Abstract

In recent years, research on metamaterial or metasurface based absorber has gained momentum due to its compact size, and lightweight, compared to the conventional absorber. These artificially engineered structures have ability to control electromagnetic waves. In the literature, various types of single, dual, multiband, and wideband absorbers have been reported based on artificial engineered structure based periodic surface. However, a limitation of many of the reported structures is the lack of information regarding their cross-polarized reflected component of incident waves. Although these periodic surface based absorber have simple unit cell structures, but without introducing large amounts of ohmic or dielectric loss, it is very challenging to achieve ultra-wideband absorption. Therefore, there is need to be addresses the challenges in the design of wideband or ultra-wideband absorber with low loss metamaterials/metasurfaces or frequency selective surfaces. Moreover, rigid absorbers have a very limited scope, when it comes to non-planar surfaces. In practical scenarios where absorbers need to be deployed over curved surfaces, there is growing demand for conformal ultra-wideband absorbers.

In this thesis, the analysis, design, and development of an ultra-wideband absorber for planar and conformal applications is presented. We have addressed the above practical limitation. This thesis provides a strategically designed approach conformal absorber with low cross polarization level characteristic. This design is scalable from lower to higher frequencies and incorporates some miniaturization aspect of absorbing structure. The simulation of these absorbers is performed with Ansys HFSS version 2019, 2022 R2, and is further validated through experimental studies after fabrication in different chapters.

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. We demonstrate the anisotropic geometry of the structure and highlight the high cross-polarized reflected component that was overlooked in previous calculations. This critical analysis will help to prevent further misinterpretations and facilitate progress in the field of efficient absorber.

After addressing the challenges in the design of ultra-wideband absorbers with low-loss periodic surfaces, the investigated inferences are utilized in the careful selection of unit cell geometry and the design of absorbers with an ultra-wideband configuration in the next subsequent chapters.

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. This chapter provides a step by step strategically design approach to synthesized ultra-wideband absorber while maintaining the conformal characteristics. In this design approach, flexibility is incorporated to choose unit cell geometrical parameters as per the limiting frequencies (upper and lower) of desired band along with some miniaturization aspect of the absorbing structure.

Chapter 4 presents the design of a low profile, low cross-polarization level, conformal ultra-wideband absorber using three concentric resistor-embedded rings. In this chapter, along with low profile and ultra-wideband performance, an absorber is designed in which each resonant frequency and, hence, operating bandwidth can be independently controlled. Therefore, absorber's design flexibility is best suited to adopting a variety of devices.

Lastly, Chapter 5 concludes the major contribution and future possibilities of the thesis.