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Characteristic Mode Analysis of Low-Profile Superstructure Loaded Microstrip Antenna for Improved Polarization Purity

Kaushik Mandal
Institute of Radio Physics and Electronics, University of Calcutta, Kolkata, India;
e-mail: kaushikrpe@gmail.com

Though, several works addressing the challenges and methods of cross-polarization (XP) reduction in microstrip antennas having symmetric patch shapes are available in literature, very few works address the XP issue in asymmetric patch shapes like triangle. In this work, the enhancement of polarization purity in a triangular microstrip patch antenna (TMSA) has been explored using characteristic mode analysis (CMA). CMA is used to explore the source of higher XP in triangular patch by analyzing the near-field E-field distribution of the desired mode TM_{10} for both triangular and rectangular patch geometries. Unlike the rectangular patch, triangular patch exhibits an overlap between the co-polarized and XP field components of the desired mode near the apex. The modal near-field E-field distributions obtained from the CMA have been found helpful in identifying the cause behind high XP in TMSA. It also helps in choosing the placement location of the XP suppression tool. The inherent geometrical asymmetry of the triangular patch stands as the root cause behind its unique XP behavior compared to the rectangular patch. Attempts to perturb the antenna cavity near the patch apex using standard techniques like shorting pins or metallic stubs affect the dominant mode significantly. Therefore, in this work, a low-profile surface-mounted metal pin-based superstructure is proposed to strategically perturb only the XP generating fields in the near-field region without affecting the co-polarized fields. A detailed parametric study to identify the location of each metal pin on the patch surface for the optimum XP suppression is conducted. The proposed design is studied using full-wave analysis and validated experimentally as well. The experimental results show a peak XP suppression of 12 dB, 7 dB, and 2 dB in the E-plane, H-plane, and diagonal plane, respectively, confirming the reliability of the proposed technique. The proposed superstructure loaded TMSA delivers good XP suppression and gain with very minimal change in antenna profile. Moreover, the surface mounting of superstructure pins enables a quick and easy fabrication of the antenna prototype. The proposed study can further be extended for analyzing XP suppression in any arbitrarily shaped patch geometry.

Keywords: characteristic mode analysis, cross-polarization, microstrip patch antenna, modal near-field, polarization purity, superstructure, surface mount technology