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6.0 Introduction

The results of the experimental investigations, simulated results and their analysis are described in the preceding chapters. In this chapter, the conclusions drawn from those extensive results are summarized. The futuristic scopes for carrying out further investigations related to this work are also reported.

6.1 Inferences drawn from CRMSA and RMA

The antennas reported in this thesis have been designed and fabricated using low-cost glass epoxy dielectric substrate material. The CRMSA is designed for the resonant frequency of 3.5GHz. From the return loss graph of CRMSA as shown in Fig. 4.5, it is clear that, the antenna resonates for single band of frequency at 3.27GHz which is close to the design frequency of 3.5GHz with minimum return loss of -47.50dB. The variation of experimental and simulation return loss of CRMSA is in good agreement with each other. The impedance bandwidth obtained for CRMSA is 3.65% (3.22GHz-3.36GHz) with a peak gain of 2.76 found in its operating band. The typical 2D and 3D E and H-plane radiation patterns measured at the resonant frequency, the patterns are broadsided and linearly polarized in both E and H plane. Further, the impedance bandwidth of CRMSA is enhanced by using monopole technique where the rectangular monopole antenna (RMA) is realized from CRMA by using a single 50Ω microstripline feed of length \((L_g+g) = 27.7\text{mm}\). This length of feed line is 28.8% shorter than the length \((L_f+L_{tr})\) of microstripline used for CRMA as shown in Fig.4.5 which makes RMA compact in its size and simplifies the design structure. A continuous copper ground plane of height \(L_g = 26\text{mm}\) is placed below the microstripline feed on the bottom layer of the substrate. When CRMA is modified as RMA, the antenna operates from 1.98 GHz to 4.52 GHz. This means that, the antenna operates for a wide band of frequencies \(BW_2\) as shown in Fig. 4.10 which is quite
large compared to the operating band of BW\textsubscript{1} as shown in Fig. 4.5. The magnitude of impedance bandwidths of RMA is found to be 78.40%. Hence 3.65% of impedance bandwidth of CRMA has been enhanced to 78.40% by constructing RMA. Further, from Fig. 4.10 it is clear that, the lower cut off frequency of RMA is 1.98 GHz. By comparing the lower cut off frequency of CRMA shown in Fig. 4.5 which is at 3.22 GHz, this indicates that, the RMA also shows the property of virtual size reduction which is 51.87%. The peak gain of CRMA and RMA are measured in their operating bands and are found to be 2.10 dB and 8.83 dB respectively. Hence, by constructing RMA gain can be enhanced by 3.85 times more than the peak gain of CRMA. Further, the broadsided radiation pattern of CRMA has been converted into omnidirectional radiation pattern by constructing the RMA. The omnidirectional pattern of RMA is more useful because signal can be sent in all the direction compared to broadside radiation pattern of CRMA.

### 6.2 Inferences drawn from single wideband gap-coupled monopole RMA

The gap-coupled monopole technique has been used in the present research work in order to enhance the impedance bandwidth of CRMA without changing the actual size of radiating patch. For this, different types of gap-coupled monopole antennas such as TSTGSRMA, CTDSGRMA, VHSGRMA, GCTRMA, RSCTGRMA, TRPSGSRMA, RRTSTGRMA, VSCTSRGRMA, and CTSTSGRMA have been designed and fabricated in this category. For all these antennas the optimized simulation study has been conducted before fabrication. All the antennas are wideband in nature and gives omnidirectional radiation pattern. Among these antennas the TRPSGSRMA gives highest impedance bandwidth of 153.15% with a peak gain of 8.69 dB in its operating band. It is noted here that, all most all antennas shows the property of virtual size reduction and maintains almost constant gain as
shown in Table 5.22 in spite of reducing the copper area of radiating patch when compared to CRMSA. The variation of experimental and simulation return loss of these antennas are in good agreement with each other.

6.3 Inferences drawn from dual band gap-coupled monopole RMA

Sometimes dual band antennas are more useful than single band antenna because each band can be used independently for transmit receive application. The notch band between the two operating bands can be used as reject band. In this study the antennas such as ILSGRMA, CTGRMA, DSGRMA, CTSRGRMA and FRGSRMA have been designed and fabricated. The repetitive simulation work is carried to optimize the dimensions of each antenna before fabrication. Among these antennas the FRGSRMA give two highest operating bands. All the antennas show the property of virtual size reduction, omnidirectional radiation characteristics retaining almost constant gain as shown in Table 5.23. The variation of experimental and simulation return loss of these antennas are in good agreement with each other. These antennas are more useful for many microwave transmit receive communication applications operating in the frequency range of 1.5 GHz to 10 GHz of frequency range.

6.4 Inferences drawn from triple band gap-coupled monopole RMA

Triple band antennas are sometimes better than dual band antennas because the notch bands are two between the three operating band. In this category five antennas have been designed and fabricated such as TRSGRMA, TRSSGRMA, USVSGRMA, VSTTGRMA and TGRMA. The detailed simulation work is carried to optimize the antenna parameters before fabrication so that antenna can work distinctly for three operating bands. Among these the TRSGRMA gives highest operating bands. All the antennas shows the property of virtual size reduction compared to the
size of CRMSA and they retain almost constant gain with omnidirectional radiation characteristics as shown in Table 5.24. The variation of experimental and simulation return loss of these antennas are in good agreement with each other.

6.5 **Inferences drawn from quad band-gap coupled monopole RMA**

In the design and development of gap-coupled monopole quad band antennas categories three antennas have been fabricated namely DSRMAW2G, CSGRMA and IURRGRMA. All these antennas works for four distinct bands of frequencies between nearly 1.5 to 10 GHz. They show the property of virtual size reduction, omnidirectional radiation characteristics and retain almost constant gain as shown in Table 5.25. The variation of experimental and simulation return loss of these antennas are in good agreement with each other. The proposed antennas are designed mainly to work in the frequency range of 1.5GHz to 10 GHz because antenna applications are more in this range.

From the detail research work it is concluded that, the most important parameters namely impedance bandwidth and gain of MSAs can be enhanced by using gap-coupled monopole technique without increasing the actual size of the radiating patch. The proposed antennas are simple in their design and fabrication and they use low cost substrate material. Further, these antennas give omnidirectional radiation characteristics and planar in nature becomes more useful for housing in small antenna real estate. The proposed antennas may be used for LAN, WLAN, Wi-Max, Blue-tooth, SAR etc. applications.
6.6 Futuristic scope

In spite of detailed research work it is still insufficient to fully fill the need of modern developing technology. The research is endless and hence encourages getting even better results than reported in the literature. The study reported here has opened for the following interesting point for further investigations.

1. The proposed antennas may be studied for different geometries other than rectangular.
2. Different shapes of parasitic elements may be used which are gap-coupled to the driven elements for better results.
3. Different materials may be used to fabricate the antennas.
4. Exact notch band properties may be studied for particular communication applications.
5. Antennas may be excited using different feeds.
6. Gap-coupled monopole array antennas may be constructed for higher gain.