ABSTRACT

Tremendous growth in wireless communication, demands the need for high performance compact antennas and microwave devices in the field of RF and microwave engineering. The recent wireless communication protocols require antennas with narrow, wide and ultrawide frequency bands with higher directivity. By definition, antennas are a means to radiate or receive radio waves. There are numerous types of wire and aperture antennas designed for different application. Microstrip and planar monopole antennas have reached their own heights to suit different compact devices of various fields of communication. They can be designed to operate in single or multiple frequency with narrow and wide bands. The faster transmission systems with higher data rate are realized with the Federal Communications Commission (FCC) regulated Ultra Wideband (UWB) spectrum in the frequency band from 3.1GHz to 10.6GHz. This fascinated the antenna engineers to design the UWB antennas for different applications like Cognitive Radio (CR) and Software Defined Radio (SDR). The planar antennas are suitable for Global Positioning System (GPS), Satellite communication, Radar communication, Global System for Mobile communication (GSM), Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), Wireless Fidelity (Wi-Fi), and vehicular communication. Long-Term Evolution (LTE) and 5G technologies have created a networking environment capable of transmitting multimedia signals at a very faster rate with low latency. The present-day antenna portfolios are adaptable to portable devices and networking counterparts with certain gain and bandwidth. The wireless market requires

narrow, wide and UWB operating devices with compact antenna geometries to occupy less volume in the wireless boards, transceivers and gadgets.

This dissertation addresses the design of few planar UWB antenna structures which are compact in size with higher gain, improved bandwidth and band rejection properties for WLAN and WiMAX frequencies. Artificial periodic structures, slots, and additional stubs are used to improve the antenna performance with notch bands for interference rejection from Industrial, Scientific, and Medical (ISM) band wireless systems. A novel Frequency Selective Surface (FSS) with UWB property is used as the periodic structure for gain improvement of the antenna. Band rejection is achieved by narrow slots and additional strips on the radiating element. Ground plane of the antenna is also modified for bandwidth performance improvement.

The inherent periodic property of nature is used to create artificial surfaces with metal or dielectric substances of smaller thickness compared to a wavelength in its operational frequency band. These artificial periodic surfaces are used in various electromagnetic applications. The periodic structures consist of one, two- or three-dimensional array of metallic structures either freely constructed or printed on dielectric substrates. The artificial periodic surfaces can be designed with extensive properties like frequency selectivity, high surface impedance, negative and zero refractive index.

Frequency selective property is considered for designing a periodic structure functioning as FSS, suitable for performance improvement of UWB antenna. The single layer FSS surface is designed to operate from 2.39GHz to 13.67GHz covering the UWB spectrum which offers a bandwidth of 11.28GHz. The proposed novel FSS layer is a combination of square and circular loop with convoluted cross dipoles and loaded branches, grown on

FR-4 substrate. The periodicity of the square unit cell FSS measures 17.4mm. The designed FSS unit cell acts like a band stop filter centred at 8GHz frequency.

The unit cell structure is also analysed with an equivalent circuit model. The transmission characteristics of the FSS unit cell has been analysed for structural parameters to maintain polarization and angular stability of the incident signal. The proposed FSS design with loops, dipoles and branch loading provides better angular and polarization stability with 141% bandwidth which is higher as compared to the existing works.

The characteristics of the proposed UWB FSS unit cell is proved with the circular monopole antenna, by backing the FSS layer with 5×5 unit cell element array. The proposed UWB FSS is used for gain improvement of circular UWB antenna. The proposed FSS antenna achieved higher gain compared to circular monopole antenna without FSS. The FSS backed UWB antennas exhibit an average gain of 9.43dB. The fabricated antenna measures $87\times87\times15.27mm^3$ which is equivalent to $0.899\lambda_0\times0.899\lambda_0\times0.157\lambda_0$ in terms of free space wavelength.

Several attempts have been made to reduce the size of the antenna. The circular monopole antenna is modified further in their design to improve the performance. It is observed from the literature that fractal geometry are good candidate for UWB antenna. Fractal geometries provide better miniaturization, wideband and UWB response. The circular monopole antenna is truncated to semi-circular wine cup antenna. In addition, Koch fractal curve is induced on the upper side segment for band width improvement. The antenna is also provided with a pair of L slot and an N slot for mitigating the interference of WLAN and WiMAX frequency bands within the UWB spectrum. The antenna is fabricated on FR-4 substrate and has a dimension of $0.31\lambda_0\times0.268\lambda_0\times0.0165\lambda_0$. Conventional circular monopole with a bandwidth of 10.98GHz ranging from 3.1GHz to 14.08 GHz is modified with Koch curves. This aids to achieve a wider bandwidth of 13.104GHz with a shift in lower frequency to 2.688GHz due to increase in transmission line length. The notch bands of the proposed UWB antenna are centered at 3.5GHz and 5.2GHz frequency and their corresponding bandwidths are 0.944GHz and 1.52GHz respectively. The simulated and measured results are validated with a fabricated prototype.

The designed semi-circular antenna with Koch curves aims for reducing the size, with a novel design. The proposed antenna is compact in size, and the design incorporates an extended strip in the semi-circular arc. Further, the antenna ground plane is modified for better performance. The proposed miniaturized antenna prototype model measures $0.142\lambda_0\times0.17\lambda_0\times0.0165\lambda_0$. The additional stub offers band rejection in the lower frequency bands, which causes interference in the UWB system.

The extended strip and the modified ground plane play a major role in improving the bandwidth of the proposed antenna. The proposed arc monopole antenna shows a stable gain in the operational band with less than 1dB deviation. Maximum bandwidth achieved by the antenna is 17.304GHz, with single notch band rejecting both WLAN and WiMAX interference. The impedance bandwidth of the proposed arc monopole antenna ranges from 3.036GHz to 20.34GHz covering the FCC regulated unlicensed UWB spectrum. The antenna achieved a fractional bandwidth of 148.05%.

The proposed high-performance antennas in the present research, radiates well in the entire UWB spectrum. The advantages of compact size, wider bandwidth and higher gain, makes the antenna suitable for high-speed wireless applications.