Chapter 7
Design of High Efficiency Power Amplifier for RFID Readers

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ABSTRACT

In RFID reader systems, power amplifier plays a critical rule for efficiency enhancement. A high efficiency power amplifier may not only increase the life expectancy of portable RFID devices but also reduce the reliance on heat sinks. Heat sinks usually occupy plenty of space and lead to packing difficulties. A well-designed power amplifier with high efficiency and output power may also increase the reading range of RFID and system reliability, especially for the applications requiring long reading range (e.g. vehicle tagging in complicated traffics) or in a lossy environment (e.g. in sensing in rainy weather). This chapter systematically introduces the typical power amplifiers classified as Class A, AB, B, E, and F. The principles of Class F are emphasized due to its outstanding performance in efficiency enhancement. A practical design example is also presented, and also some recent typical techniques for improving the performances of Class F power amplifier are summarized.

1. INTRODUCTION

In modern wireless communication systems, efficiency enhancement has become one of the most popular topics, which significantly attracts much attention of researchers. For radio frequency identification (RFID) systems (especially for the portable readers and active tags), high efficiency power amplifiers play a crucial rule due to the limited capacity of the portable battery. Moreover, it is usually expensive and difficult to improve the capacity of a battery, so the best way to prolong the lifetime of a portable RFID device is efficiency enhancement.

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RFID is a contactless data-capturing technique, which uses radio frequency (RF) waves for automatic identification of objects. In terms of implementations, the applications of RFID can be categorized into five different groups (Glover & Bhatt, 2006): smart shelf, access control, tag and ship and track/trace. In different implementations, the RFID tags and reader systems have to be specially designed based on the conditions of the environments. A general RFID system usually consists of a tag system and a reader system. The tag system with active components and on-tag battery is known as active RFID, while the system with only passive circuits is known as chipless RFID. Active and chipless RFID are two classifications of RFID system distinguished by the criterion that whether the tag system is using a battery or not. For the RFID readers, both active and chipless systems have the same topologies of transmitter and receiver parts (Preradovic & Karmakar, 2007; Karmakar, 2010). The transmitter part is composed of a transmitting antenna, a power amplifier (PA), a bandpass filter and an oscillator, while the receiver part is composed of a receiving antenna, a bandpass filter, a low noise amplifier (LNA), a demodulator and base band processing units.

As a key component in RFID reader system, a power amplifier plays a significant rule of transmitting RF signals to the tag system. For an active tag system or a portable reader system, power added efficiency (PAE) of the power amplifier affects the lifetime of a battery. High PAE means an endurable performance of the system and that the system is more applicable for the long time sensing situations (for example of equipments tracking and patients monitoring in hospital [Cangialosi, Monaly, & Yang, 2007; Hakim, Renouf, & Enderle, 2006]). Moreover, high PAE can effectively reduce the requirements of heat sinks, which will significantly reduce the packaging complexity and cost.

The active device in a power amplifier can be a field-effect transistor (FET) or a bipolar-junction transistor (BJT). For convenience, this chapter only utilizes FET models. This chapter is suitable for those readers, who have certain elementary knowledge of power amplifiers and RFIDs. A summarized theory of the classical high efficiency power amplifiers - Class F is provided, including a practical design example. The readers will be benefit from the example which can be further applied during the development of future RFID system.

This chapter is organized as following: section 2 presents the background of the conventional RFID reader system and the general knowledge of power amplifier classification. In section 3, as a classical high efficiency power amplifier, Class F power amplifiers is introduced, including the principal theories, design methodologies and the latest development. In last section, a summary of the chapter is presented.

2. BACKGROUND

2.1 RFID Readers

RFID is an automated contact-less data capturing technique which can be found in more and more applications in numerous fields. The RFID system mainly includes two basic parts: RFID tag and RFID reader. An RFID reader is a device that is applied to interrogate an RFID tag. The reader emits radio waves via reader antenna to the tag system and the tag responds by sending back a unique identification data. Figure 1 shows the block diagram of a reader system. In a conventional RFID reader system, HF (high frequency) interface is used to enable RF signal to be transmitted and received. HF interfaces consists of two paths with signal flows from and to the antenna — one is transmitting path and the other is receiving path. In the transmitting path, the oscillator circuits generate a HF signal. However, the power of the generated signal is relatively low and the generated signal cannot be transmitted over a long