Chapter 6
Multi-Input-Multi-Output Antennas for Radio Frequency Identification Systems

Shivali G. Bansal
Deakin University, Australia

Jemal Abawajy
Deakin University, Australia

ABSTRACT

In this chapter the authors discuss the physical insight of the role of wireless communication in RFID systems. In this respect, this chapter gives a brief introduction on the wireless communication model followed by various communication schemes. The chapter also discusses various channel impairments and the statistical modeling of fading channels based on the environment in which the RFID tag and reader may be present. The chapter deals with the fact that the signal attenuations can be dealt with up to some level by using multiple antennas at the reader transmitter and receiver to improve the performance. Thus, this chapter discusses the use of transmit diversity at the reader transmitter to transmit multiple copies of the signal. Following the above, the use of receiver combining techniques are discussed, which shows how the multiple copies of the signal arriving at the reader receiver from the tag are combined to reduce the effects of fading. The chapter then discusses various modulation techniques required to modulate the signal before transmitting over the channel. It then presents a few channel estimation algorithms, according to which, by estimating the channel state information of the channel paths through which transmission takes place, performance of the wireless system can be further increased. Finally, the Antenna selection techniques are presented, which further helps in improving the system performance.

1. INTRODUCTION

The signal transmission in Radio Frequency Identification Systems (RFIDs) takes place through a wireless medium where it tends to deteriorate due to multipath, fading and inter-symbol interference (ISI). The RFID technology communicates through radio waves to transfer data between a reader and a tag attached to an unit for the purpose of tracking, sensing, and identifying various targets in wide-range of applications like supply chain, transportation, airline baggage handling,

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medical and biological industry, homeland security identification, tracking and surveillance and many more. Unlike barcodes, RFID technology offers several other key benefits such as no line of sight (LOS) requirements, robustness, speed, bidirectional communication, reliability in tough environments, bulk detection, superior data capabilities, etc. Because of this, RFID is proving very successful for wide area of applications where traditional identification technologies are inadequate for recent demands. Presently, RFID technology is being wide-spread and applied to real world system. The designing of RFID systems requires a wide range of hardware and software, protocols and algorithms, applications, etc. Signaling through wireless channel is one major technical factor that needs to be carefully understood. The reliability of a wireless channel is closely related to the signal fading conditions occurring during the transmission and reception of signal to and from the tag, respectively.

Wireless communication plays a significant role in understanding and dealing with the effects of channel fading. It has been a topic of study for over half a century now but the past decade has been the most exhaustive period and this research thrust in the past decade has led to a much richer set of perspectives and tools on how to communicate over wireless channels. The high rise in demand for new wireless capacities, low-powered sophisticated signal processing algorithms and coding techniques, the successful second-generation (2G) and third-generation (3G) digital wireless standards surge towards the demands for continued research activities in this area. Adachi (2001) focused on some of the wireless technologies that emerged in the past and also provided an insight into the future wireless technologies. The conventional single-input single-output (SISO) systems failed to meet the growing demands for supporting transmission of images, voice, data and video related services, new wireless multimedia services such as Internet access, and multimedia data transfer, hence, wireless systems with multiple element antennas (MEAs) were proposed. In the recent years, there has been exploring interests in multiple input multiple output (MIMO) systems because of their ability to greatly enhance the data rates and channel capacity. MIMO technology can be defined as a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time. It takes advantage of the radio-wave phenomenon called multipath where transmitted information bounces off walls, ceilings, and other objects, reaching the receiving antenna multiple times from different angles and at slightly different times due to reflection, refraction and scattering. Due to this multipath phenomenon, an accurate and reliable transmission may not be always possible. To deal with this multipath behavior, communication researchers have thought of many different possibilities to increase the so-called diversity, by using multiple transmitters and receivers. Several different types of diversity modes are used in order to make the communication system more robust like time, frequency, spatial diversity and so on. The higher the diversity is, the lower is the probability of a small channel gain. Besides the advantages of spatial diversity in MIMO systems for improved robustness, multiple antenna technology can also be used to increase data rates by using spatial multiplexing. However, in practice, both diversity and spatial multiplexing can be used, separately or in combination, depending on the channel condition.

The present day invention relates to use of multiple antennas for a RF reader on a RFID system to significantly increase the operating range. RFID systems with single or multiple antenna in reader or in tag have been studied in (Nikitin & Rao, 2008), (Ingram et al., 2001), (Griffin & Durgin, 2008) both theoretically and through simulations. Similar to MIMO systems, spatial diversity can be achieved through the use of multiple antennas at either the reader transmitter or the reader receiver, or at both. It follows the basic principle that by combining the signals from multiple antenna elements, the received signal-to-noise