CHAPTER 6 CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

Ultra wideband technology is emerged as a promising technology for providing convenience and mobility of wireless communications to high-speed interconnections in devices throughout the digital home and office. The design of an antenna, a critical part of any communication system, is very challenging due to strict requirements for a competent UWB antenna compared to its narrow band counterpart. UWB antennas having compact and small sizes are highly desirable and essential for easy integration into space limited systems. Therefore, the analysis and miniaturization of UWB antennas are conducted in this thesis. While analyzing the potential antenna designs suitable for UWB applications, several parameters like impedance bandwidth, phase, group delay, radiation pattern, directivity and gain, radiation efficiency and physical profile are considered.

Three types of potential UWB antenna candidates i.e. monopoles, fractals, and dipoles antenna structures are designed, simulated, tested and characterized. The time domain performance of all the designed antenna structures are also studied. The effect of both the transmitting / receiving antennas and the source pulse on the received signal waveform is determined. For a high fidelity or cross-correlation, flat magnitude and linear phase response of the antenna system transfer function over the operating band is required. There must be a a good match between the spectrum of the source signal and the operating band of the system transfer function. Investigations have shown that a high signal fidelity is achieved by applying the carrier-modulated Gaussian pulse since its spectrum matches the antenna system transfer function well. The designed antenna structures include ladder shaped fractal, beveled monopole, and crescent shaped dipole antenna.

In first chapter, a brief study of already reported UWB microstrip antenna structures is presented. It included a brief introduction of antenna geometry, methods used to enhance the antenna performance and achieved results. A brief introduction to monopoles, fractals and dipoles is also presented.

In second chapter, a detailed description of methods used while designing monopole structures is presented. It is followed by the various fractal geometries, their evolution, presence in nature, applications, advantages and disadvantages are discussed. Lastly, various geometries of dipole antenna structures are discussed.

In third chapter, a ladder shaped fractal antenna structure is designed and analyzed in both frequency and time domains. It is observed that the use of asymmetrical coplanar waveguide feeding of H-shaped radiating patch and slot loaded ground planes resulted into three bands of operation (4.61-4.77 GHz, 5.87-8.63 GHz and 11.18-12.16 GHz) along with bandwidth enhancement of first operating band. It is also found that three operating bands got merged into single operating band with increase in the number of iterations from one to three. This merging of operating bands increased the impedance bandwidth to 8.51 GHz. After second iteration, very less bandwidth enhancement is observed. Due to some fabrication errors the experimental bandwidth is found to be 10.84 GHz. The far field radiation patterns at lower resonance frequencies (<10 GHz) are found to be omnidirectional in H-plane and bidirectional in E-plane. For higher resonances, the patterns in both planes acquired distorted omnidirectional nature due to excitation of higher modes. A variation of peak realized gain from 1.62 to 4.68 dB along with an average radiation efficiency of more than 80% and average total efficiency of more than 70% is observed. In the time domain performance, a fidelity factor of more than 65% is found for both configurations i.e. face to face and side by side. A group delay variation of 0.5 ns is achieved over the entire band of operation except a group delay of 2 ns around the lower band edge frequency. An isolation of more than -40 dB and linear isolation phase variation is also observed in the entire band of operation. During the parametric analysis, three different dielectric materials i.e. carbon nanotubes, FR-4 epoxy and $Ni_{0.2}Co_{0.2}Zn_{0.6}Fe_2O_4$ are used as the substrate of the designed antenna. It is found that the impedance bandwidth got reduced from 10.5 GHz to 4.27 GHz with increase in the relative permittivity of the substrate material. A typical size reduction upto 95.35% along with a bandwidth of 134% is achieved over other antenna structures in the same domain and having approximately equal lower band edge frequency.

In fourth chapter, beveled monopole antenna structures is designed and analyzed. It is noted that the division of a conventional rectangular patch into three sub-sections and the beveling of radiating edges of lower two subsections increased the number of operating bands from two (8.63-16.39 GHz, 17.7-18.45 GHz) to three (2.67-14.33 GHz, 15.66-16.78 GHz and 18.34-19.03 GHz). This beveling of edges shifted the lower band edge and higher band edge frequencies towards lower and higher frequencies respectively. It is also found that the replacement of conventional partial rectangular ground plane with partial semicircular ground plane enhanced the bandwidth of first operating band from 11.66 GHz to 12.2 GHz and that of second operating band from 1.12 GHz to 1.47 GHz with the disappearance of third operating band. Further loading of ground plane with a pair of wavelength long rectangular slots excited an additional resonance at the frequency of 15.8 GHz to provide a single wide band of 2.45-16.6 GHz. The omnidirectional and bidirectional radiation patterns in H-plane and E-planes are observed to be achieving distorted omnidirectional nature with increase in the frequency. The difference between the co-polar and cross-polar patterns in both planes is also noted to be reducing with increase in the frequency. A peak realized gain variation between 2.91 dB and 5.49 dB along with an average radiation efficiency of more than 75% is obtained. An average total efficiency of more than 70% is also observed. A group delay variation of 1 ns for both configurations are obtained. It is found that the time domain signal gets more distorted for face to face configuration (fidelity factor(%) = 50) in comparison to side by side configuration (fidelity factor (%) =75). An isolation of more than -20 dB and a linear variation of S_{21} phase is noted. It is also noted that the impedance bandwidth of the antenna depends inversely on the dielectric constant of the substrate. A typical size miniaturization of 58.19% and a fractional bandwidth of 150.77 % is achieved over the other similar structures.

In fifth chapter, the design and analysis of double printed crescent shaped dipole antenna structure is presented. Loading of the elliptical dipole element with semi-elliptical notch along its major axis to acquire crescent geometry, merged the two operating bands (3.18-10.16 GHz and 10.68-17.88 GHz) into a single wide band (3.28-17.85 GHz). The bidirectional and omnidirectional natures of radiation patterns in E-plane and H-plane respectively are found to be shifting towards distorted omnidirectional nature with increase in frequency. A peak realized gain variation from 1.08 dB to 4.85 dB is observed. The total efficiency is found to have its variation between 59% and 91%. For radiation efficiency, the variation is between 67% and 93%. For both configurations i.e. face to face and side by side, the fidelity factor of ~60% and a group delay variation of 2ns are noted. The isolation is observed to be more than -20 dB. Phase of S_{21} is varying linearly across the entire band of operation. The impedance bandwidth is increasing with increase in the substrate thickness from 0.8 mm to 1.6 mm and afterwards it started decreasing. The antenna performance is found to be almost unaffected for major axis variation from 3 to 6 mm whereas for 2 mm the performance is slightly worse. In case of minor axis variation, the reflection coefficient curve is observed to be shifting downwards around the frequency of 11 GHz for the variation from 1 to 3 mm. For further increase in the minor axis between 3 to 5 mm, it is observed that the reflection coefficient plot is shifting upward i.e. towards -10 dB line, around the frequency of 15 GHz resulting into bandwidth reduction. It is noted that during the elliptical notch movement along the negative x-axis from 0 to 4 mm i.e. moving away from the major axis of the elliptical radiator, the reflection coefficient plot is shifting upward i.e. towards -10 dB line. For the elliptical notch movement in +y direction from 0 to 4 mm, two operating bands with a notch around 10.5 GHz with the shifting of lower edge of the first operating band towards higher frequency are observed. For the value of 6 mm, the notch is shifted from 10.5 GHz to 15.5 GHz due to improvement and worsening of the reflection coefficient level these two frequencies respectively. In addition to this notch shift, the lower edge of the first operating band got reduced from 3.25 GHz to 3.41 GHz. For movement from 6 to 10 mm, the reflection coefficient curves are found to be shifting towards -10 dB line resulting into bandwidth reduction The optimum value of y-axis movement is found to be 10 mm. A typical size reduction of 84.46 % and a fractional bandwidth of 141% is achieved over other structures in its domain.

From these investigations, it is found that the all the designed antenna structures have compact dimensions in their domains. The impedance bandwidth of designed antenna structures is enhanced from 10.84 GHz to 15.84 GHz on moving from fractal antenna to dipole antenna. The dipole antenna has large dimensions and maximum bandwidth among all structures. All of these antennas proposed in the thesis demonstrate the feasibility of enhancing the impedance bandwidth with an increase in dimensions of UWB antenna structures by using different methods which makes them suitable for space-limited systems and various applications. Since the group delay is almost constant across the operating frequency range of all three antenna structures and the average gain is also more than 2 dB so these structures will find their applications in body area network, microwave imaging, through wall imaging etc.

6.2 Future Scope

Based on the conclusions drawn and the limitations of the work presented, the following work can be carried in future to improve the performance and applications of UWB microstrip antenna structures:.

It has been noticed that the bandwidth is enhanced with increase in antenna dimensions. So, some methods can be find out to enhance the impedance bandwidth without increasing the antenna dimensions to provide service for super wideband applications i. e. to cover both long range and short communication services. To cover both frequency ranges the antenna impedance bandwidth should have the ratio of equal to more than 10:1. Small sized UWB antenna structures are always desirable for several applications especially for mobile and portable devices. Some methods like metamaterial loading, self-complementary structures, etc. can be investigated for further reduction of the antenna dimensions. Due to overlapping of UWB systems with reserved frequency bands of other commercial wireless systems, the filtering of those bands is required to avoid the potential interference. So, band notch properties can be introduced in the antenna structures designed in this thesis as a future work.