A Platform-Based, Small-Aperture Bandwidth Enhanced Direction Finding System for an Unmanned Ground Vehicle

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Precise direction of arrival (DoA) estimation of an electromagnetic wave has many commercial and military applications including collaborative localization of autonomous agents and tracking of dismounted soldiers. In many HF/VHF direction-finding systems, antennas are mounted on vehicular platforms and the platform is a part of the antenna, whether intentional or not. Recently, various research groups have investigated platform-mounted antennas and proposed different techniques that exploit the presence of the large metallic platform to enhance the performance of such antennas. In one approach (T.-Y. Shih and N. Behdad, IEEE Trans. Ant. Propag., 64, 2648-2659, 2016), the natural resonant modes of the platform were excited using electrically-small antennas to improve the overall bandwidth of an otherwise narrowband HF antenna. However, in this and most previous platform-based antennas, the underlying platform was an electrically large structure at the frequency of operation.

In this work, we investigate the applicability of this concept for platform-based antennas that operate on electrically-small platforms such as small unmanned ground vehicles (UGVs) operating at the VHF band. Specifically, we report the design of platform-based antennas operating at the lower end of the VHF band for a small UGV ($0.13*\lambda$ x $0.09*\lambda$ x $0.05*\lambda$ at 40 MHz). We use the characteristic mode theory (CMT) to evaluate the performance of two different antennas designed for operation on this platform. Using CMT, performance metrics of the antennas including the maximum antenna bandwidth and its radiation characteristics can be investigated. Both antennas are designed to generate vertically-polarized, monopole-like radiation patterns. The performances of these antennas when operating in a realistic operational environment are simulated using numerical simulations in FEKO. We also investigate the use of the radiating elements as part of a two-element, small-aperture direction finding system designed for operation at the VHF frequency band. Due to the small-spacing between the two antennas and the significant coupling between them through the platform, these two elements are used in conjunction with an external coupling network. The coupling network is used to both decouple the antennas from each other and create enhanced contrast between the amplitudes and phases of the two output signals. The direction finding performance of this small-aperture antenna array is evaluated by examining the Cramer-Rao lower bound (CRLB) of the array over the entire frequency range of operation with and without the coupling network. The simulation and preliminary measurement results of this system will be presented and discussed at the symposium.