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FACULTY OF ENGINEERING

Electronics and Communications Engineering Department

Low Power Transmitter Design for Wireless Sensor Networks

A Thesis

Submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

Submitted by

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

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The usage of wireless links in our everyday life is increasing dramatically. One example of this is the emerging field of wireless sensor networks (WSN). This new field presents many opportunities and challenges. One particularly difficult aspect of wireless sensing is the implementation of the radio link.

This dissertation demonstrates the design of a low power transmitter for wireless sensor networks (WSN). It begins with an introduction to WSN, their applications and requirements. Current state-of-the-art transmitter implementations for WSN transmitter are presented and compared favoring ultra-wide band impulse radio (UWB-IR) as an enabling technology for low power radio links. The IEEE 802.15.4a standard for UWB-IR is presented and design constrains are extracted.

Next, the dissertation presents the design of a standard compliant UWB-IR transmitter. The system architecture is explained, it is subdivided into two major blocks: a digital frequency locked loop (FLL) and a pulse generation, modulation and shaping circuit. The FLL is used for RF carrier generation between 3 and 5GHz, it includes a digitally controlled oscillator, a high frequency divider and an early-late frequency detector. The pulse generation and shaping circuit shapes the RF carrier into UWB pulses using a triangular pulse generator and a pulse shaping

mixer. These main blocks of the transmitter are analyzed, designed in 0.13μm CMOS technology, and Spectre simulation results are shown. Exploiting the inherently low duty cycle of UWB signal, low power operation was achieved by turning-off most of the transmitter blocks between two communication bursts. Operating at a data rate of 1Mbps, the power consumption was only 1.44mW.

Key words: low power transmitter, wireless sensor networks**,** ultra-wide band impulse radio (UWB-IR), IEEE 802.15.4a standard, digitally controlled oscillators, pulse shaping mixer.

SUMMARY

This dissertation demonstrates the different issues of implementing a low power transmitter for wireless sensor networks (WSN) applications. The dissertation is divided into four chapters organized as follows:

Chapter One: This chapter is an introduction to WSN. Main applications and requirements are identified. The requirements for a wireless transceiver and current research trends for its implementation are discussed.

Chapter Two: In this chapter, the Ultra-wide Band impulse radio technology is presented together with its IEEE standard requirements. The proposed transmitter architecture and its operation are explained.

Chapter Three: In this chapter, the design of the digital frequency locked loop (FLL) for carrier generation in 0.13µm CMOS technology is presented. The main blocks of the FLL are analyzed, designed, and simulated.

Chapter Four: In this chapter, the design of a pulse generation, modulation and shaping circuitry in 0.13µm CMOS technology is presented. The main building blocks are analyzed, designed, and simulated.

Finally, the thesis ends by extracting conclusions and stating future work that may be done based on this work.

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CONTENTS