"I / We hereby certify that I / We have read and understood the following project thesis. To my / our opinion, this thesis is sufficient in terms of scope and quality to achieve partial fulfillment of requirements for the Degree of Bachelor in Electronic Engineering (Industrial Electronic)".

Signature : 
Name of supervisor : Kok Swee Leong
Date : 31 March 2005
ULTRASONIC COLLISION AVOIDANCE MOBILE ROBOT

OOI SEE KOK

This Report is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree of Electronic Engineering (Industrial Electronic)

Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Kolej Universiti Teknikal Kebangsaan Malaysia

March 2005
"I admitted that this reports is my own works except for the sentences or phrases that I have stated its sources"

Signature : 

Writer's Name : Ooi See Kok

Date : 1 April 2005
To my Beloved family.
Especially my parent.
ACKNOWLEDGEMENT

First of all, many thanks and gratitude to Mr. Kok Swee Leong, my supervisor; for the guidance, the patience and the help that he gave me throughout the commencement of this project.

Many thanks also to the Dean, Prof. Abdul Hamid Hamidon, Mr. Soo Yew Guan, the PSM Project Coordinator, the technicians and all my fellow friends on helping me to complete this project.

Not forgotten to my family members, my colleagues, and for all who had involved directly or indirectly by giving inspirations and support throughout the year.
Now a day, the intelligent robotic technology is popular and being used in industry and also in daily life. Because of this, the prototype of ultrasonic sound sensor machine is being designed.

There are many application using ultrasonic sensors. Ultrasonic sensor is low cost, available, high sensitivity and it function is easily to be understood. It can be applied as a collision avoidance detector.

Ultrasonic sensor measure distance by producing voltage proportional to a distance between the sensor and object. When the sensor is interfaced to a microcontroller, signal received can produce an output to the motor drive and hence avoid collision which is reflection of an obstacle.

At the end of this project, a prototype of a collision avoidance mobil robot resemble a mower machine will be build.
ABSTRAK

Pada masa kini, teknologi robotic menjadi semakin popular dan semakin banyak digunakan dalam bidang industri. Oleh kerana ini, projek ini telah direkabentukkan

Ultrasonic mempunyai pelbagai kegunaan. Harganya juga tidak begitu mahal, senang digunakan, mempunyai kepekaan yang tinggi dan fungsinya juga senang difahami. Ultrasonic juga boleh digunakan sebagai pengesan objek

Ultrasonic mengesan jarak antara objek dengan pengesan dengan menghantar isyarat dalam bentuk voltan. Apabila pengesan ini disambungkan dengan penggawal mikro, maklumat yang diterima daripada pengesan itu akan dihantar ke pemandu motor supaya mengelakukan kemalangan.

Pada penghujung projek ini, satu prototaip bagi robot pengelak telah dihasilkan.
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CHAPTER I

INTRODUCTION

1.1 Background Of The Project

Ultrasonic Collision Avoidance Mobil Robot is the project which will avoid the mobile robot from obstacle. The mobile robot will automatically detect the object if there have any object in front of it. With this, it will turn to make sure the mobile robot is not crash with the object.

This project has ultrasonic sensor, microcontroller, comparator, and servo motor. Each component has each function. The fully function will be explain in following chapter.

At the last of the project, the model of ultrasonic sound collision avoidance mobile robot was build.
1.2 Problem Statement

This might help avoid workers from accidents. After the ultrasonic sensor was mounted on automated vehicle or machine it will allowed it to sense obstacles and objects nearby. This intelligent robot based on ultrasonic sensor can be functioned automatically to avoid accident.

1.3 Objective of the Project

1.3.1 Objective

In this project, the main objective is to build Ultrasonic Collision Avoidance Mobile Robot prototype. Before starting this project, the characteristics of ultrasonic sensor was studies. Then the ultrasonic sensor controller circuit will be design and built. Microcontroller AT89C2051 and Octal Buffers SN74LS244 were used to construct the controller circuit platform and 2 servo motors are used to implement movement of the robot. The robot consists of 3 wheel. It will be constructed and interfaced with the controller circuit.
1.4 Methodology

1.4.1 The Methodology Flow Chart

![Methodology Flow Chart]

Figure 1.1: The Methodology Flow Chart
1.4.2 Methodology Of the Project

First of all, all related components were searched and emphasize have to put on less expensive components, parts, kits and the availability in the market. Second is study the characteristic of ultrasonic sensor and compare with reference books and internet source where analysis was done on the relationship between the output voltage and obstacle distance. After this had been done, simulation was carry out to check the operational of the circuit. This follow by installing the components on breadboard to verify the simulation. After that, testing the circuit on breadboard. Do correction if any problem occurred on the design. Design the PCB with the complete schematic of the ultrasonic sensor collision robot circuit. Design should be suited to provide locomotion to a robot. Finally, after completed installing components and join it with constructed chassis, test on the mobile robot is carried out to make sure the robot is functioning well.

1.5 Introduction Of Avoidance Mobile Robot

The term obstacle avoidance describes is a set of software techniques that allow mobile machines to adjust their trajectory according to their surroundings. It is used in conjunction with distance measurement and motor control solutions. Obstacle avoidance technology gives mobile machines and robots life-like reflexes and allows them to navigate intelligently. The result of a collision is generally a garbled message.

Collision avoidance is another example where specific applications may exhibit criticality in safety and concurrency. Collision avoidance software systems are safety-critical in the sense that lives depend on their correct and continued interaction with the real world. They have a concurrent character to them because they are attempting to control one or more things that are moving in a continuous
fashion. A robot moving through a maze is a good example of a collision avoidance system controlling one thing in order to prevent a collision with a wall. (Fomenko, 1975).

1.6 Theory Of Robot

A robot is a device that responds to sensory input. Besides that, it is a program that runs automatically without human intervention. Typically, a robot is endowed with some artificial intelligence so that it can react to different situations it may encounter. Two common types of robots are agents and spiders which can be referred to http://www.webopedia.com/Term/r/robot.html, 18th Feb 2005.

The first true robots was an experimental model called SHAKEY, designed by researchers at the Stanford Research Institute in the late 1960s. (Karel Capek). It was able to arrange blocks into stacks using a television camera as a visual sensor and a small computer for processing.

1.7 Report Organization

This report is divided into several sections. They are:

- Introduction
  In this chapter, the background of project, problem statement, objective and also the methodology is covered.

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- Literature Review
  In this chapter, the background of ultrasonic sensor is covered. Besides that, design and analysis on ultrasonic sensor used in this project is discussed.

- Mobile Robot Platform
  In this chapter, microcontroller and servo motor are covered and discussed in detail.

- Construction
  This final chapter will conclude all the work had been done in this project.

- Conclusion
  Here will discuss about the conclusion about this project.
CHAPTER II

ULTRASONIC SENSOR

2.1 The Background Of Ultrasonic Technology

In the 17th century, Galileo and others (Lindsay, 1966) made contributions to the relation between pitch, frequency, and the physical factors affecting these for a vibrating string. Well before that time the Greek philosopher Pythagoras started a school to understand sounds from bodies such as strings of different lengths and associated tone differences. Again in the 17th century Robert Hooke gave us the law of elasticity, which relates stress and strain for bodies undergoing elastic deformations. Also in this same period Joseph Sauveur suggested that the science of sound be called acoustics from the Greek word meaning hearing. In 1660 Robert Boyle concluded that a medium was necessary for propagation of sound.

Many others have made major contributions to the development of acoustics and the mathematical description of acoustical phenomena. Only a few more will be named. Brook Taylor applied Newton’s law to the fundamental mode of the vibrating string to derive a formula for the frequency. Bernoulli proposed the principle of superposition based on the existence of several modes simultaneously. Fourier supplied the concept of representing an arbitrary function as an infinite series of sines and cosines. Laplace suggested that the velocity in air, which had been measured
accurately in 1738, was controlled by the adiabatic rather than the isothermal compressibility. In 1822 Poisson showed that in solids both longitudinal and shear waves could propagate. Further contributions were made by Green, Euler, d’Alenlert, Kirckhoff, Helmholtz and others.

The end of the classical era in acoustics and the beginning of the modern age of sound was marked by the publication of Lord Rayleigh’s "Theory of Sound" in 1877. This provided a higher level of, and more widespread understanding of, acoustics. In 1880 the Curie brothers discovered the piezoelectric effect which was later taken advantage of in sources and receivers and is used today in most ultrasonic systems. Earlier (1842) Joule had discovered magnetostriction which has been extensively used for sources and receivers of ultrasound. These two effects combined with the vacuum tube oscillator and amplifier made possible the production and reception of sound at all frequencies and fostered the development of ultrasonics.

The first studies of ultrasonic wave propagation were done by Paul Langevin in 1917. The first application attempted was the detection of submarines spurred by WW I. However, this application was not developed until later and the first use was for depth determination with loaded quartz transducers. Later during WW II, ultrasound was used for submarine location and the hydrophone receiver was used as a guidance mechanism on a torpedo. Transducers were fabricated from various materials including rochelle salt, ammonium dihydrogen phosphate and nickel magnetostrictive elements.

At the time of this first employment of ultrasound the first example of effects of ultrasound on living systems was observed. As a consequence of the very high intensities, small fish and other marine life were found dead near the radiation field used by Langevin. The first extensive investigation of the physical effects, including bioeffects, associated with high intensity ultrasonic radiation was reported by Wood and Loomis (1927). In the 30’s and 40’s some early imaging techniques using ultrasound and applications to nondestructive testing and medical imaging started to
develop. Ultrasound was also used for therapy during this period and some transmission imaging was tried. World War II fostered the use of ultrasonic delay lines in radar systems as part of the approach to a moving target indicator (MTI) radar system. Later, dispersive delay lines were developed for use in high power radar systems. Also, at the end of WW II, ferroelectrics which could be polarized to act as piezoelectric crystals were developed and are now the most widely used transducers. The last three decades have seen the development of ultrasonic: pulse-echo systems for nondestructive evaluation and medical imaging; cleaning and numerous other low intensity industrial applications; and high power industrial applications. Surface wave devices have developed as very useful signal processing devices. The acoustic microscope has provided an imaging technique with greater resolution than possible before. Ultrasound has been applied to the measurement of properties of materials to frequencies of 100 GHz and more. The use of ultrasound in all the areas mentioned is continuing to grow at a rapid rate. New applications are continually being discovered and techniques are improving to provide every reason to expect growth of the ultrasound industry to continue.

2.1.1 Theory Of Ultrasonic Technology

Ultrasonic sensors are commonly used for a wide variety of noncontact presence, proximity, or distance measuring applications. These devices typically transmit a short burst of ultrasonic sound toward a target, which reflects the sound back to the sensor. The system then measures the time for the echo to return to the sensor and computes the distance to the target using the speed of sound in the medium. (Frank Massa. May 1992.)

It is an application based on high-frequency sound waves, usually in excess of 20kHz (20,000 cycles per second). (Kathi Graham, September, 1999). This sound waves are above the limits of human audibility. The frequency of a sound wave
determines its tone or pitch. Low frequencies produce low or bass tones. High frequencies produce high or treble tones. Ultrasound is a sound with a pitch so high that it can not be heard by the human ear. Frequencies above 18 Kilohertz are usually considered to be ultrasonic. Although sound above 20 KHz is inaudible to humans, many animals have auditory ranges far exceeding ours, even as high as 150 KHz. The Table 2.1 is a table of some common animals, and their auditory frequency ranges.

Table 2.1: Auditory frequency ranges of some common animals

<table>
<thead>
<tr>
<th>Animal</th>
<th>Frequency (hertz)</th>
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<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Humans</td>
<td>20</td>
</tr>
<tr>
<td>Cats</td>
<td>100</td>
</tr>
<tr>
<td>Dogs</td>
<td>40</td>
</tr>
<tr>
<td>Horses</td>
<td>31</td>
</tr>
<tr>
<td>Cattle</td>
<td>16</td>
</tr>
<tr>
<td>Elephants</td>
<td>16</td>
</tr>
<tr>
<td>Bats</td>
<td>1,000</td>
</tr>
<tr>
<td>Grasshoppers and locusts</td>
<td>100</td>
</tr>
<tr>
<td>Rodents</td>
<td>1,000</td>
</tr>
<tr>
<td>Whales and dolphins</td>
<td>70</td>
</tr>
<tr>
<td>Seals and sea lions</td>
<td>200</td>
</tr>
</tbody>
</table>

Ultrasonic sensors can be used to measure distance. A sensor would normally be mounted at the top of a tank and direct a sound wave down towards the surface of the product. When the sound wave hits the product it is reflected and returned to the sensor. The greater the distance between the sensor and the product, the longer it will take for the sound wave to travel down and back up again. The sensors calculate the time interval and give a signal proportional to the distance. They also compensate for the changes in the speed of sound due to changes in temperature. Ultrasonic
instrumentation for industrial process usually include accuracy, fast response, low maintenance and the absence of any hazard. (Stimpson B.P, et al., 1990).

![Diagram of Ultrasonic Sensor Function](image)

**Figure 2.1: Function Of Ultrasonic Sensor**

### 2.1.2 Generating Ultrasonic Waves

Ultrasonic waves can be generated using mechanical, electromagnetic and thermal energy sources. They can be produced in gasses (including air), liquids and solids. (Kathi Graham, September, 1999) It is generated similarly to regular sound, using a transducer to convert electrical or magnetic energy into waves. There are three basic types of transducers, all using different elements to produce the waves, namely piezoelectric, capacitive transducers, and pneumatic and hydrodynamic transducers.

Piezoelectric transducers employ the inverse piezoelectric effect using natural or synthetic single crystals (such as quartz) or ceramics (such as barium titanate) which have strong piezoelectric behavior. Ceramics have the advantage over crystals in that it is easy to shape them by casting, pressing and extruding (Kathi Graham, September, 1999). It converts alternating electrical energy directly to mechanical energy through use of the piezoelectric effect in which certain materials change dimension when an electrical charge is applied to them. Electrical energy at the