Chapter 4
Differential Integrated Circuit Package Antenna for RFID Reader

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ABSTRACT

The emphasis of this chapter is to introduce the design of the integrated circuit package antenna (ICPA), which is a compact and cost-effective antenna design method for RFID reader. The concept, the architecture, and the characterizations of the ICPA will be discussed in details. As differential circuitry dominates in RF transceiver integrated circuit design due to its good performance, microstrip antennas can be seen for use in radio systems with differential signal operation. In this chapter, the improved theory of single-ended microstrip antennas based on the cavity model is expanded to analyze the input impedance and radiation characteristics of the differentially-driven microstrip antennas and ICPA. The occurrence of the resonance for the differentially-driven microstrip antennas, which can be tuned by adjusting the ratio of the separation of the dual feeds to the free space wavelength, will be analysed. Furthermore, the frequency band selection capability of the differential ICPA will be presented.

1. INTRODUCTION TO ICPA

Radio Frequency Identification (RFID) procedures, in recent years, have become very popular in many service industries, purchasing and distribution logistics. “An archetypal RFID system consists of an interrogator, more often known as a reader, a transponder or tag, and antennas to mediate between voltages on wires and waves in air” (Dobkin, p.22). Figure 1 shows the overview of the RFID system.

A RFID reader plays a quite important role in the whole RFID system. There is an un-ignorable trend toward more flexible applications and toward higher carrier frequencies for RFID readers. Higher integration density is in need due to the demand for smaller and lighter portable or hand-held RFID devices. The ultimate goal would be a single-chip solution. However, the integration of the passives for high frequency bottlenecks the single-chip solution. Until now, no absolutely true single-chip solution is available, a package is still

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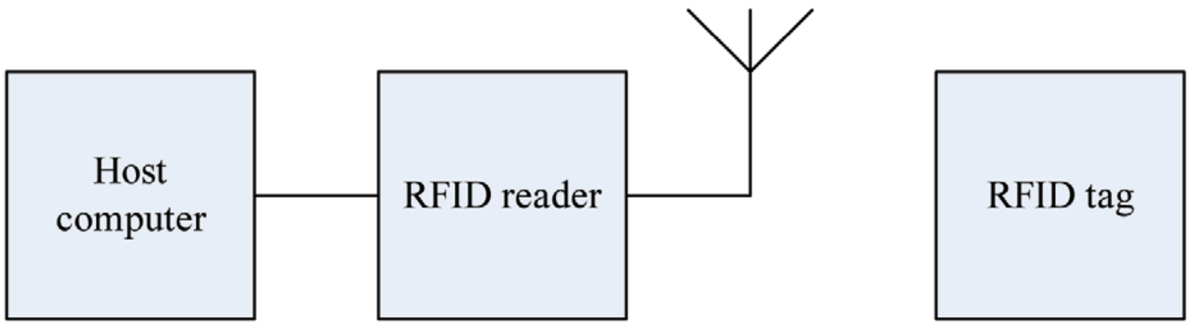
Figure 1. Overview of the RFID system



necessary in order to connect the antenna or external filters.

Antenna is another key component of the RFID system. Antennas applied in RFID systems particularly in handheld devices are usually required to have a small size and be easy to be integrated with other components. Compact planar antennas meet the need of high integration density of the RFID devices and become the favorite candidates for the RFID applications because of their clear advantages in terms of weight, manufacturability, compatibility with microwave circuits and cost. Considering good performance of the compact planar antennas, a lot of researchers have paid great efforts to develop novel antenna types that can be applied in RF applications (Hwang, Moon, et al., 2004; Midrio, Boscolo, et al., 2009; Thomas and Sreenivasan, 2010; Avila-Navarro, Cayuelas, et al., 2010). In Hwang, et al. and Avila-Navarro, et al.'s works, printed dipole antennas are presented. The proposed dipole antennas operate in the 2.4 and 5.5 GHz bands with a compact size. Midrio, et al., presented a compact planar dual-band antenna for the wireless application. In this work, a printed dipole antenna and a bowtie antenna are used to get the dual-band characteristic. In Thomas's work, a coplanar waveguide patch antenna is proposed for the 2.4 and 5.5 GHz dual-band application.

Nowadays, differential circuitry dominates in RF transceiver integrated circuit (IC) design because of its good performance. Hence, microstrip antennas can be seen for use in RF systems with differential signal operation. The differentially-driven microstrip antenna takes full advantages of the standard surface-mounted package; consequently, the system-level board space and the system-level assembly can be reduced and facilitated, respectively. The differentially-driven microstrip antenna introduces a virtual ground; accordingly, there is no need for connecting the ground of the solid-state devices and the ground plane of the antenna, and the parasitic effect caused by interconnect is eliminated. Furthermore, the state of the art single-chip and single-package solutions of RFID readers call for differential antennas to reduce the bill of materials and to improve the receiver noise performance and transmitter power efficiency. Kinds of planar dipoles have got much attention (Hwang, Moon, et al., 2004; Midrio, Boscolo, et al., 2009; Avila-Navarro, Cayuelas, et al., 2010). As a type of balanced antenna, a dipole antenna offers the ability to avoid the disturbances from nearby dielectrics which is quite significant for the handheld RFID devices. However, a dipole antenna always has a large size and this makes it difficult to integrate a dipole antenna and other RF components together with a high integration level. A dipole antenna can be made compact by bending it. Bent dipoles have a much smaller size than conventional straight dipoles and are much easier to be integrated into the RFID devices, but the gain and bandwidth also decrease. One approach to making a high-gain compact antenna is to construct a patch antenna (Dobkin, p.281).