WIRELESS SENSOR NODE FOR VIBRATION LEVEL MONITORING

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To my dearest parent and my beloved friends

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ABSTRACT

Wireless sensor networks are becoming more and more common now. It has wide application in different fields, namely health care and industrial monitoring. Traditionally, there are many tools to monitor the vibration level of industrial machinery, but most of them requires some wiring and manually inspecting each machinery individually. With wireless sensor network to monitor the machinery, many problems can be reduced. This project aims to design and build a simple wireless sensor node for monitoring the vibration level of a single artificial source. The sensor node is small in size, portable, cost effective and it is consumes only a 3V battery. The sensor node is went through a simple testing a triggering a receiver node few meters away while monitoring an artificial single source vibration. The results of this project are a small foot print wireless sensor node that can monitor the acceleration of the vibrating source and trigger the receive node if the acceleration level is higher than the threshold value.

ABSTRAK

Rangkaian sensor tanpa waya telah menjadi semakin popluar dalam masa kini. Rangkaian tersebut mempunyai kegunaan yang luas dalam banyak bidang yang berbeza, seperti penjagaan kesihatan dan pemantauan industri. Cara-cara lama untuk memantau tahap getaran mesin industri biasanya melibatkan sistem yang mempunyai banyak pendawaian dan pekerja perlu semak setiap mesin sendiri. Dengan menggunakan rangkaian sensor tanpa waya sebagai sistem pemamtauan, masalah in dapat diatasi. Projek ini bertujuan untuk mereka dan membina satu nod sensor tanpa wayar untuk memantau tahap getaran yang datang dari satu sumber buatan manusia. Hasil projek ini adalah satu nod sensor tanpa wayar yang sangat kecil dan murah dihasilkan. Selain itu, nod sensor tersebut boleh memerhati getaran yang data dari satu sumber. Kalau tahap getaran itu melebihi tahap yang ditetapkan, nod tersebut akan memberi amaran kepada nod menerima.

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CHAPTER 1

INTRODUCTION

1.1 Chapter Introduction

This chapter gives reader a brief introduction of what the project is and the motivation behind it. The problem statements along with the objectives of this project are also described here. In order for the reader to understand the significance of this project, a section was dedicated to it, whereas another section listed out the scope. Thesis outline describing the structure of the whole report is also provided.

1.2 Project Overview

Imagine you are a forest ranger stationed at your country"s national park, with patches of tree stretch as far as your eyes can see in every direction. As a forest ranger, one of your duty would be to ensure the prevention of forest fire. But, how could one possibly spot the spark of forest fire soon enough when there is just so

much area to monitor at the same time? With the help of Wireless Sensor Network that monitors temperature, this task no longer seem troublesome. Wireless sensor nodes that spread throughout a larger area in the forest, monitoring that patch of forest for its surrounding temperature, any spike in temperature is noticeable earlier on.

Now, imagine a modern factory, this time, with different shape and size of machineries operating in the factory floor. The amount of machinery to be monitored for breakdown prevention, too, seem to be tedious work for the worker there. By introducing the same Wireless Sensor Network, but monitoring a different parameter, vibration level, this problem can be reduced. Health condition of hundreds of machinery throughout the whole factory can be monitored at once, provides factory worker a more efficient way to ensure the machineries are in working condition and prevent any catastrophic failure.

In this project, a cost effective and low power wireless sensor node for vibration level monitoring is proposed. A wireless sensor node is the simplest unit of a wide network called wireless sensor networks (WSN). WSN is usually built of hundreds or thousands of sensor nodes, whereby each sensor node is connected to at least one kind of sensor. Sensors connected to each node can either be, temperature sensor, humidity sensor, light sensor, or in this project, vibration sensor.

Each node may or may not be capable of processing data or contain multiple types of memory. Nodes are connected to each other in a WSN through wireless communication and are coded to be self-organize after being deployed in an ad hoc setting. [1]

WSN is widely used in monitoring environmental condition of a wide area, for example, monitoring a huge part of the forest for any possible indication of forest fire. A simple wireless sensor node will be developed in this project to monitor the vibration level of a chosen source. The wireless sensor node only transmits the data

received from the vibration sensor. The data is then received and monitored by a receiver node, at a distance away, hence keeping the hardware away from the vibration.

1.3 Motivation

The motivation behind this project is to introduce wireless technology into present monitoring system. One of the main disadvantages of wired monitoring system is the huge number of wires needed to support the system. Suppose one wire is needed for data transmission and another one for power supply go into each node, 20 sensor nodes will have up to 40 wires to support the network. All this wiring makes it troublesome to install, not to mention maintaining it. By going wireless, wiring problem can be reduced.

Besides, the various applications wireless sensor node can provide is another motivation for this project. Some application can even save lives. For example, structural health monitoring in bridge and building. With continuous monitoring, disaster can be avoided when maintenance are carried out accordingly. Whereas monitoring seismic activity with wireless sensor node can contribute to data collection for research purposes for better preparation in the event of earthquake.

Sustainability of this project is also what motivates the author to propose this title. The sensor node in this project will be designed with as few components as possible to reduce its hardware footprint yet at the same time provides simple vibration level monitoring. With smaller footprint, the device consumes lesser power compared to sensor node with higher complexity. In a long run, the number of battery cells consumed by the whole network is reduced since replacing battery cells is not frequent. This helps bringing down the requirement for battery cells, hence

reducing battery cells manufactured and the manufacturing process that may harm the environment.

Finally, technological advancement in the field of WSN greatly motivated the integration of wireless sensor network into vibration level monitoring system. This project hopes to lower the manufacturing cost and installation cost by introducing an alternative, cost effective solution. With lesser components involved and smaller size, each node is cheaper to manufacture and easier to install.

1.4 Problem Statement

Traditional methods of vibration monitoring involves wired sensor nodes to be installed onto the machinery or hand held device for the workers to go around the factory collecting data. Wired sensor network present the user with too much wire to deal with, whereas employing man power to acquire vibration level data of each machinery individually can be time consuming.

Most wireless sensor node offered nowadays are expensive due to the expertise and time required to design a sensor node. Since the design was done by expert and a lot of time was spent on it, sensor nodes available on the market usually are compact devices with multi sensing feature. For example, nodes that monitor vibration can monitor the inclination of the node, or even the surrounding temperature and ambient light at the same time.

This feature does sound great as customer can fully utilize a sensor node, but it is not practical from a financial standpoint to those who may only need to sense one parameter for a more specific use. Furthermore, sensor node with multi sensing feature contains a lot more components then a single parameter sensing node. This

increases the size of individual node. With the size increases, it will be slightly harder to find a suitable spot for permanent placement.

Aside multi sensing, wireless sensor network solution available on the market nowadays usually employs different wireless protocols, such as, Wi-Fi or ZigBee. Each protocols has their own advantages but they consume more power compared to a transmitter that uses sub 1 GHz Radio Frequency (RF) to transmit data. Beside higher power consumption, these wireless protocols require extra module to be installed or a bigger size microcontroller to be integrated into the system. This space consuming feature is not needed if the user intends to use the system only in a small area.

Besides all that, there is not much development in the field of wireless sensor network that uses sub 1 GHz RF as its wireless protocol. Last but not least, wireless sensor network customised for specific uses only is not that common in today‟s market.

1.5 Project Objective

The goal of this project is to design a wireless sensor node to monitor vibration level. This provides a wireless and a more time efficient monitoring method to monitor machine health. Besides, this project aims to build a wireless sensor node for a more specific use that is both cost effective and low power. In short, the objectives are as follow:

- To design a wireless sensor node for vibration level monitoring
- To build a small, cost effective and low power monitoring system consisting of MCU, RF receiver and accelerometer.

1.6 Significant of Project

The novelty of this project lies here in the wireless communication part, by using a fairly new microcontroller from Microchip Technology Inc. with the model name PIC 12LF1840T39A. This particular microcontroller has a fully integrated Radio Frequency (RF) transmitter in it. The operating frequency of this controller ranges only from 310 MHz up till 915 MHz [2]. Operating frequency of this range are usually used in remote keypad, this project will investigate the possible use of this miniature RF integrated MCU as a sensor node to monitor vibration level.

With its integrated RF transmitter, an even smaller design of sensor node is now possible, effectively shrinking the space occupied by the node. Besides reducing space, a smaller design means lesser parts, and this in turn reduces manufacturing cost and maintenance fee of this sensor node.

The significant of this project also lies in the capability for it to be scalable, and sustainable. The RF band used in this project is license free and common enough to be easily integrated into other projects. Besides, with lesser modules involved, it consumes a lot less power and hence, can sustain longer with battery cell alone.

1.7 Scope

This WSN project involves only a pair of nodes for the purpose of monitoring vibration level. The pair of nodes consists of a sensor node (transmitter node) and a receiver node. The pair of nodes communicate through Radio Frequency (RF) wave.

The testing ground planned for this project is the university‟s laboratory. Whereas the vibration source set for this project will be the vibration generator

available in the laboratory. The shaker"s frequency and amplitude can be tuned to provide a clear picture of the reliability of the microcontroller in acquiring the data.

Vibration level monitoring system can be applied into many field, for this project, only the application in the field of machine health monitoring will be considered. With only one year being allocated for this project, only a few aspects of the project are focused on.

First and foremost, the coding of the microcontroller is one of the main focus since this microcontroller is fairly new and not much examples were found. The design of the circuit inside the sensor node is also one of the focus throughout the year long project. To effectively shrink down the size of the sensor node, optimization of the circuit and better placement of components is required. This project also focused on the reliability of the data transmitted by the sensor node. The output signal is closely observed to ensure the signal transmitted by the sensor node is reliable.

Since the signal strength and vibration frequency is not the focus of this project, therefore, the range of transmission of the sensor node is not looked into and the transmitter only transmits to the receiver that is 5m away. Whereas the range of vibration frequency to be monitored is set to around 5 Hz up to 100 Hz. A small DC battery is used to power up the sensor node whereas the receiver node will get its power from laptop through USB cable.

The sensor node built in this project is set to monitor only vibration level coming from one type of source. Due to time constraint, this project monitors only one source of fixed artificial vibration generated by vibration generator, instead of random vibration level from multiple source overlapping each other.

1.8 Thesis Outline

In Chapter 1, Project Introduction provides a brief overview of this project. It helps reader to easily visualise the said project‟s structure. Motivation and significant of the project is also discussed to give a clear image of why this title is suggested. Scope and limitation is then outlined to act as milestone for this one-year project.

Following it, Chapter 2 that covers Literature Review for this project. This section presents some explanation on perspective and method used in previous research. It also discussed how much this project is related to those researches.

In Chapter 3, Research Methodology, the method used for designing the circuit, collecting data, and analysing it is presented. The considerations for choosing which method to use will also be discussed in this section. Then, it also states what are the advantages of the method chosen compare to the other methods available.

For Chapter 4, Results and Discussion aims to provide the user a clear view of what the project has achieved. The findings of this research is presented with the help of table and figures and some comparison with any related previous research will be done. This section also discussed whether the achievement is related to the objective and the problem statement set by this research initially.

The last chapter is Conclusion and Recommendation. Chapter 5 summarises the results obtained and recommends some direction for future research. This section will also investigate how far the objectives has been reached with the results acquired. In the final part, it will discuss the knowledge and contribution this project has provided to the university.

1.9 Concluding Remarks

Subtopic 1.8 concludes the introductory part of this report. The next chapter covers the review of past researches done and how they are related to this project.

CHAPTER 2

LTERATURE REVIEW

This chapter presents the background information or past research done by other researchers to the reader. There are three parts in this chapter, namely, „Wireless", „Sensor Node", and „Vibration and hardware".

2.1 Wireless

This section gives a simple explanation of what Wireless Sensor Network (WSN) is. The performance targets that must be hit when designing a WSN and what factors affect the design are mentioned here. This section also reviews the work of Lee et al. [3] regarding the four wireless protocols widely used in today"s world.