Preface

Surface plasmon polaritons (SPPs) are unique surface waves that exist at the metal (a conductive material) and dielectric (a non-conductive material) interface and occur in the optical frequency range. These waves propagate along the side of the interface and exponentially diminish in the direction perpendicular to the interface. When the frequency is dropped to the microwave region, the metals behave more like perfect conductors than plasmas with negative permittivity. As a result, surface plasmon polaritons lose their properties. So, plasmonic metamaterials (or engineered SPPs or spoof SSPs) have been proposed to accomplish SPPs at low frequencies. The spoof surface plasmon polaritons (SSPPs)-based devices are trending nowadays because of their very attractive features, such as depressed mutual coupling, low profile, less complexity, and high signal integrity. Moreover, the SSPPs-based structures can concentrate electromagnetic (EM) waves into subwavelength scales, which is a boon in miniaturizing advanced circuits and systems. The SSPPs can play a vital role as an alternative platform for the next generation of electronic circuits and systems because of their high field confinement, enabling them to overcome the compactness limits of traditional circuits. In recent years, numerous devices have been developed based on SSPPs concepts, such as antennas, filters, couplers, power splitters etc. In antennas, leaky-wave antennas (LWAs) and endfire antennas have received considerable interest because of their benefits of easy feeding, low profile, and ease of design and fabrication using the spoof SPP-based waveguides. In this thesis, leaky-wave antennas (LWAs) and endfire antennas are designed based on the same SSPPs waveguide. To explore the inherent features of the SSPPs, a novel application, an endfire MIMO antenna, is designed and discussed. A novel application of the endfire MIMO antenna to stimulate the reflectarray has also been designed and investigated for beam scanning applications.

This thesis begins with a historical overview of the natural surface plasmons and their characteristics to the spoof surface plasmon polaritons (SSPPs) at lower frequency regimes. An overview of the different devices based on SSPPs is included,

along with a review of the relevant literature. A brief overview of MIMO antennas, their features, and their diverse performances is discussed. A quick history of the reflectarray antenna, including its operation principle and methods of phase tuning, is also included in this chapter. The motivation and organization of the thesis are also outlined in the **Chapter 1**.

A variable-width strip dipole-based leaky-wave antenna using spoof surface plasmon polaritons is proposed. It is a single-port, miniaturized, and high-gain frequency beam-scanning leaky-wave antenna with 55° beam-scanning capability in the operating region. The second port of the highly efficient antenna is eliminated to shorten its physical length. The designed antenna is intended to be used as a low-profile antenna for radar and wireless communications, which is discussed in **Chapter 2**.

A novel application, a three-element, low-profile, coplanar endfire multiple-input-multiple-output (MIMO) antenna, is designed and discussed to investigate the intrinsic properties of the SSPPs. This work achieves high isolation without any decoupling structure. The measured isolation has been observed to be well below −35 dB. Wider beam widths for ample azimuth and elevation coverage with a stable pattern in the endfire direction are achieved in the operating band, as presented in **Chapter 3**.

A novel application of the endfire MIMO antenna to stimulate the single-layer, low-profile beam scanning reflectarray (RA) has been designed and investigated. The SSPPs-based endfire MIMO antenna mitigates the aperture blockage, achieves high isolation between the feed elements, and accomplishes continuous one-dimensional (1-D) beam scanning. The proposed RA benefits nano-satellite applications, as explored in **Chapter 4**.

Finally, this thesis encapsulates the research and observations that were carried out. It merely points out the conclusions and suggests directions for future investigations, as stated in **Chapter 5**.