Chapter-5
Conclusion and Future Scope

5.1 General Conclusion:

This thesis is focuses on analysis, design and development of ultra-wideband absorbers for planar and conformal application. Chapter 1 starts with a historical overview and the limitations of traditional absorbers. Then, how this practical limitation has been overcome in two decades by an artificial engineered-based periodic surface is discussed. The physics behind plane wave absorption with the help of the transmission line model and impedance matching approach have been discussed. After that, the classification of periodic structure-based absorbing configurations, based on the dominant nature of losses, is summarized. Further, based on an in-depth literature survey, research gaps were identified, which motivated me to present this thesis. Finally, the motivation and organisation of the thesis are presented in the last part of this chapter.

Chapter 2 addresses the challenges in the design of wideband or ultra-wideband absorber with low loss metamaterials/metasurfaces or frequency selective surfaces. This chapter provide a critical analysis of the manuscript published by Si-Jia-Li *et al.* on analysis and design of three-layer perfect metamaterial-inspired absorber based on double split-serration-rings structure [33]. We found that the incident linearly y-polarized wave is converted into a reflected wave with orthogonal polarization. We demonstrate the anisotropic geometry of the structure and highlight the high cross-polarized reflected component that was overlooked in previous absorptivity calculations.

Chapter 3 presents the design, modeling, and analysis of ultra-wideband absorber based on two concentric resistive serration ring metasurface. The proposed absorber is conformal, low cross polarization level, and low radar cross section characteristic. In this chapter, a centro-symmetric unit-cell configuration is chosen because such a configuration provides a lower cross-polarized reflected component of the incident wave. A step-by-step strategic design approach was used to synthesize an ultra-wideband absorber while maintaining conformal characteristics. Moreover, flexibility is incorporated in this design approach to choose unit cell geometrical parameters based on the limiting frequencies of the desired band, along with considerations for the miniaturization aspect of the absorbing structure. The proposed absorber is designed for more than 90% absorptivity and wideband fractional bandwidth of 105.70%, covering *X-, Ku-,* and a major portion of *K*-bands applications.

The radar cross section formula is derived by including the cross-polarized reflection component of the incident wave in estimation. Finally, the proposed absorber was fabricated and validated through experimental studies for both planar and conformal applications.

Chapter 4 presents a design of low profile low cross polarization level conformal ultra-wideband absorber using three concentric resistor embedded rings. In this Chapter 4, we have judiciously chosen three concentric rings with the minimum possible resistance in order to maintain the centro-symmetric unit cell configuration. Therefore, in this chapter, along with low profile and ultra-wideband performance, we have designed an absorber in which each resonant frequency and, hence, the operating bandwidth can be independently controlled to adapt to a variety of devices. This proposed absorber is designed for more than 90% absorptivity and wideband fractional bandwidth of 106.70 %, covering *X*-, *Ku*- and some portion of the *C*- band applications. Further, the simulation results of the proposed absorber were validated through experimental studies for both planar and conformal applications after fabrication.

Lastly, Chapter 5 includes the conclusion and future possibilities of the thesis.

5.2 Future Scope

The exploration of future opportunities in the realm of conformal absorbers designed using resonating-type Frequency Selective Surfaces (FSS), particularly Circular

Loop FSS, opens up promising directions for further research and development. Herein, we propose several areas of future work to enhance the efficacy and versatility of conformal absorbers:

1. **Scan Compensation**

- ✓ To investigate alternative resonating FSS designs, such as cross-dipole resonators, to mitigate the issue of varying operating bandwidth with the angle of incidence.
- ✓ To explore the use of sub-wavelength low-pass arrays, such as periodic square patches, to achieve a larger bandwidth for conformal absorbers at higher oblique incidences for both TE and TM polarizations.
- ✓ To enhance scan angle performance by incorporating multilayer dielectric structures.

2. **Conformality at Higher Bending:**

- ✓ To develop a variable-size unit cell strategy to ensure stable absorption performance even at higher bending radii. This involves optimizing the unit cell dimensions to accommodate bending without compromising absorption efficiency.

3. **Miniaturization:**

- ✓ To investigate methods for further miniaturization of conformal absorbers, exploring advanced materials and manufacturing techniques to achieve compact designs while maintaining optimal absorption characteristics.

4. **Lumped Resistor Replacement:**

- ✓ To explore the replacement of several lumped resistors with screen-printed planar resistors, aiming to streamline the manufacturing process and potentially improve the overall performance and reliability of the absorber.

These proposed directions offer a roadmap for future investigations, addressing challenges and expanding the capabilities of conformal absorbers for diverse applications. The suggested improvements encompass a range of considerations, from addressing bandwidth limitations to enhancing stability under bending, achieving miniaturization, and optimizing the absorber's structure for improved performance. These avenues hold the potential to advance the field and contribute to the development of more efficient and versatile conformal absorbers.