Preface

Of particular interest is MIMO antennas, which, due to their various advantages compared to the single antenna system, find their utility in many wireless technologies, where high data rate with low latency is attracting more attention after 4G toward 5G and beyond. Because of that, implementing need of a multiple antenna system with low correlation in place of a single antenna in the transmitter and/or receiver of the user devices is rapidly growing. Still, the area available to integrate the multiple antenna elements inside the compact/low-profile devices is minimal. For completion of this task, the antenna elements should be highly compact, low-profile, and closely spaced. Consequently, the mutual coupling/correlation between antenna elements is highly increased; hence the antenna performance degraded. Therefore, a compact/low-profile high-order MIMO antenna system with low coupling/correlation between antenna elements has a great potential for extremely high data rates with throughput.

In this thesis, the research studies are primarily focused on the development and implementation of some novel highly-isolated/compact/low-profile 2-element/4-element MIMO antenna, which is utilized to realize the high-order MIMO antennas such as 12-element, 20-element, and 32-element for different wireless application-based user's devices, i.e., smartphone, localization system, vehicular, and smartphone's back cover. The number of MIMO antenna elements increases with satisfactory performances without compromising any aspects in the chapter-wise studies, including four different MIMO topologies applicable for the modern communication spectrum, i.e., 5G sub-6 GHz (new radio), wideband, ultra-wideband, 5G sub-6 GHz & mm-Wave (new radio). These antennas simulation studies were carried out using the 3D electromagnetic simulator Ansys HFSS version 2020 R1, and the results are validated in calculations and

measurements. The investigations of which are carried out in different chapters that integrate the present thesis.

This thesis begins with the theory of channel capacity in the communication channel links. The need of large channel capacity and high data rate are motivated to design, develop, and implement MIMO antenna whereas can be utilized in the transmitter and/or receiver of the user devices. This is possible by finding the suitable antenna structures utility in portable user's devices. Because of that, fundamental and review on the monopole antenna are studied and explored for configuring the high-order MIMO antenna as antenna elements. A brief study on MIMO antenna and its characteristics and diversity performances is explored. The related state-of-art review on MIMO antenna, i.e., two-, four-, and eight-element, is presented and utilizes low correlation techniques between antenna elements are also reviewed. The problem identified in the literature reviews, solving these findings, is this thesis's objective. These topics are incorporated in **Chapter-1.**

A new promising technique of 5G along with the MIMO system is more demanding because it will greatly increase the data rate with a low latency rate. Due to this, a two-element MIMO antenna having the same antenna orientation is proposed for 5G sub-6 GHz. By utilizing that, a 12-element MIMO antenna is realized, which can be applicable for low-profile 5G smartphone applications, as presented in **Chapter-2.**

For a higher data rate with enhanced bandwidth, an extremely compact quad-element MIMO antenna with the orthogonal antenna orientation is proposed for wideband application. Further, low-profile quad-element MIMO antennas are arranged orthogonally at the four corners, and a quad-element MIMO antenna at the centre of forms a 20-element 3D-MIMO antenna. It can be utilized as a localization system where different user's devices are connected to the primary host, as presented in **Chapter-3**.

Further, to enhance the data rate with enhanced bandwidth, a compact ultra-wideband eight-element MIMO antenna with the same and orthogonal antenna orientation is proposed for intelligent internet of vehicle (IoV) applications. Furthermore, the ultra-wideband eight-element MIMO antenna utilized as a unit cell, vertically orthogonally rotated around the central axis, forms a 32-element 3D-MIMO antenna, which can be highly suitable for modern vehicular applications, as presented in **Chapter-4.**

A new generation system looking toward integrating the 5G spectrum of sub-6 GHz and mm-wave has recently attracted more attention for many prospective advantages such as extremely high data rates and minimal latency rate. Due to this, an extremely low-profile higher-order MIMO system is proposed by integrating the eight-element MIMO antenna (5G sub-6 GHz) and 1×4 array-based quad-element MIMO antenna (5G mm-wave) on a common-aperture for 5G spectrum band n79/n257/n258. Further, the proposed MIMO antenna is installed inside the smartphone's cavity-loaded dielectric back cover; thereby inside device volume will reduce, as presented in **Chapter-5.**

Finally, the investigations and observations carried out in the present thesis are summarized, emphasizing the scope for future research work is also stated, as presented in the last **Chapter-6.**