CHAPTER 5

CONCLUSION AND FUTURE STUDY

5.1 CONCLUSIONS

This thesis covered the entire design cycle of wearable antennas including analysis of deployment conditions, performance enhancement of textile antennas, and suitable material selection to the fabrication of integrated textile antennas. Even though several investigations of textile antennas are reported in the open literature, there is plenty of room for considerate antenna research related to the mechanism and phenomena of its working in the vicinity of a body particularly with respect multi-frequency antennas. In addition to examining the opportunities of using radiators close to body in the thesis, the impact of use distance to body was also demonstrated. An attempt was made to study, design, analyze and fabricate textile antennas catering to GSM and ISM applications. Finally suggestions for future work that can be done in this area are also given as part of this chapter.

The characteristics of human body tissues at the ISM microwave frequency band were examined and demonstrated for three outermost tissue layers of the body. The impact of the tissue layer thickness on the planar antenna performance was demonstrated in terms of the reflection coefficient, efficiency, pattern behaviour and SAR values. All the above said analyses were performed on a novel dual frequency polygon shaped textile antenna.
A statistical tool was then employed on the designed antenna to quantify the effects of deformations that had maximum impact on the antenna’s performance. A dual band planar monopole radiator was used for this study. The outcome of this study brought out the significant effect of bending deformation compared to other deformations on the performance of the textile antenna. To work towards a possible solution to compensate for deformations and body effects a new design of dual band planar fractal textile monopole antenna integrated with an EBG plane was designed, fabricated and tested. This construction of a textile antenna was seen to considerably reduce the effects of bending deformation on the designed dual band textile antenna. The SAR calculated was also reduced by about 99 % when compared to the structure where EBG surface is not used.

After ensuring optimum performance in the working of textile antennas the next aim was to increase the wearability of the same for the end user. Hence various materials were investigated for the design of textile antenna. A copper foil sheet used for the conducting regions of the patch was found to work appreciably well but suffered from the problems of rigidity in addition to being uncomfortable for the user. Hence the uses of conductive coatings were investigated. First a coating of conductive carbon was used on a denim substrate to form the conductive regions of the patch. Next a nylon fabric coated with silver was used as the radiating patch. Both these coatings increased the drapability of the textile antenna. However both these antennas suffered from a possible loss of conductivity over time due to wear and tear because of erosion of the conductive coating. Moreover the use of binders for these coatings causes a reduction in the conductivity.

In order to design the conductive regions of the textile antenna as part of the fabric, weaving has been done. Initially copper thread was used as the warp and weft in a traditional loom to weave out the pattern of the
radiating patch. This was then glued on a denim substrate and tested. The textile antenna thus designed worked satisfactorily. However there was still the mechanism of aligning and fastening the components of the textile antenna. Hence a brocade type weaving of the radiating patch was done to offer integration with the substrate. But this design required the use of another substrate/spacer to avoid the patch from shorting with the ground plane.

To offer complete integration of the antenna elements at the point of production, a novel method of textile antenna production was then proposed in this dissertation. Using a modified specially set up table loom, a multilayer weaving was done to achieve this. The first layer consists of conductive threads that formed the radiating patch. The second and third layers were made of cotton threads forming the substrate. The fourth layer was made of conductive threads forming the ground plane. This textile antenna was completely integrated while offering maximum comfort to the person wearing it.

5.2 FUTURE WORK

This thesis has investigated wearable antenna design cycle and proposed some new wearable antenna design concepts. However any new design leads to more questions and future study. There is still an enormous amount of research and development that needs to be performed in this exciting area of wearables.

The feeding method determines how comfortable the person can be in carrying around the textile antenna. Hence a study of the effect of different feeding methods on the overall performance can be carried as a future research idea. Also a fully flexible sensor module employing the proposed conformal textile antenna can be designed for healthcare, defense and search & rescue operations. Development of looms with the capability to manufacture fully integrated textile antenna facilitating automation in
production to enable large scale production of the same. The multi-layer method of textile antenna weaving can also be used to fabricate other planar microwave components such as filters, couplers etc.,