CHAPTER VII

CONCLUSIONS AND FUTURE WORK

7.1 Conclusion

7.2 Future work
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The work carried out is essentially motivated by the need to address the well known and inherent limitations of the most popular antenna type in the current era—the microstrip patch antenna. Its low bandwidth limitation has led to numerous innovative designs to enhance the bandwidth, with accompanying trade off, to cater to specific needs. In this same context of bandwidth limitations, a tunable or a multi-frequency antenna may be a more convenient approach in circumventing these limitations, at least in many of the applications.

Intuition plays a major role in antenna technology and hence ideas and approaches of earlier workers form the basis for newer design concepts. The designs presented in this work, draw clues from earlier designs in tackling the limitations mentioned.

In one of the designs studied, a pair of very narrow parallel slits (compared to patch length) is introduced on the patch conductor. The modification results in two resonant frequencies, both on the higher side of the resonant frequency of the original patch, but with lower return loss values. Two resonant frequencies are observed again when one of the slits is removed, retaining only the slit nearer to the feed point. The return loss values are less than that for the simple patch at its resonant frequency (4.86 GHz, -17.46 dB). The lower resonant frequency of 2.17 GHz has a return loss of -12 dB while for the higher resonant frequency at 4.86 GHz, it is -16.4 dB. A size reduction of 76% corresponding to the lower resonant frequency is achieved, which is comparable to the best reported in the literature, using a very simple design. On varying the length of this slit, both the resonant frequencies change and the return losses also vary. This length variation can, therefore, be used to tune the resonant frequencies and adjust the matching. The best return loss performance for both the resonant frequencies can be seen for a slit length of 16 mm (patch width = 18 mm). For this slit length, the lower resonant frequency is 2.33 GHz with a return loss of -22.84 dB while for the upper resonant frequency, these values are 5.11 GHz and -29.9 dB respectively. Both the E- and H-plane patterns at the two resonant frequencies are consistent with the patterns for the conventional simple patch. When the isolated patch sections due to the two parallel slits mentioned earlier are elevated symmetrically at an angle above the substrate, multiple resonant frequencies are observed at different elevation angles which were not seen for the original simple patch. The best results are obtained for elevation angles of 65° and 85°. For an elevation
angle of 65°, the two best resonant frequencies are at 4.04 GHz and 8.83 GHz with return losses of -20.02 dB and -28.48 dB respectively. For an elevation angle of 85°, the two resonant frequencies are 4.23 GHz and 10.26 GHz with return loss values of -36.61 dB and -32.31 dB. All these four return loss values are better than -16.31 dB for the original simple patch at 4.42 GHz. Significant bandwidth enhancements are also obtained at these two elevation angles. A large -10 dB return loss bandwidth is obtained covering the frequency range from 6.84 GHz to 9.24 GHz for the 65° elevation angle which amounts to a percentage bandwidth of 29.9%. For elevation angle 85°, the frequency range is from 8.43 GHz to 10.59 GHz with a bandwidth of 22.71%.

Size reduction is obtained for another patch geometry formed by notionally superposing a stripline on a rectangular patch making an angle (tilt angle) with the radiating edge. In addition to one resonant frequency near that for the simple patch, another resonant frequency, which is less than half of that for the simple patch, is observed. Hence the design can be used as a dual frequency antenna with one frequency in S-band and the other in the C-band. Both the resonant frequencies change to some extent with change in tilt angle; again providing a method for tuning. For a specific tilt angle, a size reduction of 57% is achieved. All the radiation patterns are similar to the patterns for the conventional patch. This is an advantage as transmitted/received power level concerns are eliminated for communication link in a particular direction when frequencies are tuned or bands are changed. Moreover, the notionally superposed stripline can be converted to an actual stripline which can be rotated, converting the structure into a reconfigurable antenna. The limitation is that only one resonant frequency can be independently tuned.

Dual band operation is obtained when triangular conductor sections (spikes) are added to the two radiating edges of a rectangular patch. The two operating frequencies are closer (less than 1 GHz apart) in comparison to the previous patch structures studied, where the band separation was higher. The structure turns into a tri-band antenna when all the three vertices of the three spikes on one particular edge of the patch are connected by a strip line. Also, when a strip line section connecting two of the vertices is moved down the height of the spikes, dual band performance is achieved at specific heights. The resonant frequencies can be slightly tuned by changing the stripline position along the spike height.
A dielectric plunger moving within an air pocket in the substrate layer of a rectangular patch is found to tune the operating frequency. However matching is poor. A second fabrication approach is adopted allowing extension of the air pocket throughout the substrate height which was not possible with the first approach used for fabricating the antenna. The structure fabricated using this approach yields better results with the return loss being at least -10 dB for all plunger positions. The feeding method, which in this study is microstrip line edge feeding, can also, be modified through further study to improve the matching.

The investigations on the different patch structures designed indicate that performance improvement; specifically broadband characteristics, dual or multi-frequency operation, pre- or post fabrication tuning as well as size reduction can be achieved to a reasonable extent without seriously compromising on the basic advantages of the microstrip patch antenna. Many of the designs are simple as compared to other techniques reported in the literature with equivalent performance enhancements.

7.2 Future work

The work presented in the dissertation is, in some sense, time limited for a degree. It is therefore inevitable that a more detailed study of parameter variation is left to be done. In addition, the work was carried out within the limitations of available resources.

The slitted patch structures, presented in the third chapter, can be fabricated using accurate CNC prototyping techniques to obtain more accurate results. Further studies with slits of different configurations, such as meandered slits etc. can reveal interesting results. The notionally superposed strip line design can be made mechanically reconfigurable by incorporating a rotating strip line section.

A more detailed study with different spike dimensions, number of spikes, non linear spike profile and spike loading can be areas for further study.