Preface

With the growing demand for flexibility, adaptability, and optimization in present wireless communication systems, there is always a need for adaptable multifunctional antennas. Traditional antennas are designed for fixed frequency, pattern, and polarization characteristics. Therefore, using fixed performance characteristics antennas in a wireless device makes the system bulky and increases complexity. Reconfigurable antennas offer an attractive solution for the above-discussed issue due to their dynamic adaptability in changing scenarios. Due to its adaptability, a reconfigurable antenna is comparable to several fixed characteristics of antennas. This results in a more compact design, cost reduction, and simplified integration into systems. Several reconfigurable techniques, including electrical switching, mechanical switching, material tuning, and optical switching, have been adapted to achieve reconfigurability. However, the electrical switching technique is the most usable technique due to its fast switching speed, low loss, and easy integration. One of the major design challenges of designing reconfigurable antennas is their inconsistent performance while switching from one state to another. Besides the use of additional matching networks, complex beam forming networks and placement of active components and the biasing circuits on the radiation layer increase the antenna volume and degrade the antenna radiation performance. Therefore, this research aims to develop new design methodologies for reconfigurable antennas with single and hybrid reconfigurability functions to overcome the above-discussed limitations. The simulations of these antennas are carried out using Ansys HFSS version 2020 R1 and validated through measurements. Further, a comparison is also performed with the similar existing work in different chapters.

This thesis begins with the evolution of the reconfigurable antennas over traditional fixed characteristics antennas. The advantages of the reduced size, reduced cost, and easy integration with the system are motivated to design, develop, and implement multifunctional reconfigurable antennas for modern wireless communications. This is achieved by integrating multiple switchable antenna characteristics in a single antenna structure by using some reconfiguration techniques. Therefore, different switching techniques, their advantages, and limitations are studied. A brief review on designing pattern reconfigurable antennas, polarization reconfigurable antennas, and hybrid reconfigurable antenna are also performed. All these topics, including the problem identification from the literature review, scope, and objective of this thesis, are included in **Chapter 1**.

A transmission line-based phase tunable phase shifter employed with PIN diodes to connect different switchable feeding paths for beam steering is proposed and utilized to feed a two-element microstrip patch array antenna for WLAN application. By selecting the different excitation paths on the designed tunable phase shifter, a beam steering of up to ± 36° is realized with an impedance bandwidth of 5.5% from 5.12-5.41 GHz., as presented in **Chapter 2**.

In this work, a reconfigurable antenna with circular polarization agility and beam switchability is presented. The design incorporates an E-shaped patch antenna paired with four switchable feed probes, enabling switchable circular polarization. Additionally, it integrates a phase-tunable phase shifter, detailed in Chapter 2, to facilitate beam steering. The proposed antenna exhibits an overlapped operating impedance bandwidth of 23%, spanning 4.6–6.1 GHz, and a 3 dB axial ratio bandwidth of 17% from 4.7-5.6 GHz. Besides, beam steering capabilities of up to ±30° with an almost 2 dB gain variation while maintaining stable radiation performance across the entire operating band are also achieved, as depicted in **Chapter 3**.

In the final section of this thesis, a reconfigurable antenna array with multifunctionality and 2-D beam switching is presented for 5G n78 applications. The initial design involves a quad-polarized antenna element with vertical polarization (VP), horizontal polarization (HP), left-hand circular polarization (LHCP), and right-hand circular polarization (RHCP). Subsequently, this quad-polarized element is utilized to construct a 2×2 antenna array, incorporating 2-D beam switching and quad polarization agility. The proposed antenna demonstrates an overlapped operating impedance bandwidth of 28.5% within the 3.5–4.7 GHz range and a 3 dB axial ratio bandwidth of 13% from 3.6-4.1 GHz. Additionally, it maintains a stable gain, as elaborated in **Chapter 4**.

Finally, this thesis encapsulates the conducted investigations and observations. It succinctly summarizes the findings while highlighting potential avenues for future research, as outlined in the concluding **Chapter 6**.