Preface

The tremendous growth of wireless mobile communication has supported the promotion of GSM/EDGE, WCDMA-HSPA/HSPA+, and 4G/LTE systems worldwide for flourishing of mobile broadband, enhanced multimedia, and voice services. The transformation of mobile network to internet from their telecom root has started from second generation (2G) to third generation (3G) which first launched in 2001 and has become more Internet protocol (IP)-based network as in fourth generation (4G). 4G has developed around 2005 with orthogonal frequency-division multiplexing (OFDM), multiple-input multiple-output (MIMO), and link adaptation technologies and enables a wide range of services including computing and multimedia applications ranging from navigation to mobile video streaming. The emergence of such technologies and the increasing growth of subscriber demand have triggered the researcher and industries to move on to the 5G network that are expected to be launched in 2020. Devices like cars, clothing and home appliances will be connected to the Internet via mobile networks and can do wireless communication with one another. In this regard, the antenna community has played an important role that targeted low-profile, small, and multiband antennas together with multiple antenna systems design for emergent multifunction wireless devices. Concurrently, UWB systems operating at short range communication has attracted a lot of attention due to the advantages of high data transmission rate, good privacy, low power consumption, and simple structures. Its main applications includes remote sensing, through-the-wall radar imaging. However, the frequency range for UWB systems between 3.1 and 10.6 GHz will cause interference to the existing wireless communication systems such as wireless local area networks operating in 5.15-5.35 GHz and 5.725-5.825 GHz bands, WiMAX. In addition to that indoor radio wave propagation usually suffers multiple reflections which lead to signal depolarization along with strong signal attenuations because of the presence of dense clutters such as walls, floors, furniture, doors, etc. Therefore, a novel radiation system is required which can be achieved with a careful design of antenna system. Moreover, for practical implementation of antennas in wireless devices, a number of challenges still remain such as antenna packaging, antennas on chip without sacrificing its
bandwidth and achievable gain. As a result, innovative solutions are required to reduce the degree of complexity and difficulty in the design of wireless device antenna systems.

The objective of this book is to present current R&D trends and novel approaches in design, analysis of broadband, multiband, and reconfigurable antennas for wireless and UWB applications, as well as to the identification of integration techniques. This book provides theoretical and experimental approach to some extent that is more useful to the reader. Also highlights unique design issues to help the reader to be able to understand more advanced research.

It is worth mentioning that 27 chapter proposals were received from 18 different countries (China, Australia, Qatar, Saudi Arabia, Canada, France, Bangladesh, Hong Kong, Greece, India, Malaysia, Spain, Brunei Darussalam, Thailand, South Africa, Singapore, United Kingdom and United States of America) for this book. A rigorous review process was enforced with the help of 10 experts, almost all of them with a PhD in topics related to the book.

After reviewing the chapter proposals and complete chapters, 11 were accepted to be published (41% acceptance ratio). All authors and coauthors (except two) of the accepted chapters are holding PhD.

Chapter 1 provides an idea of current research trends and novel approaches in design, analysis and synthesis of broadband, multiband and reconfigurable antennas for the new generation of mobile communication devices, as well as for UWB communications, radars and so on. The modern wireless devices will operate in smart cognitive systems, switches to different bands with a single terminal antenna to optimize services on the different radio standards. In this chapter, some of the latest advances in wideband, multiband and reconfigurable antenna technology have been also described.

Chapter 2 discusses the design idea, structure and working mechanism of various wideband antennas including low-profile sleeve monopole antenna, dual-sleeve monopole antenna, disc-conical sleeve monopole antenna, wideband with dumbbell-shaped open sleeve antenna, wideband unidirectional patch antenna with Γ-shaped strip feed, wideband folded bowtie antenna with Γ-shaped strip feed and tuning stubs, wideband bowtie antenna with inverted L-shaped coupling feed and tuning stubs.

Chapter 3 presents the design, simulation, fabrication and testing of different high gain broadband antennas for 60-GHz short-range wireless communications. Printed dipole array (PDA) antennas, particularly the printed log-periodic dipole array (PLPDA) antennas are studied in this chapter. Loading these types of antennas with low-cost spherical or hemispherical dielectric lenses is presented which increase the gain of the antenna. Another type of antennas called electromagnetically coupled (EMC) elliptical patch antenna arrays is also investigated. Antipodal Vivaldi antenna and corrugated antipodal Vivaldi antenna are also introduced as
good candidates for 60-GHz short-range communication applications. Detailed comparisons is carried out among those entire antennas in terms of size, impedance bandwidth, gain, radiation efficiency, total efficiency, half power beam width, side love levels (SLLs), front-to-back (FTB) ratio, cross-polarization levels (XPLs), etc.

Chapter 4 discusses few issues in designing multiband antenna which includes size reduction required by the limited size wireless devices against the antenna efficiency, the complexity and difficulty in adjusting the multi resonating system to match the required frequency bands. Three new multiband antennas were presented to successfully demonstrate the multiband characteristics. Consequently, innovative solutions are presented to reduce the degree of efficient power complexity and difficulty in the design of wireless device antenna systems. Therefore two, three, and four separated bands antennas have been discussed and present their simulated and measured results.

Chapter 5 highlights the advantages of MIMO technology and its use in current 4G and future 5G wireless communication standards. It provides the various performance metrics that are needed to evaluate the behavior of a MIMO antenna system. The new metrics for MIMO performance characterization such as the total active reflection coefficient (TARC) for multi-port antenna systems, correlation coefficient, diversity gain and channel capacity evaluation are also discussed in details. Several examples of single band and Multi-band MIMO antenna systems are considered next with various types of antenna elements covering a variety of wireless applications and device sizes. This chapter is concluded with some general design guidelines for practicing engineers and researchers involved in MIMO antenna design.

Chapter 6 presents miniature high isolated MIMO antenna system. A practical MIMO antenna system should have a low signal correlation between the antenna elements and good matching features for input impedance. Moreover, MIMO system performance can be improved by reducing mutual coupling between closely spaced antenna elements. Furthermore, several MIMO antenna evaluation methods have been discussed in this chapter. It is difficult to evaluate and compare the mutual coupling isolation techniques used in MIMO antenna due to the conflicting individual characteristics (such as operating frequency, antenna area, and the achieved isolation value S12). Therefore, this chapter concludes by recommending a new method to evaluate isolation methods and MIMO antenna systems.

Chapter 7 reviews the mechanisms underlying the reconfigurability aspect of the antennas and identifies the challenges and provides all current techniques that are used to reconfigure the antenna parameters for different applications (frequency, radiation pattern, and polarization). Following the different methods and features characterizing the reconfigurability of antenna technologies, this chapter makes available the summarization of the most promising techniques. Moreover, a comparative study of the aforementioned methodologies is given based on the
fundamental reconfigurable principles and techniques. This chapter concludes with a discussion of the promising approach of variable reactive loading. The ultimate goal of this chapter is to provide a detailed survey of reconfigurable antennas to the readers (researchers, engineers and business organizations) which might be useful as reference for them.

Chapter 8 presents two new design of narrowband to narrowband frequency reconfigurable slot antenna. For the first reconfigurable antenna, a compact microstrip slot antenna is used to reconfigure six different narrow bands. The authors have achieved 33% size reduction with the bending of slot and transmission line. In addition to size reduction, an easy and compact biasing circuit is integrated into the ground plane which does not affect the performances of the antenna. The second reconfigurable antenna is a combination of microstrip patch and slot antenna. The slot is positioned in the ground plane, underneath the patch. The combination of these two antennas has the potential to provide extra functionality as each antenna has its own characteristics in term of frequency and radiation pattern. The simulated and measured results are used to demonstrate the performance of these antennas.

Chapter 9 provides an overview of different types of reconfigurable antennas and illustrates how a complete reconfigurable antenna system can be designed by an example using basic components (PIFA antenna, PIN diode and microcontroller). In this chapter, the complete 8-shape RPIFA antenna system is simulated, optimized and realized. An AVR microcontroller is integrated onboard with the antenna. The control of PIN diodes is carried out through programs in the memory in the AVR. The combination of AVR, PC and ED allows that the AVR processes the data obtained from those devices and produces feedback signals, which then automatically corrects the antenna and allows an adaptive operating system like in cognitive radio.

In summary, we can say that this chapter better defines the role and the principle of reconfigurable antennas which provides ways for the design of future antennas dedicated to cognitive radio.

Chapter 10 provides an overview of nature-inspired algorithms which analyze and synthesize antenna characteristics in a meaningful manner. Traditional approaches to this topic are based on simplified electromagnetic calculations which can only approximate real antenna performance. Currently, nature-derived computational intelligent methods are used to facilitate improved antenna design using mathematical optimization techniques before construction. Among the presented algorithms in this chapter, the invasive weed optimization (IWO) is very suitable for electromagnetics. In addition, some new optimization methods such as biogeography-based optimization (BBO), seeker optimization algorithm (SOA), and central force optimization (CFO) are likely be an attractive alternate in the electromagnetics and antennas research.

Chapter 11 gives the conceptual and the empirical research details about the recent development of low cost circularly polarized UWB antennas for indoor po-
This chapter also talks about the difference between circular polarization and linear polarization as well as the advantages of the former compared to later one in an indoor environment. The propagation of radio wave usually suffers multiple reflections which lead to signal depolarization along with strong signal attenuations because of the presence of dense clutters such as walls, floors, furniture, doors, etc. The use of circular polarization gives more chance of signal reception as it uses all planes during propagation whereas linear polarization remains confined in a given single plane. Following the above discussion, two-dimensional antenna designs and its polarization schemes for minimizing the sever effects of an indoor environment are presented for indoor positioning/Localization System. Some recent developments in antenna designs are also presented as an example for the better understanding and its future perspective.

This book attempts to present current and emerging trends in research and development of wideband, multiband, and smart reconfigurable antennas for modern wireless communications featuring a structured approach. Features include:

- Reviews design methodologies as well as offering an in-depth treatment of wideband, multiband and reconfigurable antennas for modern wireless communications.
- Provide up-to-date materials for wideband, multiband antennas and practical design information and extensive discussion.
- Include an extensive survey of broadband, MIMO and reconfigurable antennas literature published over the past several years.
- Presents simulation and experimental results to illustrate concepts.
- The chapters are written by experts at the forefront of antenna research, highlight current design and engineering practices, emphasizing challenging issues related to antennas for modern wireless applications.
- The book includes more than 180 illustrations and analytical techniques for all types of broadband and multiband antennas which is reference for R&D organizations, researchers, practitioners, consultants, RF professionals and communication engineers.
- This book supplements its content with extensive references to enable researchers for further investigation of broadband, multiband antennas and applications.

It is also hoped that this book will serve as a comprehensive reference for graduate students who wish to enhance their knowledge of all aspects of antennas for wireless communications.

*Mohammad A. Matin*

*Institut Teknologi Brunei, Brunei Darussalam*