

Low-Profile Vertically-Polarized Omnidirectional Antennas for V2X Communications

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Abstract

For many such wireless systems as vehicle-to-everything (V2X) communication, vertically-polarized omnidirectional antennas are desired for the full coverage over the horizontal plane. For these applications, monopole antenna and its variations are the primary choices. The height of the state-of-the-art monopole based antenna is still too high for many applications. The main objective of this study is to innovate new low-profile vertically-polarized omnidirectional antenna designs with wider bandwidth and higher gain for better V2X communications. Based on literature survey, circular patch antenna (CPA) and monocone antenna are two popular and promising candidates for this study. Therefore, much of the study is devoted to the innovative designs based on these two antenna types.

The first design is a low-profile circular-patch antenna with over 3 dB gain enhancement in the horizontal plane for the emerging DSRC (Dedicated Short Range Communications) application. To further increase the omni-directional gain in the horizontal plane, six groups of magnetic dipole-like resonators are introduced around a shorted circular patch-ring antenna. These resonators help to guide the wave along the horizontal surface. In addition, the number of resonators in each group can be adjusted to control radiation patterns in the horizontal plane.

The second design is a wideband circular patch antenna with omni-directional gain enhancement in the horizontal plane. The gain enhancement over 1 GHz bandwidth is achieved by introducing low-profile I-shaped loading structures without increasing the thickness of antennas. The effective refractive index of the new structure is larger than that of conventional substrate with same material, therefore the new structure behaves as a lens to concentrate the energy and enhance the omni-directional radiation performance. In addition, the proposed antenna design can achieve a fractional bandwidth of 19% by combining the multiple resonant frequencies of the antenna structures.

The third design is an ultrawideband low-profile monocone antenna with dielectric loading. The operating modes of the proposed antenna are different from those of conventional monocone antenna while similar to those of the circular patch antenna. The first mode is studied with the aid of the epsilon-negative transmission line. To further improve the matching properties of the monocone antenna, an innovative dielectric structure is introduced. The dielectric loading can effectively change the impedance of the monocone antenna and provide additional freedom for increasing the fractional bandwidth.

In summary, three new low-profile vertically-polarized omnidirectional antenna designs are presented in the thesis with theoretical study, computer-aided design and optimization, prototype fabrication, measurement verification, and analysis study. The thesis is concluded by pointing out a few recommendations for future investigations.