Chapter 5.9
Microsystems for Wireless Sensor Networks with Biomedical Applications

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ABSTRACT

This chapter introduces the concept of wireless interface, followed by the discussion of the fundamental items, concerning the fabrication of microsystems comprising low-power devices. Using as example, a design of a RF transceiver the frequency of 2.4 GHz and fabricated using a UMC RF CMOS 0.18 µm process, it will be discussed the main issues in the design of RF transceivers for integration in wireless microsystems. Then, it will be presented two biomedical applications for wireless microsystems: the first is a wireless EEG acquisition system, where it is presented the concept of EEG electrode and the characterisation of iridium oxide electrodes. The other application, is a wireless electronic shirt to monitoring the cardio-respiratory function. The main goal of these applications, is to improve the medical diagnostics and therapy by using devices which reduces healthcare costs and facilitates the diagnostic while at the same time preserving the mobility and lifestyle of patients.

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1 WIRELESS INTERFACES AND MICROSYSTEMS

1.1 Introduction

Wireless communication microsystems with high density of nodes and simple protocol are emerging for low-data-rate distributed sensor network applications such as those in home automation and industrial control. This type of wireless microsystem with sensors and electronics are becoming of interest for biomedical applications. Moreover, in order to implement an efficient power-consumption wireless sensor it is necessary to develop a low-power low-voltage RF CMOS transceiver. As is of common knowledge, the CMOS technology has reached its maturity. Therefore, design engineers used it for developing RF circuits. The advantages of CMOS technology are the higher integration, low-power consumption, low-voltage supply and low-cost compared with Bipolar technology. The use of CMOS process with low length for the channels of the MOSFETs is very important for high-frequency devices. As will be seen further in this chapter, this was one of the main reasons that were behind the choice of the UMC RF 0.18 μm CMOS process to design, optimise and fabricate, a radio-frequency (RF) transceiver for the operation in the frequency of 2.4 GHz.

1.2 System Requirements

In wireless sensors networks, the communication is made by way of a radio-frequency (RF) link. Thus, in order to such a communication be possible, a wireless interface must be designed. This wireless interface is a RF transceiver, which after be connected to an associated antenna, makes possible to wirelessly communicate with the exterior. The RF transceiver must present dimensions comparable with the other elements of the microsystem, in which it will be integrated, such as the sensors and the electronics of processing and control. Miniaturised microsystems makes possible to have mass productions with low prices, favouring the spread of applications relying on these same microsystems. Moreover, solutions relying in wireless microsystems, offer a flexibility such as it is possible to chose how many and which are the sensors to be integrated together with the RF transceiver and the remain electronics. Using multi-chip-module (MCM) techniques and a limited number of components in different technologies, it is possible to fabricate devices for a huge range of applications. Figure 1 shows a generic microsystem architecture for use in wireless sensors networks applications. This microsystem connects to an antenna and it is given a special focus to the way the different blocks interact between each other.

In wireless communications, the antenna is one of the most critical subsystem, thus, in order to not compromise the desired miniaturisation, the antenna must be small enough to comply with size constraints of the microsystems. The investigation of new frequency bands (Celik *et al*., 2008) and new geometries (Mendes *et al*., 2006) will make possible to have smaller antennas to integrate in wireless microsystems (Touati & Pons, 2003; Carmo *et al*., 2006). This makes the chose of the most suitable frequency, one of the more decisive aspects in the design of RF transceivers. Normally, the desired range, baud-rate and power consumptions are key-aspects in the design to take in account, when the frequency of operation is to be selected. At a start-up point, the range limits the maximum usable frequency, because the loss suffered by the radiowaves in the free-space increases with the distance. Considering the loss for a line-of-sight (LOS) scenario (Lee & Lee, 2000):

$$a = [\lambda/(4\pi d)]^2 \qquad (1)$$

where, λ is the wavelength [m] and d [m] is the separation between the transmitter and the receiver, thus anyone concludes that a way to compensate