Design of a Reconfigurable, Platform-Based HF Direction Finding System Using the Characteristic Mode Theory

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Most practical antennas tend to have electrically-small dimensions at the high-frequency (HF) band in the 3-30 MHz range due to the large wavelength of electromagnetic waves, which range from 100 m at the lower end of the band to 10 m at the upper end. Such electrically-small antennas usually suffer from narrow bandwidth and low radiation efficiencies. In direction finding (DF) applications, the problem is exacerbated by the need for using more than one element in the array. These elements are usually needed to be spatially separated by a reasonably large fraction of the wavelength to achieve high DF accuracy. In many applications, however, HF antennas are usually mounted on some vehicular platform. Therefore, the presence of the platform may be exploited to alleviate some of the challenges associated with bandwidth and efficiency of electrically-small, platform-mounted HF antennas.

In this paper, we present the design of a platform-based, reconfigurable HF direction finding system. The proposed system consists of a series of platform-based electrically-small coupling elements designed to operate on a mid-size aircraft using the characteristic-mode theory. In this design, the airborne platform having different significant characteristic modes is used as the main radiator and the antennas mounted at different locations on the platform are used to excite a given mode or a combination of different characteristic modes of the platform. A main premise of this work is that the system used for DF in conjunction with this array has a limited number of coherent receiver channels (i.e., four in this specific example). Therefore, when the array has more than four elements, the system needs to select a subset of the available elements to perform DF. We will demonstrate that in this operating situation, the CM combination that offers the best DF accuracy is different at different frequencies within the HF band or for different fields of views at the same operating frequency in the HF band. Thus, to enhance the accuracy of the DF system over the entire HF band, a reconfigurable DF system may be employed. We will discuss the design of the proposed reconfigurable direction finding system and present simulation and measurement results of a scaled-model prototype fabricated to demonstrate the validity of the underlying hypotheses.