Chapter 5
MIMO Antennas

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ABSTRACT

Multiple-Input-Multiple-Output (MIMO) technology has appeared to overcome the data throughput limit faced by conventional Single-Input-Single-Output (SISO) wireless communication systems. In MIMO, a significant increase in the data throughput is obtained using multiple data streams sent and received by multiple antenna elements on the transmitter and receiver ends, and this is why fourth generation (4G) wireless systems are supporting more real time multimedia applications and videos compared to older generations. The design of MIMO antenna systems is not a trivial task, and needs careful design practices. Several performance metrics have been identified for MIMO antenna systems that need to be evaluated on top of the conventional single element antenna systems. In this chapter, we will start by giving a brief background on wireless systems evolution and then highlighting the advantages of MIMO technology and its use in current 4G and future 5G wireless communication standards. The second section will treat in detail the various performance metrics that are needed to evaluate the behavior of a MIMO antenna system. The new metrics that are required 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 will be discussed in details. Several examples of single-band and Multi-band MIMO antenna systems are considered next with various types of antenna elements and covering a variety of wireless applications and device sizes. The chapter ends with a discussion on some of the challenges encountered in the design of MIMO antennas.

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I. INTRODUCTION

Wireless communications has seen a quantum leap in the past two decades. The wireless age where you can talk, browse the internet, and play high definition games on your phone has become a reality. Smart phones nowadays have the computing power of a PC two decades ago if not even beating it. Tremendous technological advancements have taken place and now we cannot even imagine how our lives would be like without high speed internet and being always connected via portable and wireless smart phones and devices.

The wireless revolution has taken several steps and evolved with the advancements in technology and wireless standards and algorithms. The push was first for having reliable portable wireless devices, then size reduction came into play, and then multi-standard support and multi-band operation, and finally the push for higher data rates that exceed the theoretical limits set for single channel communication systems.

The need for higher data rates to support high definition video and online gaming, as well as multi-application support is a driving technology demand that is always on the rise. The step from third generation (3G) to fourth generation (4G) wireless technology in terms of higher achievable data rates was not possible without relying on multiple-input-multiple-output (MIMO) technology. In MIMO, multiple data streams are sent from multiple antennas at the transmitter and are received by multiple antennas at the receiver end. This has shown to provide a linear increase in the data rates as a function of the number of the antennas used. Current 4G mobile terminals are all equipped with MIMO antenna systems to provide the true high data rate advantage anticipated.

In this chapter, we will start with a brief introduction about MIMO communication systems and their advantages, and then focus on MIMO antenna systems, their performance metrics, challenges and some examples from various mobile terminal devices.

I.1 MIMO Advantages and Evolution

A MIMO based wireless communication system can be represented as shown in Figure 1. MIMO systems can provide high data rate transmissions through spatial multiplexing. In spatial multiplexing, the high data rate signal is split into several lower rate streams. Each stream is passed to a different antenna for transmission. Given that each stream will have a unique signature, the receiving antennas can distinguish between the multiple streams and decode the data and receive a higher data transmission rate. This requires high signal-to-noise (SNR) ratio levels.

Fourth generation wireless standards such as Long Term Evolution (LTE) have a theoretical peak of 300 Mbps/20 MHz = 15 bits/Hz (with the use of MIMO ca-
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