Frequency Bandwidth Adjustment of Dual-Polarized Four-Arm Archimedean Spiral Antennas

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In center-fed four-arm Archimedean spiral antennas, broadside radiation patterns with dual-polarized operations in both senses of circular polarization can be realized by confining the spiral circumference to less than three wavelengths. Such antennas with orthogonal circularly polarized waves are excellent candidates for frequency reuse applications, such as multimode Global Positioning Systems (GPS), modern satellite navigation, and radar systems. These dual-polarized antennas improve the wireless channel capacities with higher bit-rate capabilities. A compact, unidirectional, and air-filled structure of the four-arm Archimedean spiral antenna has been proposed by the authors in [1], where both right- and left-handed circularly polarized waves are produced over a respectable frequency band. As it is known, inserting dielectric materials into an antenna structure is widely used to miniaturize the antenna structure, as it leads to an increased electrical path length [2]. Generally, high-contrast substrates are needed in order for a significant reduction in the antenna size. However, the associated dielectric loss becomes particularly troublesome, which deteriorates the antenna efficiency performance. Low contrast dielectric materials, on the other hand, become quite beneficial for frequency tuning of already compact antenna structures, without a significant degradation in antenna performance.

In this paper, frequency responses of the compact dual-polarized four-arm Archimedean spiral antennas are investigated, when they are loaded with relatively low contrast dielectric materials of dielectric permittivity up to 4.0. Antennas with a ground plane radius as small as $0.375\lambda_o$ are studied, where λ_o is the free-space wavelength at 3 GHz. Three different dielectric loading profiles are discussed, namely full, partial, and grooved dielectric structures. It is shown that the frequency bandwidths of such dielectric loaded antennas can be adjusted without enlarging the physical size of the antenna aperture. The partial profile is inspired by confining the creation of low-phase-velocity waves within the spiral arm region. It is shown that the frequency bands, shared by both senses of circular polarization, widen as the dielectric region shrinks in the spiral central zone. As the frequency tuning capability of dielectric loaded antenna under study may require specific value of dielectric permittivity, grooved substrates are also investigated to address how such materials can be electrically realized using a conventional substrate with ε_r=2.5. Antenna parameters such as CP gain, cross polarization, beamwidths, radiation patterns, and frequency bandwidths of each case are fully addressed for both senses of polarization. All the corresponding results will be discussed and presented in the conference.

REFERENCES

[1] A. M. Mehrabani, “Radiation and Polarization Diversities of Compact Archimedean Spiral Antennas” Ph.D. dissertation, ECE Dept., Univ. of Manitoba, Winnipeg, MB, 2014.

[2] J. L. Volakis, C. Chen, and K. Fujimoto, *Small Antennas Miniaturization Techniques and Applications*. New York: McGraw-Hill, 2010.