CHAPTER 6

CONCLUSION

This thesis aims to extend the bandwidth and enhance the gain of various patch antennas with the EBG structure. Compactness and patch area reduction can be achieved through suitable unitcells of Electromagnetic BandGap (EBG) structures. With this perception in mind, the author of this work has designed a set of geometries (mushroom-like, spiral-like and ring-like) for bandwidth and gain improvement. Initially, the impedance bandwidth is investigated for several different patch antennas with various ground sizes. Three of them (square, slotted rectangular and circular) are chosen, due to their compact nature, and also because their simulated results show good agreement with the measured results. The antenna will be designed to operate at frequencies of 1.54 GHz, 1.8 GHz, 2.3 GHz and 2.4 GHz for high speed local area networks. To improve its performance, with respect to the gain, bandwidth, radiation efficiency and directivity of the antenna, electromagnetic bandgap structures are used. The EBG structure demonstrated the effects of surface wave suppression and reduction on broadside radiation power. The above chosen patch antennas are surrounded by three different EBG structures (mushroom-like, Spiral-like and ring-like) with different sizes of the ground plane, and operating at single and dual frequencies. For comparison, an EBG array is fabricated on the same substrate with the same patch parameters, and this has also been simulated. To compare the performances, the return loss, radiation pattern, gain, bandwidth and directivity of the various patch antennas, with and without various EBG structures, are investigated. To validate the proposed concept, the measured
results have been presented and the following conclusions arrived at, showing that

i) The fractional bandwidth and gain of a single frequency square patch antenna is observed to be 3.72% and 2.6dBi respectively.

ii) The gain of a dual frequency slotted rectangular patch antenna is observed to be 2.6dBi and 2.9dBi.

iii) The fractional bandwidth of a dual frequency slotted rectangular patch antenna is observed to be 13.25% and 10.98%.

iv) The fractional bandwidth and gain of a single frequency circular patch antenna is observed to be 5.59% and 5.31dBi respectively.

v) A gain and bandwidth enhancement of 3dBi and 67.4% respectively is achieved, when a square patch antenna is surrounded by an 11×11spiral-like EBG array.

vi) A gain and bandwidth enhancement of 0.2dBi and 13.61% respectively is achieved, when a square patch antenna is surrounded by an 11×11mushroom-like EBG array.

vii) Compared to the mushroom-like EBG antenna, the gain and bandwidth of a 11×11spiral-like EBG antenna is enhanced by 2.8dBi and 79.8% respectively.

viii) A gain and bandwidth enhancement of 3dBi and 78.17% respectively is achieved, when a circular patch antenna is surrounded by a ring-like EBG array.

ix) The bandwidth is improved by 93.2% and 11.75% at lower and higher resonant frequencies respectively, when a Slotted
rectangular patch antenna is incorporated with a 15\times15 spiral-like EBG array.

x) The gain is enhanced by 2.6\,\text{dBi} and 0.2\,\text{dBi} at lower and higher resonant frequencies respectively, when a slotted rectangular patch antenna is incorporated with a $15\times15$ Spiral-like EBG array.

xi) The VSWR and directivity of the single frequency spiral-like EBG antenna is found to be 1.05 and 5.8\,\text{dBi} respectively.

xii) The VSWR and directivity of the single frequency ring-like EBG antenna is observed to be 1.29 and 8.7\,\text{dBi} respectively.

xiii) The VSWR of the dual frequency spiral-like EBG antenna is observed to be 1.12 and 1.27.

xiv) The directivity of the dual frequency spiral-like EBG antenna is observed to be 5.8\,\text{dBi} and 6.6\,\text{dBi}.

The analytical investigations carried out, reveal the following.

i) The reflection characteristics of the EBG are not sufficient to evaluate the EBG performance, when it is used as an antenna ground plane. Hence, the dispersion equation for the mushroom-like EBG is obtained using the TLM based code.

ii) The dispersion equation and dispersion diagram for the mushroom-like EBG structure are obtained theoretically, using the Multiconductor Transmission-Line (MTL) theory, which is illustrated through extensive simulation and measurement results. From the diagram, passbands and stop bands are obtained.
More stable results are found when using EBG structures with the patch antenna. Thus, we demonstrate that EBG structures are good candidates for the design of antennas characterised by a low profile, wide band and high gain. The present thesis is the outcome of the experimental, simulated and theoretical investigations carried out on a compact patch antenna, using the electromagnetic bandgap structure.

6.1 SCOPE FOR FUTURE WORK

As a future work, it would be interesting to investigate the other examples of EBG structures and their applications. The analytical formulation introduced here can be extended for the case of a patch antenna embedded in a multilayered artificial dielectric structure. For further performance enhancement, waveguide feed networks could be utilized to substantially lower the feed loss and improve the efficiency of large arrays. Stacking more patches could also be employed to further widen the operating bandwidth. Human errors during the fabrication process are the major cause of the discrepancies between simulated and measured results. Hence, some development have to be done to help the fabrication process is easier to handle. Besides that, a few of prototypes should be fabricated in order to obtained good result in measurement. Therefore, a strong knowledge and experience is required.