DESIGN AND ANALYSIS OF A CLASS OF ULTRAWIDEBAND ANTENNAS

ABSTRACT

The wireless spectrum is very crowded due to the exponential increase in the utility and number of wireless devices. This necessitates the exploration of new techniques for sharing the wireless spectrum. The Ultra-WideBand (UWB) technology is evolving as a very efficient solution to address the problem of spectrum scarcity. The unlicensed usage of the frequency band 3.1 GHz to 10.6 GHz is legalized by the Federal Communications Commission for the UWB commercial applications. The antennas used in UWB systems require good return loss and radiation characteristics, to establish stable communication in an environment with very high level of interferences from the licensed users. It is necessary for the UWB antennas to resonate for the entire range of frequencies in the range 3.1 GHz to 10.6 GHz. The printed monopole antennas have a compact size with large resonance bands and hence they are the most preferred structures for UWB antenna design. Antennas developed for narrowband applications are designed for their resonant frequencies but the UWBantennas due to their large bandwidth of operation are designed for their lower band-edge frequencies. The different geometries of printed monopole antennas were analyzed for their return loss performance. The antennas with circular and hexagonal radiator geometries have good return loss characteristics over the entire UWB range of frequencies. However, the antenna with circular radiator has smaller dimension compared to the antenna with hexagonal radiator for the same lower band edge frequency. An Iterated Function (IF) is used to generate a fractal geometry on the printed circular monopole antenna to enhance its return loss characteristics. The printed circular monopole radiator with the fractal geometry is developed on FR4 substrate with relative permittivity 4.3 and thickness 1.6 mm. The fabricated prototype of the printed circular fractal monopole antenna with fractal geometry measures 43 mm × 48 mm × 1.6 mm and resonates for the entire range of frequencies from 2.74 GHz to 12 GHz with a fractional bandwidth of 161.49 %. However, the antenna exhibits very high levels of cross-polarization in its radiation pattern. A novel narrow-strip radiator geometry with inductive loading is introduced to overcome the limitation faced in the printed circular fractal monopole antenna. Lumped inductors are used to make the antenna resonate for a single resonance band covering the entire range of UWB frequencies. The inductive-loaded printed UWB monopole radiator is developed on FR4 substrate with relative permittivity 4.3 and

thickness 0.8 mm. The fabricated prototype measures 42 mm × 19 mm × 0.8 mm and resonates for the entire range of frequencies from 3.05 GHz to 10.6 GHz with a fractional bandwidth of 132.78 %. The radiating elements are made of three narrow strips and hence low cross-polarization levels are obtained in its radiation pattern. The inductive-loaded narrow-strip UWB printed monopole antenna resembles the printed monopole with Stepped Impedance Resonator (SIR), but for the inductors in series loaded between each strip of the radiating structure. A theoretical design approach is proposed to calculate the resonant frequencies of the inductive-loaded printed monopole antenna by modifying the design approach for SIR printed monopole antenna. A two-strip inductive- loaded printed monopole antenna is considered for the analysis. The radiator geometry is developed on FR4 substrate with relative permittivity 4.3 and thickness 0.8 mm. The fabricated prototype measures 42 mm × 20 mm × 0.8 mm and resonates for the range of frequencies from 2.58 GHz to 10 GHz with a fractional bandwidth of 146.08 %. The simulation and measurement results are compared with the calculated values of the resonant frequencies. The effect of ground plane is neglected in this approach and hence, slight deviations are observed in the resonant frequencies computed by the proposed design approach for inductive-loaded UWB monopole antenna. The inductive-loaded printed monopole antennas have good return loss and radiation characteristics, but are highly vulnerable to interferences from the licensed users of the spectrum. A novel band rejection filter is developed to reject the major interference bands in the UWB range. A square-patch dual mode resonator with modified 'T' shaped perturbations is used develop the band rejection filter. The resonator is shorted for miniaturization. The shorted parasitic dual mode resonator band rejection filter rejects the entire range of frequencies in the band 5.15 GHz to 5.95 GHz, with steep roll-off from stopband to passband. The prototype of the band-rejection filter fabricated on the same substrate measures 15 mm × 13 mm × 0.8 mm. The novel band rejection filter is integrated with the miniaturized inductive-loaded UWB monopole antenna, to form a miniaturized and band-notched inductive loaded UWB monopole antenna. The fabricated prototype of the miniaturized and band-notched inductive-loaded UWB monopole antenna measures 30 mm × 14 mm × 0.8 mm. The antenna resonates for the entire range of frequencies from 3.1 GHz to 10.5 GHz, excluding the rejected band ranging from 5.15 GHz to 5.95 GHz. The fractional bandwidths achieved for two bands of resonance are 51.31 % and 55.83 %