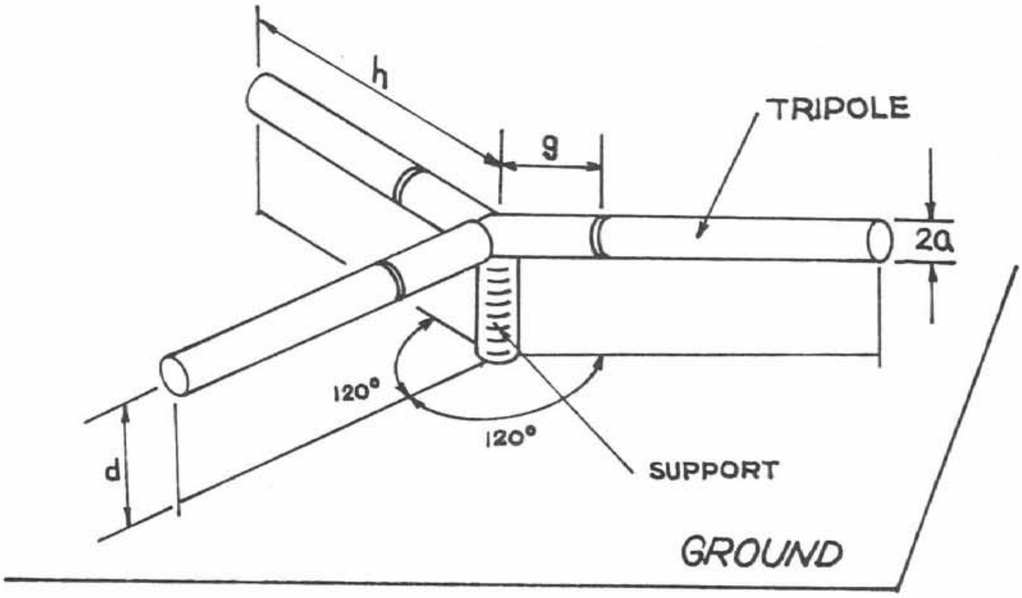

Figure 1 A Tripole Antenna Over a Large Ground Plane.

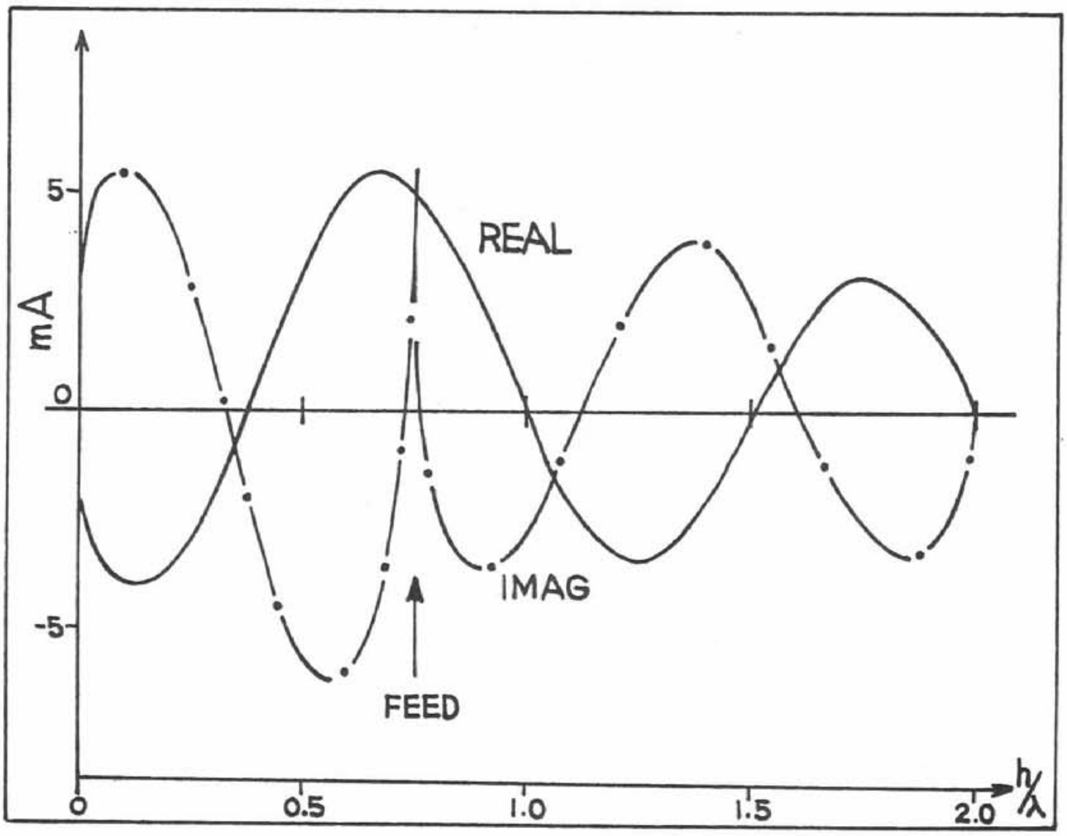

Figure 2 Current Distribution on the Representative Tripole.

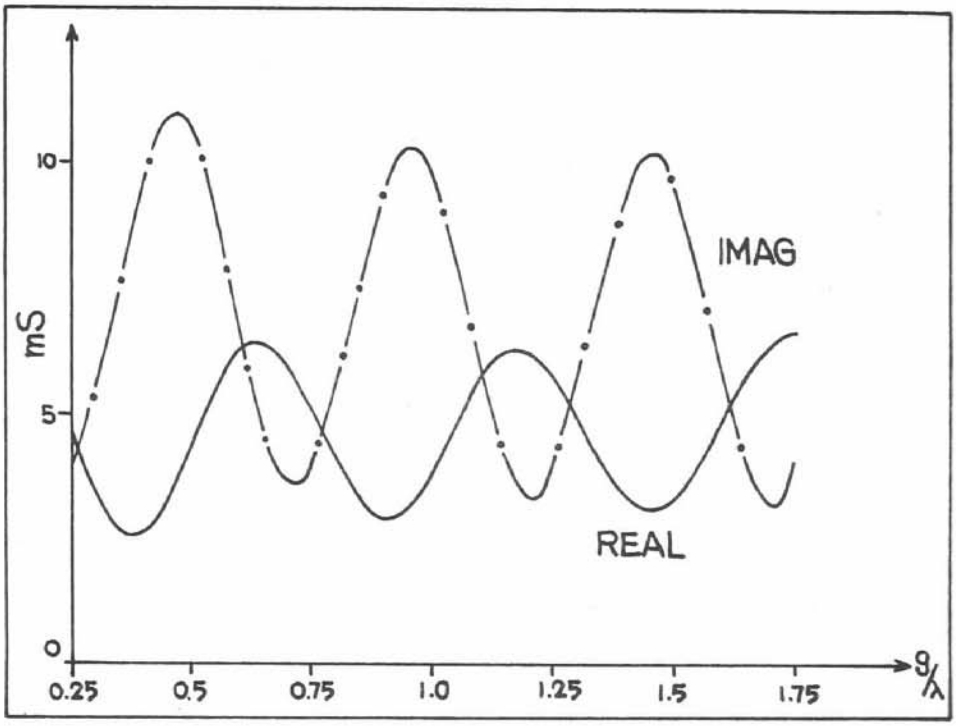

Figure 3 Variations of the Input Admittance of a Typical Tripole With Respect to Its Driving Point.

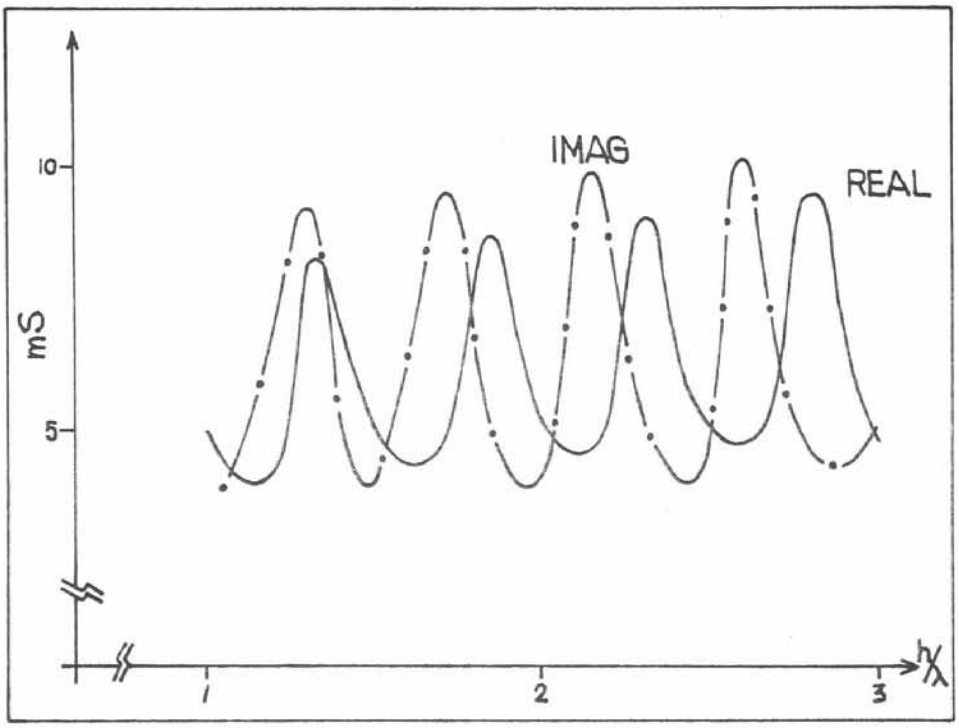

Figure 4 Input Admittances of the Representative Tripole Relative to the Variation of Its Length.