Chapter 6

Summary and Scope for Future Studies/Applications
In this dissertation, we have explored some novel designs of wideband and ultra-wideband dielectric resonator antennas with monopole-like omnidirectional radiations. Specialty of these designs lies in achieving improved input impedance and radiation characteristics. All the designs have been realized using dielectric materials having relative permittivity 10. They are low volume, light weight, highly compact, and easily machinable. The investigations presented in this dissertation are based on theoretical calculation, optimization of parameters using commercial simulator, and thorough experimental measurements. All the prototypes were made from Eccostock’s HiK material and those were machined using sophisticated instrumentation facility available in Central Tool Room, Govt. of India, Kolkata. Major parts of these experiments have been executed in the antenna measurement laboratory of the department. To meet some special requirements, we had to take measurement supports from the antenna measurement laboratory of ISRO, Bangalore, India.

Novel antennas and these results have been presented through Chapters 2-5. Chapter 1 provides a brief introduction on dielectric resonator (DR) and dielectric resonator antenna (DRA) along with their chronological developments. Silent features of DRAs have also been discussed.

In Chapter 2, “Pawn”-shaped dielectric ring resonator loaded hybrid monopole antenna has been investigated for obtaining ultra-wide impedance bandwidth. “Pawn” is a piece of chess with a conical bottom portion and carrying a hemisphere on the top. The shape of the dielectric ring resonator (DRR) resembles a pawn. The prototype provides 122% impedance bandwidth with peak gain varying from 4 to 6 dBi as a function of frequency. Such a compact, low weight, monopole type antenna can be extremely useful in many portable broadband wireless applications.

After investigating pawn shaped DRA in Chapter 2, two different types of hybrid antennas have been explored in Chapter 3. Pawn is a combination of two geometries, namely hemisphere and cone. In this chapter, hemispherical and conical dielectric resonator loaded hybrid monopole antennas were introduced. The aim was to improvise the DRR shape to provide favorable interactions and adjustment of electromagnetic (EM) fields between the DRR and the electric monopole. Compared to conventional hybrid
structure "ring or annular DRR", the combination of hemisphere and cone by virtue of its shape offers smoother transition of the domain of electromagnetic interaction. Instead of combined structure like "pawn", individual structure hemisphere or cone was found to be efficient enough to provide similar ultra-wide operating bandwidth. These two simple geometries can be fabricated employing lesser amount of dielectric material which ultimately reduces machining cost and weight. Starting from conventional annular hybrid geometry, systematic parametric studies were carried out for designing optimized structures using HFSS. They were followed by experimental verification. A set of useful design guidelines has been developed for each geometry, along with the verification for different frequency ranges. Both the geometries provide about 120-126% impedance bandwidth with consistent monopole-like radiation over entire operating bandwidth. The physical insight behind UWB radiation was also provided. A considerably compact monopole providing 126% impedance bandwidth or 4:1 ratio bandwidth with an average 4 dBi peak gain should find a wide range of applications starting from wideband EM sensor to UWB communication.

Therefore, Chapters 2 and 3 contribute to the development of ultra wideband hybrid DRA with monopole type radiations. Chapters 4 and 5 have employed a different approach in composite DRA structures to achieve very low profile wideband monopole-DRA. In Chapter 4, a new geometry, i.e., quarter of a hemispherical DRA (q-HDRA) has been explored. This is thoroughly characterized and has been examined for two-element configuration.

In Chapter 5, the four-element composite combination of q-HDRA has been discussed. A comparative study with an earlier version, i.e., a combination of two units of half-HDRA (h-HDRA) has also been presented. Both four-element q-HDRA and two-element h-HDRA are the variants of a hemispherical DRA (HDRA). Two resonating modes $TE_{111}$ and $TM_{101}$ take identically symmetric field distribution when two h-HDRAs are placed face to face and generate monopole-type radiation over 35% impedance bandwidth ($S_{11}$≤-10 dB). But the gap between two h-HDRAs causes structural asymmetry and results in asymmetry in radiation patterns. Present investigation is partially aimed to
alleviate this shortcoming in an innovative way. The present configuration is free from earlier shortcomings like asymmetry and non-uniformity in radiation patterns.

All the antennas discussed in this dissertation are monopole-like wideband and ultra wideband composite and hybrid antennas respectively. They provide wide (about 30%) or ultra-wide (about 122-126%) impedance bandwidth with suitable gain. The theoretical and experimental analyses presented in this dissertation will be helpful for antenna engineer while designing broadband antennas.

In this dissertation, all the investigations are solely based on frequency domain analysis. Our primary aim was to explore new hybrid and composite DRA geometries towards the development of monopole-type DRAs. Time domain analysis is another important aspect to characterize the ultra wideband features of the antennas. This would need almost equal volume of investigation involving transient analysis and experiments. Time domain studies of the proposed antennas could be taken up for future investigations.

For designing hybrid antennas in Chapters 2 and 3, we explored different DRR geometries. But in each structure the electric monopole is the conventional quarter wave length monopole. Introducing different kinds of loading to reduce the effective height and volume of the radiator may be another part of future works in the same area.

Again in our design, a uniform metallic ground plane has been used. Introducing single or array of defects in the ground plane could be a new area of investigation with potential future. This may improve some new features in impedance, resonance and radiation characteristics. It may also be extended to excite higher order modes with the ability of producing higher gain.