Analysis of a Compact Microstrip Patch Antenna with Tuning Stubs for Dual Frequency Trimming and Dual Polarization

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A novel printed antenna element embedded with tuning stubs capable of providing dual polarized operation over two widely separated frequency bands is described.

Dual Frequency dual-polarized antennas are generating great interest due to the development of wireless communication over recent years. They find applications in satellite communication systems to realize frequency reuse for doubling the system capability. They can also be used in mobile communication systems to obtain polarization diversity for enhanced reception and transmission functions into one antenna for reducing the antenna size.

The antenna geometry consists of a square patch loaded in the centre with a square slot having four extended arms (Placed at right angles to each other). It is fabricated on a substrate of thickness h and relative permittivity ε_r. The square slot is centered in the square microstrip patch antenna. It is observed that two distinct operating frequencies are excited. Here, the slot geometry creates another resonance near the fundamental resonance of the antenna, which will result in dual frequency operation. By changing the length of the tuning slot arms, the frequency ratio of the proposed antenna can be varied effectively. The optimum feed position remains practically the same even when the arm slot length is changed.

With a square slot alone, it is observed that the antenna is resonating at 1.611 GHz, whereas the introduction of the first base arm as well as the other three stubs initiates an additional resonance frequency at 1.155 GHz. It is also observed that the second resonance frequency falls to 1.341 GHz from 1.61 GHz. It can be concluded that the slot is effectively increasing the patch dimensions and hence lowering the resonant frequencies. Both the two resonant frequencies are well below the resonant frequency of the standard square patch. By changing the length of the slot arm, the frequency ratio of the proposed antenna can be tuned effectively. By varying the number of stubs from one to four we can also trim the frequency of operation over a wide band. The transmission characteristic studies reveals the orthogonal polarization studies of the antenna.

The analyses of the antenna by simulating the antenna geometry using the Zeland IE3D also were carried out. IE3D is an integrated full wave electromagnetic simulation and optimization package for the analysis and design of three dimensional microstrip patch antennas. The experimental observations are found to be in very close agreement with the IE3D results.

The area requirements of ordinary square patches operating at f_1 and f_2 frequencies of the new design are found to be more; typically when $f_1 = 1.155$ GHz and $f_2 = 1.341$ GHz, the reduction in patch areas are $\sim 69\%$ and 54% respectively. By changing the slot arm dimensions we can merge or shift apart the resonating frequencies. It is observed that the percentage bandwidth remains almost invariant even when the slot arm dimensions are changed to reduce the operating frequencies. The reduction in relative gain of the newly designed antenna is found to be 1.8 dB less compared to standard rectangular patch.