Design of Dual-Polarized, Platform-Based HF Antennas for NVIS Applications Using the Characteristic Mode Theory

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There is a growing interest in high-frequency (HF) communications links with more than 24 KHz bandwidth to achieve robust, non-line-of-sight, and high data rate transmission over the 3-30 MHz range. Most practical antennas tend to have electrically-small dimensions in the HF band 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 bandwidths and low radiation efficiencies, especially at the lower end of the band. In many applications, however, HF antennas are usually mounted on some vehicular platforms. Therefore, the presence of the platform may be utilized to improve the bandwidth and efficiency of electrically-small, platform-based HF antennas.

In this paper, we present the design of a dual-polarized, platform-based HF antenna for near vertical incidence skywave (NVIS) applications operating over the lower end of the HF band from 3 to 10 MHz. The proposed antenna consists of several platform-based electrically-small coupling elements (CEs) designed to operate on an Amphibious Assault Vehicle (AAV) using the characteristic-mode theory. In this design, AAV is used as the main radiator and the antennas mounted at different locations on the platform are used to excite the two horizontally polarized characteristic modes of the platform. The antennas are designed to achieve dual polarization operation and have a high isolation. Simulations are performed by considering the presence of realistic ground and using commercially available lumped elements for the external impedance matching networks of the antennas. The power handling is considered in choosing the impedance matching network elements. Due to the loss in the ground and lumped elements, the high isolation level between two horizonal modes and 24 KHz bandwidth can be achieved at 3 MHz without adding any external resistors and external decoupling, where the realized gain is approximately -20 dBi. To achieve a higher realized gain (larger than -20 dBi) while maintaining the 24 KHz bandwidth at 3 MHz, the CEs designed with the need for using low inductance values were considered. To satisfy the 24 kHz bandwidth at 3 MHz with an optimum realized gain, these factors were considered: 1) The quality factor (Q) for coupling elements; 2) Q for external impedance matching; 3) Natural losses from both realistic ground and external impedance matching and their effects on bandwidth; 4) Decoupling level between two horizonal modes; and 4) Power handling and its effect on the choice of elements for the external impedance matching. We will present simulation and measurement results of a scaled-model prototype fabricated to demonstrate the design of the dual-polarized, platform-based antenna for NVIS applications.