2-11 D2

USEFUL SLOT-UNIPOLE ANTENNA SYSTEMS

Kiyohiko Itoh
Faculty of Engineering, Hokkaido University, Sapporo, Japan

and

David K. Cheng
Electrical Engineering Dept., Syracuse University, Syracuse, N. Y., U.S.A.

It is well known that unipole and slot antennas can be used to detect electric and magnetic fields respectively. An antenna system comprising a suitable arrangement of these two types of antennas can therefore be expected to yield characteristics which would not be attainable if either type is used alone. This paper discusses the principles of operation and applications of two slot-unipole antenna systems. The antenna itself consists of a monopole and two slots mutually perpendicular to one another. It will be shown that, together with a suitable processing circuitry, the antenna can be made (1) to serve as a receptor of electromagnetic energy density, or (2) to yield a cardioid pattern with an adjustable null location. Both of these two features have important practical applications.

An energy-density antenna is an antenna which samples the electromagnetic energy density, that is, $(\varepsilon|E|^2 + \mu|H|^2)/2$. In a situation where electric field may fade due to the existence of standing waves, an energy-density antenna will yield an essentially constant signal level. This is particularly desirable for a mobile radio system. A monopole-loop antenna combination has been proposed previously[1] for this purpose. The slot-unipole arrangement to be discussed in this paper, in comparison, has several advantages. First, a slot antenna can be matched easily by an off-set feeder line. Second, a slot antenna is more suitable for installation in high-speed vehicles such as aircrafts and rockets. Third, the coupling between a slot antenna and a unipole antenna is extremely small so that the system pattern characteristics can be obtained easily by simple superposition. The pattern characteristics of the slot-unipole energy-density antenna system will be analyzed.

When the diameter of a quarter-wavelength unipole equals one-half of the slot width, the unipole and slot antennas have the same frequency bandwidth and the same impedance characteristics. For an incoming plane wave polarized in the direction of the unipole which is perpendicular to the crossed slots, the system output can be shown to be

$$E_{out} = \frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}$$

$$+ A\sin\phi\,\frac{\cos(\frac{\pi}{2}\sin\theta\cos\phi)}{1-\sin^2\theta\cos^2\phi}$$

$$- B\cos\phi\,\frac{\cos(\frac{\pi}{2}\sin\theta\sin\phi)}{1-\sin^2\theta\sin^2\phi},$$

where A and B are complex quantities denoting attenuations as well as phase shifts in the circuitry following the two slot antennas. Suitable choices of the quantities A and B will yield a cardioid-shaped pattern with a null in any desired direction. Patterns and other numerical data will be presented.

---

[1] W.C.-Y. Lee, Bell System Technical Journal, p. 976, February 1967.