LOW POWER ULTRASOUND COMMUNICATION FOR WIRELESS SENSOR NETWORK

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Low Power Ultrasound Communication For Wireless Sensor Node

Sesi Pengajian : 2018/2019

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DEDICATION

Special thanks to my parents, my supervisor, Dr. Wong Yan Chiew and my friends.

ABSTRACT

A low power wake-up receiver by using ultrasound communication is designed. Wake-up receiver is used to detect wake-up signal to activate a device for power saving in wireless sensor network (WSN). WSN is a wireless network that consists of base stations and sensors nodes to monitor physical and environmental conditions. Power consumption is a challenge in WSN due to activities of nodes. High power consumption is required for the main transceiver in WSN to receive communication requests all the time. Hence, a low power wake-up receiver is needed to minimize the power consumption of WSN. In this work, a low power wake-up receiver using ultrasound data communication is designed. Functional block modelling of the wake-up receiver is developed in Silterra CMOS 130nm process technology. The performance of functional block modelling of wake-up receiver is analyzed with obtaining power consumption of 22.45μW. A prototype to demonstrate a wireless sensor node with wake-up receiver is built by using ultrasonic and RF communication system. The power consumption of the prototype and a sensor node without wake-up receiver are 0.105mWh and 0.311Wh respectively. Wake-up receiver used in WSN can save power and prolong the lifetime of batteries and thus extending the operational lifetime of WSN.

ABSTRAK

Penerima panggilan yang menggunakan tenaga rendah dihasiklan dengan komunikasi ultrasound dalam projek ini. Penerima panggilan digunakan untuk mengesan isyarat untuk mengaktifkan peranti untuk menjimatan tenaga dalam rangkaian sensor tanpa wayar (WSN). WSN adalah rangkaian wayarles yang terdiri daripada stesen pangkalan dan nod sensor untuk memantau keadaan fizikal dan persekitaran. Penggunaan tenaga adalah satu cabaran dalam WSN kerana transceiver utama memerlukan tenaga tinggi untuk menerima permintaan komunikasi sepanjang masa. Oleh itu, penerima panggilan yang menggunakan tenaga rendah direka dengan komunikasi ultrasound untuk meminimumkan penggunaan tenaga WSN. Pemodelan blok fungsi penerima panggilan disimulasi dalam teknologi proses Silterra CMOS 130nm. Prestasi pemodelan blok fungsi penerima bangun dianalisa dengan mendapatkan penggunaan tenaga 22.45μW. Prototaip untuk menunjukkan nod sensor wayarles dengan penerima panggilan dibina dengan menggunakan komunikasi ultrasound dan RF. Penggunaan tenaga prototaip dan nod sensor tanpa penerima panggilan adalah 0.105mWh dan 0.311Wh masing-masing. Penerima panggilan yang digunakan dalam WSN boleh menjimatkan tenaga dan memanjangkan jangka hayat bateri dan dengan itu memanjangkan jangka hayat operasi WSN.

ACKNOWLEDGEMENTS

Final year project is an important and essential part in engineering course. The students are provided an opportunity to gain new experience through application of technical skills in final year project.

First, I would like to express my deepest appreciation and gratitude to Dr. Wong Yan Chiew as my supervisor who provides support, supervision motivation and guidance throughout my final year project. I gained a lot of theoretical and practical knowledge on circuit design from her. She had inspired and motivated me to bring out a successful project.

Next, I would like to thank all the lecturers that had been taught me on the engineering course in Universiti Teknikal Malaysia Melaka. They had taught me a lot of knowledge of electronic engineering.

Lastly, I would like to sincerely thank my parents and friends who provide mental support and encouragement along my final year project.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADC	:	Analog to Digital Converter
CMOS	:	Complementary Metal-Oxide-Semiconductor
CMUT	:	Capacitive Micromachined Ultrasonic Transducer
COSR	:	Colpitts-oscillator-based Super-regenerative Receiver
FLOW	:	Free Space Low Power Wake-up
FSO	:	Free space optical
LNA	:	Low Noise Amplifier
LO	:	Local Oscillator
LOS	:	Line of Sight
MAC	:	Medium Access Control
MCU	:	Microcontroller
NLOS	:	Non Line of Sight
RF	:	Radio Frequency
STD	:	Square-law Detector
TRF	:	Tuned Radio Frequency
VCSEL	:	Vertical Cavity Surface Emitting Laser
WSN	:	Wireless sensor network

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents the background of the project. Problem statement, project objectives, scope of work and importance and significant of the project are stated in this chapter.

1.2 Background of Project

A sensor node is a small in size, light in weight and inexpensive device in a wireless sensor network (WSN). Each sensor node capable to collect sensory information, conduct some processes and communicate with other connected nodes in WSN. Every

sensor node consists of five main components which are a microcontroller, a power source, external memory, transceiver and one or more sensors.

A wireless sensor network (WSN) is a wireless network that consists of base stations and a large amount of spatially distributed and dedicated sensors to monitor physical and environmental conditions such as pressure, temperature, motion, sound vibration or pollutants at different locations [1]. WSN may consists of environmental, physical, gas and optical sensors such as humidity sensors, accelerometer, air quality sensors, infrared sensors and so on.

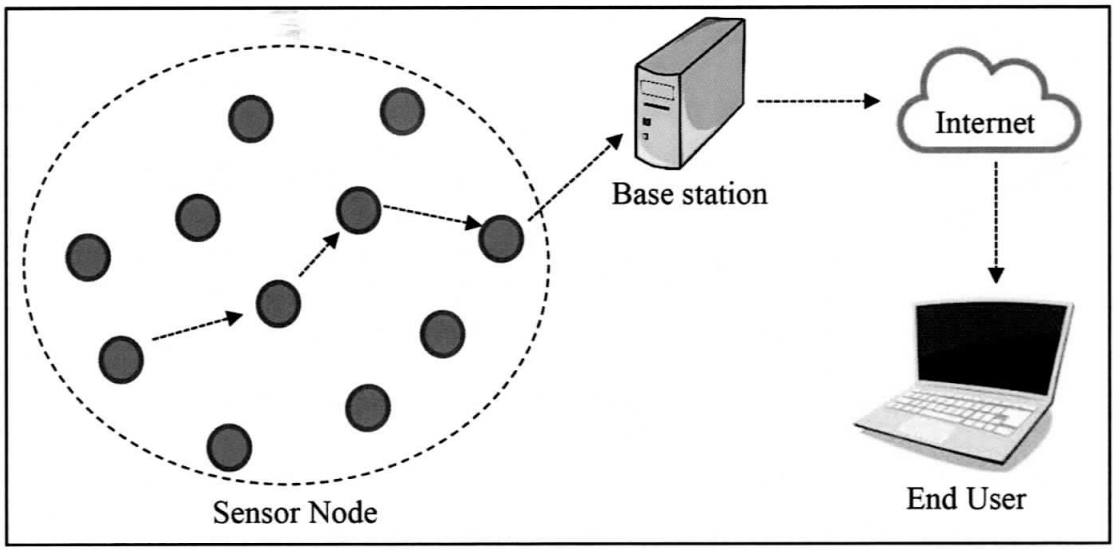

Figure 1.1 : Architecture of wireless sensor network.

WSN is a wireless network which uses radio waves for communication. The properties of its communication are short range, dynamic and narrow bandwidth and unidirectional or bidirectional of communication channel. It is difficult to run WSN smoothly due to the effect of operational environment which may affect the performance of sensors. Thus, the aspects of robustness, resiliency and security must be considered in the hardware and software of WSN for communication [2]. Sensor

nodes in WSN can only communicate with direct neighbours. It communicates with other nodes which is beyond the radio frequency of the node through multi-hop route to transmit data via intermediate nodes [3].

Sensor nodes in WSN capable of organizing themselves as preinstall of network infrastructure is not needed for the deployment of WSN. They work collaboratively to adjust themselves to perform and distribute algorithm. They act as an autonomous platform to form network and to support other network mechanisms [4]. Routing protocols must be able to handle and perform well for all sensor nodes [5].

With the emerging technology of WSN, WSN has developed rapidly and becomes a part in our life. WSN is widely used in this technology era due to its advantages of application in various areas. WSN can scalable to a large range of distribution. Hundreds to thousands of sensor nodes in WSN can be deployed in harsh and hostile environment. WSN provides real time sensory information and capable of collecting real time measurement and sensory information from sensors and processing the data and storing the data in cloud or server [6]. It is flexible for deployment as additional workstation can be added into the WSN if needed and able to adapt any changes in the network [7]. Deployment of wireless network instead of wired system to prevent plenty of wiring and save wiring cost [8].

WSN has acquired growing interest nowadays. It plays an important role in our daily life. WSN provides various uses in many fields as shown in Figure 1.2.

Figure 1.2 : Applications of WSNs. [9]

WSN can be applied in precision agriculture to collect and monitor the sensory information such as carbon dioxide gas, humidity, soil moisture, temperature and so forth. This is to reduce environmental impact and to provide an accurate environment for crop cultivation [10]. WSN is also used in disaster relief operation. Sensor nodes is dropped from an aircraft over a wildfile to measure temperature. In military applications, WSN is used to sense and monitor friendly and hostile motions. Sensor nodes can be used for battlefield surveillance to track enemy movements and detect chemical attacks. They have the capability of actuation to track mobile targets that they can incapacitate hostile entities and locate [11].

In addition, WSN can be used in biomedical applications to access patient information everywhere on real-time basis. It is involved in a generic health monitoring, tele-monitoring and vital signs monitoring [12]. Home automation is also one of the applications of WSN. Embedded sensors in home appliances such as microwave ovens, vacuum cleaners and refrigerators can interact with each other via