Ain Shams University
Faculty of Engineering
Electronics and Communications Department

Ultra-low power transceiver for no-battery applications

A Thesis submitted in partial fulfillment for the requirements of a Master of Science degree in Electrical Engineering Electronics and Communications Engineering Department

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Cairo 2016

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Statement

This Thesis submitted in partial fulfillment for the requirements of a Master of Science degree in Electrical Engineering Electronics and Communications Engineering Department.

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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Dedication and Acknowledgments

All praise is due to Allah, most merciful, the lord of the lorlds. I would like to thank God for granting upon me the chance, strength, and ability to complete this work. Alhamdulillah.

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drive and an ability to tackle challenges head on.

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Abstract

Mo'men Mansour Mohammed "Ultra Low Power Transceiver for no-battery applications", Master of Science dissertation, Ain Shams University, 2016.

This thesis presents system and circuit design techniques for an Ultra low Power Transmitter (Sub 1mW) to be used in Internet of Things (IoT) and Wireless Sensor Network (WSN) Applications. The implementation is driven by the continuous need for decreasing the energy consumption of wireless transceivers for the WSN and IoT applications, Wireless Sensor networks is seeking continuous reduction in power consumption, since frequent battery change is impractical. This transceiver aims to utilize multiple phases from a ring oscillator to generate higher frequency component at transmitter and receiver side, enabling oscillator design at much lower frequency than carrier frequency, edge-combiner-type power amplifier to operate the oscillator at only 1/3 of the RF frequency. A non-PLL based local oscillator architecture have a fast startup and calibration time to enable further energy saving. The close in phase noise is mitigated by using a largely separated tones for 1's and 0's, treading off the spectral efficiency with the ultra low power consumption. This enables installation of this transceiver on energy harvesting system without using any conventional power source. The transmitter was implemented on standard CMOS 0.18μm process (IBM7RF), occupying an active area of 0.112 mm^2. Targeting the ISM band from 902 MHz to 928MHz. The transmitter was tested on a test board using external matching network achieving power consumption lower than 1mW at -10dBm output power.

Keywords : Low Power, Ultra-low Power, Transmitter, PLL-less, Battery-less, Transceiver, Matching Network, PCB, WSN, Ring Oscillator, Edge Combiner, ISM, Radio Frequency, RF, Power Amplifier.

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Summary

This thesis is divided into six chapters as follow:

Chapter 1 is an introduction including the motivation for this work, followed by the thesis outline.

Chapter 2 includes a survey of the available transmitter and receiver architectures , and the selected architecture .

Chapter 3 describes the circuit level of the Local Oscillator (LO), consisted from a novel Vertical Ring Oscillator along with its calibration circuits. The chapter includes schematics, layouts and simulation results.

Chapter 4 reveals some theoretical background for the PA design, then it will present the design of an edge combiner Power Amplifier and the external impedance matching network, including the iteration that have been done on board level until the final design .

Chapter 5 has the top level integration and verification of the transmitter, it also depict the lab measurements for the chip and achieved results summary.

Chapter 6 is the conclusion for this work and the suggested future work on this system either an optimization or extra features need to be implemented.

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[1]This section is adopted from [44]