# DESIGN OF PARKING RANGE METER BY USING ULTRASONIC SENSOR

NURUL DIYANA BT MAT ZAIN

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honors

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

April 2011

**UNIVERSTI TEKNIKAL MALAYSIA MELAKA**

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

**BORANG PENGESAHAN STATUS LAPORAN**

**PROJEK SARJANA MUDA II**

| | | |
|---|---|---|
| **Tajuk Projek** | : | DESIGN OF PARKING RANGE METER BY USING ULTRASONIC SENSOR |
| **Sesi Pengajian** | : | 1 0 / 1 1 |

Saya NURUL DIYANA BT MAT ZAIN
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan ( √ ) :

Signature :
Author : NURUL DIYANA BT MAT ZAIN
Date :

| | | |
|---|---|---|
| ☐ | **SULIT*** | *(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972) |
| ☐ | **TERHAD**** | **(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ☐ | **TIDAK TERHAD** | |

Disahkan oleh:

_____ _____

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Alamat Tetap : BATU 16, JALAN CHANGLON,

06000 JITRA, KEDAH.

Tarikh : …… Tarikh : ……

"I hereby declare that this report is the result of my own work except for quotes as cited in the references."

Signature : …….

Author : NURUL DIYANA BT MAT ZAIN

Date : …….

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineeering (Telecommunication Electronics) With Honours."

Signature : …….

Author : DR. YOSZA BIN DASRIL

Date : ……

## ACKNOWLEDGEMENT

This project would not have been possible without considerable guidance and support. I would like to acknowledge those who have enabled me to complete this project. First of all, I am very thankful to Allah that give me bless and idea to gone through this project until the end.

In particular, I wish to express my sincere appreciation to my supervisor, Dr. Yosza Bin Dasril, for encouragement, guidance and critics towards me to finish up the entire requirement needed in completing the project.

Secondly, I would like to thank for all other University Teknikal Malaysia Melaka staff members that I may have called upon for assistance since the genesis of this project. Their opinions and suggestions have helped me in realizing this project. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Finally, I would like to express my appreciation to my family for their understanding, encouragement and support towards the completion of my project.

# ABSTRACT

This project is about designing an ultrasonic parking range meter using programmable interface controller (PIC) microcontroller system, ultrasonic sensor and several other devices. Ultrasonic parking range meter is a device that measuring the range between vehicle and wall when the vehicle is reversing. The existing device only using sensor and produce bleeping sound when the vehicle is too near to the wall. This project is created to improve this existing device to ensure people are not mistaken in judging their vehicle and the wall range to avoid crashes. This project is using an ultrasonic receiver and transmitter while the range is shown by seven segment LED display in centimeter unit. The receiver and transmitter are situated at the backside of the vehicle's bumper and its function is detecting if there is any object or wall when reverse gear in place. Transmitter will produce ultrasonic to the wall, ultrasonic will turn back to receiver when it reaches the wall and ultrasonic receiver will send the data to PIC microcontroller to calculate the distance. The objective of this project is to avoid car crashes when backing up or parking. It is also an improvement for already used device which is bleeping sound when the vehicle is too near to the object or wall. Even though sensor has many disadvantages to vehicles, but the advantages of using it is cheap, easy to manage, it allows meaningful conclusions to be drawn up about a person's lifestyle and how the system can benefit this. Tools can be developed to predict something undesirable before it actually happens.

# ABSTRAK

Projek ini bertujuan membina sebuah sistem pengesan objek di belakang kenderaan dengan mengunakan pengesan ultrasonik di mana jaraknya akan dipamerkan melalui paparan tujuh segmen. Pada masa kini, pengesan objek di belakang kenderaan hanya mengeluarkan bunyi sebagai tanda amaran bahawa kenderaan sudah terlalu hampir dengan dinding di belakang semasa mengundur kenderaan. Maka projek ini direka untuk menambah baik sistem yang sedia ada supaya kemalangan semasa mengundur kenderaan dapat dielakkan. Secara umumnya, sistem pengesan ini menggunakan penghantar dan penerima gelombang ultrasonik dan paparan tujuh segmen yang akan memaparkan jarak dalam unit sentimeter. Penghantar dan penerima gelombang ultrasonik akan diletakkan pada bahagian belakang kenderaan dan akan berfungsi apabila gear mengundur dihidupkan. Penghantar gelombang akan mengeluarkan gelombang ultrasonik kepada objek di belakang kenderaan dan gelombang tersebut akan dipantulkan semula oleh objek tadi dan diterima oleh penerima gelombang ultrasonik. Gelombang ini akan ditafsir oleh pengawal mikro dan diterjemahkan ke paparan tujuh segmen. Walaupun penggunaan pengesan mempunyai banyak kekurangan, tetapi kelebihannya adalah ia lebih murah dan senang dijaga. Ia banyak digunakan untuk menjangkakan perkara-perkara yang tidak diingini dari berlaku.

# TABLE OF CONTENTS


| CHAPTER | CONTENT | PAGE |
|---|---|---|
| | **PROJECT TITLE** | **i** |
| | **VERIFICATION FORM** | **ii** |
| | **STUDENT'S DECLARATION** | **iii** |
| | **SUPERVISOR'S DECLARATION** | **iv** |
| | **ACKNOWLEDGEMENT** | **v** |
| | **ABSTRACT** | **vi** |
| | **ABSTRAK** | **vii** |
| | **TABLE OF CONTENT** | |
| | **LIST OF TABLES** | **xi** |
| | **LIST OF FIGURES** | **xii** |
| | **LIST OF ABBREVIATION** | |
| | **LIST OF APPENDICES** | |
| **I** | **INTRODUCTION** | |
| | 1.1 Background of Project | 1 |
| | 1.2 Objectives | 4 |
| | 1.3 Problem Statement | 4 |
| | 1.4 Scope of Project | 5 |
| | 1.5 Methodology | 6 |

1.6 Outline of Thesis 6

II LITERATURE REVIEW

2.1 Literature Review Overview 8
2.2 Ultrasonic Sensor System for Collision Avoidance 8
2.3 Object Recognition Using Ultrasonic Sensor 11
2.4 Ultrasonic Sensor Having Piezoelectric and Acoustic Matching Member 12
2.5 Ultrasonic Sensor on Vehicle 15
2.6 Ultrasonic Sensor as Collision Avoidance in Different Beam Width 16

III METHODOLOGY

3.1 Method 19
3.2 Theory on Devices 20
3.2.1 PIC16F873 Microcontroller 20
3.2.1.1 Microcontroller Core Features 21
3.2.1.2 Peripheral Features 22
3.2.1.3 Program Memory Organization 23
3.2.1.4 Data EEPROM and FLASH Program Memory 24
3.2.1.5 Timer 26
3.2.1.6 Analog to Digital Converter (A/D) 27
3.2.2 Receiver Unit 28
3.2.3 Transmitter Circuit 29
3.2.4 Resonator 30
3.2.5 7 Segment Display Circuit 31
3.2.6 Detection Circuit 33
3.2.7 Signal Holding Circuit 34

3.2.8 Power Supply Circuit 35
3.3 Project Activities 36

IV **RESULT AND DISCUSSION**

4.1 Result Overview 38
4.2 Result 38
4.3 Non Technical Flow Chart 39
4.4 Circuit Explanation 42
4.5 Discussion 49

V **CONCLUSION AND RECOMMENDATION**

5.1 Conclusion 52
5.2 Recommendation 53

**REFERENCES** **54**

## LIST OF TABLES


| NO. | TITLE | PAGE |
|---|---|---|
| 3.1 | Data EEPROM and FLASH Program Memory | 25 |

## LIST OF FIGURES


| NO. | TITLE | PAGE |
|---|---|---|
| 2.1 | Detection Condition. | 9 |
| 2.2 | Installation of Ultrasonic Sensor along One Side of The Vehicle. | 9 |
| 2.3 | A Single Reading from Ultrasonic Sensor. | 11 |
| 2.4 | The Ultrasonic Recognition System. | 12 |
| 2.5 | Ultrasonic Sensors Having Piezoelectric and Acoustic Matching Member. | 13 |
| 2.6 | Detection Widths. | 17 |
| 3.1 | Flow Chart of The Project. | 19 |
| 3.2 | PIC16F873 Pin Diagram. | 22 |
| 3.3 | PIC16F873 Program Memory Map and Stack. | 23 |
| 3.4 | PIC16F873 Block Diagram. | 27 |
| 3.5 | Signal Amplification Circuit. | 29 |
| 3.6 | Receiver Circuit. | 30 |
| 3.7 | Resonator Circuit. | 31 |
| 3.8 | 7 Segment Display. | 33 |
| 3.9 | Detection Circuit. | 34 |
| 3.10 | Signal Holding Circuit. | 35 |
| 3.11 | Power Supply Circuit. | 36 |
| 4.1 | Non–Technical Flow Chart. | 39 |
| 4.2 | Ultrasonic Pulse, Echo Signal and Time Measurement. | 41 |
| 4.3 | The Circuit Operation Process. | 42 |
| 4.4 | Sensor Circuit. | 45 |
| 4.5 | PIC and Output Circuit. | 45 |

| | | |
|---|---|---|
| 4.6 | Ultrasonic Parking Range Meter Circuit. | 46 |
| 4.7 | Ultrasonic Parking Range Meter Circuit (Simulation). | 46 |
| 4.8 | Power Supply Circuit. | 46 |
| 4.9 | The Entire Circuit Combination. | 47 |
| 4.10 | The Circuit Construction. | 48 |
| 4.11 | Ultrasonic Parking Range Meter. | 48 |
| 4.12 | Parking Range Meter Display. | 49 |

## LIST T OF ABBREVIATION

| | |
|---|---|
| AD | - Analog Digital |
| A/D | - Analog / Digital |
| ADCTL | - Analog to Digital Control Register |
| ADPU | - Analog to Digital Disable Bit |
| BB | - Big Beat |
| BDLC | - Byte Data Link Communication |
| BDM | - Background Debug Mode |
| CCW | - Counter Clockwise |
| CPU | - Central Processing Unit |
| CW | - Clockwise |
| DC | - Direct Current |
| DDRA | - Data Direction Register A |
| DDRB | - Data Direction Register B |
| DDRP | - Data Direction Register P |
| DDRS | - Data Direction Register S |
| DDRT | - Data Direction Register |
| T EEPROM | - Electrically Erasable Programmable Read Only Memory |
| IC | - Integrated Circuit |
| I/O | - Input / Output |
| LED | - Light Emitting Diode |
| nsec | - nano second |
| NPN | - Negative-Positive-Negative |
| PACTL | - Pulse Accumulator A Control Register |

| | |
|---|---|
| PAD | - General Purpose Input Pin |
| PAEN | - Pulse Accumulator A System Enable Bit |
| PC | - Personal Computer |
| PORTAD | - Port AD Data Register |
| PORTP | - Port P Data Register |
| PORTS | - Port S Data Register |
| PORTT | - Port T Data Register |
| PNP | - Positive-Negative-Positive |
| PWEN | - Pulse Width Enable Register |
| PWM | - Pulse Width Modulation RAM |
| | - Random Access Memory |
| RS | - Recommended Standard |
| SCI | - Serial Communication Interface |
| SPI | - Serial Peripheral Interface |
| TEN | - Timer Enable Register |
| TSCR | - Timer System Control RegisteR |
| TTL | - Transistor-Transistor Logic |

# LIST OF APPENDICIES


| NO. | NAME | PAGE |
|---|---|---|
| A | Ultrasonic Sensor and Specification. | 55 |
| B | Simplified View of Ultrasonic Sensor. | 56 |
| C | AC/DC Characteristic Timing Requirement. | 56 |
| D | Gantt Chart of Project Planning. | 57 |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Project

Human, animal or any other thing can produce sound. This sound is creating by the physical movement which is not matter whether the movement is fast or slow. It depends on the medium that create the sound. The sound movements that been producing can be detected by using an ultrasound sensor. Ultrasonic sound waves are waves that are above the range of human hearing and have a frequency above about 20,000 hertz. So, anything that has frequency above 20,000 hertz may be considered ultrasonic.

Usually, an ultrasonic sensor consists of at least one ultrasonic transducer which converts the electrical energy into sound and vice versa. Ultrasonic sensors have been used in applications such as detecting and identifying solid objects, measuring the shape and orientation of an object, detecting possible collisions between objects to avoid the collisions from happening, room surveillance, flow

measurement and determining a type of material by measuring the absorption of sound. An ultrasonic sensor is also called as a sonar sensor is widely used in application involving range finding and object detection and avoidance. It also known as transducers when they both transmit and receive data detected. An ultrasonic transducer is a device that converts energy into ultrasound or sound waves above the normal range of human hearing.

A parking range meter is an electronic device that detects the physical movement in a given area and transforms motion into an electric signal. The range meter is connected to devices or indicator that will showed the resulting range that detected. Ultrasonic sensors are used in a wide variety of applications and it is mainly used in transportation area. In market, there are many kind of ultrasonic range detector sell, basically this project is to design a parking range meter by using an ultrasonic sensor that use to detect physical movement of human, animal, or anything that move. The design is to improving the existing sensor in detecting range and also to test the reliability and efficiency of the parking range meter by using an ultrasonic sensor.

Nowadays the application of microcontroller is widely used for consumer. A microcontroller is a functional computer system on a chip. It contains a processor core, memory and programmable input and output peripheral. It emphasizes high integration, unlike a microprocessor which only contains a CPU. Adding up to the usual arithmetic and logic elements of a microprocessor, microcontrollers include an integrated CPU, memory which is a small amount of RAM, program memory or both of it and peripherals capable of input and output. Microcontrollers often operate at relatively very low speed compared to microprocessors, but this is sufficient for typical applications. Microcontroller consumes relatively little power and will generally have the ability to maintain functionality while waiting for a process such as a button press or interrupt. Power consumption while inactive may be just nanowatts, making microcontroller ideal for low power and long lasting battery applications. Microcontrollers are used in automatically controlled products and devices such as automobile engine control systems, remote controls and appliances.

By reducing the size, cost, and power consumption compared to a design using a separate microprocessor, memory, and input and output devices, microcontrollers make it economical to electronically control many more processes. Operations of a microcontroller are difficult to be demonstrated without an application. In commercial applications, sensors are often hidden to improve appearance of the whole unit. Operation of sensors observation cannot be done thoroughly. One of the best solutions is by developing an application that is easy to use and have easily understandable operations. This type of sensor wills replace the current sensor used on vehicles that does not used any microcontroller in its sensor circuit but only adjusting their sensitivity. By replacing this ordinary sensor, driver will be more confident and car crash during reversing can be avoided.

There are several ways to measure distance without contact. One way is to use ultrasonic waves at 40 kHz for distance measurement. Ultrasonic transducers measure the amount of time taken for a pulse of sound to travel to a particular surface and return as the reflected echo. The circuit calculates the distance based on the speed of sound at 25ºC ambient temperature and shows it on a seven segment display. By using this kind of circuit, distance up to 2 meters can be measured. In this project, the ultrasonic transmitter unit will excite with a 40 kHz pulse and expect an echo from the object whose distance that wants to be measured. The transmitted burst will travels to the object in the air and the echo signal is picked up by another ultrasonic transducer unit which is receiver, that also a 40 kHz pre-tuned unit. The received signal, that is very weak, is amplified several times in the receiver circuit.

The parking range meter is designed by combining several equipments which are the ultrasonic sensor, various types of IC, resistor, capacitor, diode and transistor. It used microcontroller PIC16F873 as the main part of the circuit. The ultrasonic transducer works as a sensor to interpret the echoes from the objects or human. While the RF transmitter and receivers are the devices that transmit and receive the signal from the transducer. This system calculated the range detected by receiving information from the sensor that detects the object and it is very useful to find object even though it will be in a darker environment. The transmitter and receiver operate

using radio frequency signal that can penetrate the wall, so the system can be used by contractors to find the obstacle in the tunnel.

## 1.2 Objectives

The objectives of this project are:

1. To develop hardware and software of the parking range meter by using ultrasonic sensor.
2. To develop the interface between the hardware and software of the prototype.
3. To test the reliability and efficiency of the prototype.

## 1.3 Problem Statement

Nowadays**,** there are many devices invented to measure the distance or range of object and it is become popular among people especially to avoid the accident or car crash from happening. For example, the parking range meter that used radar as a medium of detection range for a luxury car. The luxury car had be equipped with that device that surely expensive and not affordable to the local user. Furthermore, the device is using radar as a detection medium which can detect long range objects up to 150 meters. For short range detection device, it is still in a development in a market and users are demanding for it[1].

Besides, there is device in market that invented which can detect the range of object but alarming or warning the driver the sound alerts. The sound produce is annoying and making the driver uncomfortable. Other than that, the sound alarm is usually not really accurate and the drivers cannot determine the exact range of the obstacles accurately. So, basically when the driver put on the reverse gear, the sound is starting to sound with bleeping sound until the gear is change to other. The existing product of the parking range meter is also expensive and less affordable. Because of the entire factor above, the ultrasonic parking range meter is used to detect the obstacles or object when car is backing up.

## 1.4 Scope of Project

There are several scope considered in this project, that can be categorized in five main element process. These elements can help to obtain the understanding about the whole project in order to develop the project. The elements are:

1. PIC 16F873.
2. Ultrasonic Sensor.
3. 7 Segment Display.
4. Proteus 7 Professional Edition.
5. Microsoft Visual Basic.

The scope of the project flow is stated below:

1. Develop the program for microcontroller (PIC 16F873) using Microsoft Visual Basic.
2. Simulate the program.
3. Build the project circuit and test the circuit using Proteus 7.0.
    a. Combine the receiver, transmitter and power supply circuit into one circuit and test the circuit. The circuit is converting ultrasound signal into the detection range and displaying the distance between can and obstacles in a range in cm unit using 7 segment display.
    b. The circuit consist of signal amplification circuit, detection circuit, signal detector and signal holding circuit. Resonator is used to exhibit the resonance and oscillates at some frequencies which is called resonance frequency.
4. Develop the interface between hardware and software.
5. Build a panel unit display for the circuit.

## 1.5 Methodology

For this project, there are three stages that need to be completed in order to complete the project. First, the literature review of the entire component and element in this project needed to be understood. The concept of sensor and how the sensor work are important to make sure that the device will work properly and can detect the obstacles. Other than that, the suitable type of microcontroller needed to be selected and understand to maximize the usage of the microcontroller. The data sheet of the microcontroller is used as reference to know the specification that needed by that microcontroller and how it functioned. Furthermore, the data sheet contain circuit diagram, the power consumption of the PIC, the used of every pin in PIC and it connection.

Then, the research is done on current product in the market to make sure that the device can be upgraded into more useful device. By doing some research, the product can be improved and can avoid mistakes during the circuit construction process. Other than that, the current device also can be compared to this project due to the higher or lower price offered on market. Then, the proper assembly language is developed to make sure that the microcontroller PIC can work properly. The coding also will make sure the effectiveness and accuracy of the detection range for the device is determined. The suitable power supply also need to be chose to avoid the overload power that will caused the component in the circuit suffer damaged. Then, the circuit is constructed to develop the project.

## 1.6 Outline of Thesis

This thesis consists of five chapters including this chapter. The content of the chapters in this thesis are outlined below:

1. Chapter 1 is about the introduction of the project. The basic idea of the project, the objective and overall view about the project.

2. Chapter 2 focuses on literature review of this project based on journals and other references. Discuss about the element that is used in this project.
3. Chapter 3 mainly discuss on the methodology of the project. It is contain all the information and technical data of the implement system design. This chapter including details on the progress of the project and interface between hardware and software are explained in this chapter.
4. Chapter 4 presents the result and discussion that come from the output of the project. It is focus on the result based on the experiment.
5. Chapter 5 is the last chapter which is about the overall of the project. It is contain the conclusion and future recommendation of this project. The several problems to complete the project and the solution to the problem are included in this chapter.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Literature Review Overview

In completing this project, some literature reviews have been done on several resources. The theory and description plus details about the project have taken as guidance in completing this project. By this chapter, an overview of some application that similar to the project and related project design is present.

## 2.2 Ultrasonic Sensor System for Collision Avoidance.

The ultrasonic sensor also designed for detecting the vehicle that pass by the side of the vehicle. The invention of this system is to enhance the rear- view mirrors and an improvement to the blind spot of vehicle. The detection range of this device is higher which is 6 meter because it is used more than two ultrasonic sensors to detect the target range thus increasing the cost of the device.

From this paper, the general study about other existing sensor system also being done. The Doppler radar system, ultrasonic sensor system and vision system are the most popular and usable system that used to detect the object distance. For Doppler radar system, it is no suitable for low speed because it will cause an error