Optimization of Circularly Polarized Patch and Annular Ring Antennas for Impedance Matching and Axial Ratio

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The objective of this paper is to investigate various techniques that can be utilized to simultaneously improve impedance matching and axial ratio performance of circularly polarized planar patch and annular ring antennas. These techniques include tuning the feed point along different positions on the surface of the antenna, analyzing different dielectric materials with differing dielectric constants, and optimizing the axial ratio based on the geometries of the antennas. The circular polarization is produced by notching the corners of the square patch and the square annular ring, respectively. The notching helps to generate two degenerate modes that are equal in magnitude with 90^o phase difference within the band of interest. Testing the feed point in various locations along the antenna surfaces allows the designer to improve the impedance match, or S_{11} parameter, and the radiation pattern. Peak broadside polar radiation, an S_{11} less than -10 dB, and an axial ratio less than 3 dB over a significant beam width is anticipated for maximum performance. A substrate with a low dielectric constant increases the resonance frequency of these antennas; likewise, a substrate with a high dielectric constant will lower the resonance frequency, allowing the designer to shrink the size of the aperture. As a result, the smaller aperture size allows for manipulation to fit different applications. Altering the patch geometry and optimizing the axial ratio by trimming the opposite corners of the patch, referred to above as notching, allows the designer to choose from multiple polarization types. The designer must account for the tradeoffs in S_{11}, axial ratio, and the radiation pattern as the best return loss does not necessarily correspond to the best axial ratio. With empirical/search optimization work via full-wave analysis simulator HFSS (High Frequency Structural Simulator), and experimentation, one can align the impedance matching bandwidth with the lowest axial ratio bandwidth. A similar technique is applied to a circularly polarized planar annular ring. Placing a co-planar, concentric optimized patch inside the annual ring would create a dual-band element. Re-optimization of the patch and annual ring parameters may be needed to take into account the effect of the presence of each element on the other within the structure of the combined dual-band element. Preliminary simulations of this dual band, dual polarization planar antenna show promising performance in both the S- and X-bands, simultaneously.