Broadband Small-Aperture Direction Finding Array with Azimuth and Elevation Estimation Capability

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In this paper, we present a broadband, electrically-small antenna array capable of estimating the elevation and azimuth angles of the incident electromagnetic wave, and immune to the angle-of-arrival (AoA) estimation error caused by the cross polarization of the incident wave. Electrically-small direction-finding (DF) arrays consisting of a few antenna elements are widely used in HF and VHF applications. In this frequency range, as the wavelength of electromagnetic waves is large, practical arrays are usually electrically-small. However, the compact size strongly limits the antennas bandwidth and the array's DF capability and accuracy. Typically, electrically-small DF arrays are composed of a few antenna elements which are either dipoles or loops. Therefore, to design the proposed DF array, we first qualitatively examine different array topologies and select the candidates that potentially provide the desired DF capability. Then, among these candidates, we select the array topology that demonstrates the lowest Cramer-Rao bound (CRB). Finally, we optimize this adopted array topology by using computer simulations for efficient utilization of the volume with dimensions of 14 cm $\times$ 14 cm $\times$ 5.5 cm. The DF performance is characterized by calculating the CRB with simulated and measured radiation patterns over a wide frequency range from 30 MHz to 2000 MHz. Moreover, at a number of discrete frequencies within this band, we perform a series of outdoor DF field tests with the fabricated prototype at azimuth AoAs every 15° over 0°–90° and three different elevation AoAs. The measurement results show very good agreement with simulations, and validate the proposed DF capability and the expected accuracy level predicted by CRB.

In the presentation, we will detail the topology selection process where we will discuss the way that we incorporate DF considerations (e.g., CRB, elevation and azimuth AoAs estimation, AoA estimation caused by cross polarization of incident waves, and near zenith coverage) into compact antenna array design. Moreover, we will cover the antenna element design process. Furthermore, we will compare the simulated and measured scattering parameters and radiation patterns, as well as the corresponding CRB patterns. Finally, we will report the setups and the results of the outdoor DF field tests.