AUTONOMOUS MOBILE ROBOT NAVIGATING TOWARDS A PRESET TARGET

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......Untuk ayahbonda tercinta

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ABSTRACT

This Autonomous Mobile Robot Navigating Towards A Preset Target provide the wheeled mobile robot to move to the beacon as the target of robot navigation. There was four part of this mobile robot needs to design and develop. That is: hardware and control of mobile robot locomotion, a beacon as the target of robot navigation, sonar system for obstacle avoidance and robot's task planner. The robot will be equipped with sonar system, so if there was an obstacle in the middle of its way, its capable to avoid it either move to right or left. The type of ultrasonic which used is Crystal Lock Ultrasonic Motion Detector.

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CHAPTER I

INTRODUCTION

An autonomous mobile robot is designed to govern them and make decisions. The major goal of autonomous mobile robot is to move humans out of the control loop as much as possible, so that communication between robots and humans can occur at a high level -- possibly at the human-speech level. This Autonomous Mobile Robot Navigating Towards A Preset Target provide the wheeled mobile robot to move to the beacon as the target of robot navigation. The two wheeled robot will react autonomously and capable to move in appropriate manner. This robot also capable to avoid an obstacle. The level of autonomy is semi autonomous because it's still need us to monitor it (supervised control). Fully autonomous robot is but a dream today. There was four part of this mobile robot needs to design and develop. That is: hardware and control of mobile robot locomotion, a beacon as the target of robot navigation, sonar system for obstacle avoidance and robot's task planner. This robot be able to execute a program of instructions from robot's task planner which will ask the robot to go to a beacon and able to monitor compliance with this. It's also afford to planning; know the current situation and mission goals, decide what to do next. Its locomotion will control the direction either steers to left or right. It will move at fixed speed. The robot will be equipped with sonar system, so if there was an obstacle in the middle of its way, its capable to avoid it either move to right or left. The robot's also possible to reverse. It will be embodied in chassis. These projects are expected to be a basic autonomous project which it can be used for another research and for education. It can be expand or added such the robot can be control by using notebook.

1.1. OBJECTIVES

1.1.1. To design and develop sonar system (ultrasonic) for obstacle avoidance

First, this project is conducted to develop a sonar system (ultrasonic) that could avoid any obstacle during the way to the target. The sonar will detect the distance between robot and objects (obstacle).

1.1.2. To create an autonomous robot capable of navigating an obstacle-filled arena

This project also must be able to navigating an obstacle-filled arena. It also able to navigate itself to any set target during the navigation process.

1.2. PROBLEM STATEMENTS

1.2.1. How the robot can avoid any obstacle during the way to the target using sonar system.
1.2.2. How to developing obstacles avoidance system
1.2.3. How the sonar system detect the distance between robot and object
1.2.4. How many the sonar system use for a robot
1.2.5. Define the types of ultrasonic to use

1.3. SCOPE OF WORKS

This project is to develop obstacles avoidance systems. Robot will avoid any obstacle during the way to the target using sonar systems. The sonar systems will detect the distance between robot and objects (obstacles).

1.4. METHODOLOGY

1.4.1. Explore the sonar sensors (ultrasonic) which use to avoid the obstacle.
1.4.2. Learn how robot deal with own problems to achieve those goals; suitable way for robot to move.
1.4.3. Developing obstacles avoidance systems. Robot will avoid any obstacle during the way to the target using sonar systems. The sonar systems will detect the distance between robot and objects (obstacles).
1.4.4. Find out autonomous robot capabilities and behaviors.
1.4.5. Perception :
   i. Able to locate obstacle
   ii. Able to classify terrain

1.5. STRUCTURE REPORT

This report contains of five chapters. The first chapter is the introduction about the project. The second chapter is about the literature review such as the theory of the components needed and how the operation of a motor. There are also contains the polarity of each components. Chapter 3 is the methodology of the project from the literature review to the final thesis and presentation. Chapter 4 is the result and discussion part where the analysis of the result is elaborate in this chapter. Chapter 5 is contains about the conclusion and suggestion for this project.

CHAPTER II

LITERATURE REVIEW

2.1. What Is A Ultrasonic

Ultrasonic is the study and application of high-frequency sound waves, usually in excess of 20 KHz (20,000 cycles per second) [1]. Modem ultrasonic generators can produce frequencies of as high as several gigahertz (several billion cycles per second) by transforming alternating electric currents into mechanical oscillations, and scientists have produced ultrasound with frequencies up to about 10GHz (ten billion vibrations per second). There may be an upper limit to the frequency of usable ultrasound, but it is not yet known.

Higher frequencies have shorter wavelengths, which allow them to reflect from objects more readily and to provide better information about those objects. However, extremely high frequencies are difficult to generate and to measure.

Detection and measurement of ultrasonic waves is accomplished mainly through the use of piezoelectric receivers or by optical means. The latter is possible because ultrasonic waves are rendered visible by the diffraction of light.

Ultrasound is far above the range of human hearing, which is only about 20Hz to 18 KHz. However, some mammals can hear well above this. For example, bats and whales use echo location that can reach frequencies in excess of 100 KHz "Ultrasonic' should not be confused with the term "supersonics," which was formerly applied to this field. Supersonics now refers to the study of phenomena arising when the velocity of a solid body exceeds the speed of sound.

2.2. Brief History

The roots of ultrasonic technology can be traced back to research on the piezoelectric effect conducted by Pierre Curie around 1880 [2]. He found that asymmetrical crystals such as quartz and Rochelle salt (potassium sodium tartrate) generate an electric charge when mechanical pressure is applied. Conversely, mechanical vibrations are obtained by applying electrical oscillations to the same crystals.

One of the first applications for ultrasonic was sonar (an acronym for sound navigation ranging). It was employed on a large scale by the U.S. Navy during World War II to detect enemy submarines.

Sonar operates by bouncing a series of high frequency, concentrated sound wave beams off a target and then recording the echo. Because the speed of sound in water is known, it is an easy matter to calculate the distance of the target. Prior to World War II researchers were inspired by sonar to develop analogous techniques for medical diagnosis. For example, the use of ultrasonic waves in detecting metal objects was discussed beginning in 1929. In 1931 a patent was obtained for using ultrasonic waves to detect flaws in solids.

Japan played an important role in the field of ultrasonic from an early date. For example, soon after the end of the war, researchers there began to explore the medical diagnostic capabilities of ultrasound. Japan was also the first country to apply Doppler ultrasound, which detects internal moving objects such as blood flowing through the heart.

2.3. Generation Of Ultrasound

Ultrasonic waves can be generated using mechanical, electromagnetic and thermal energy sources [2]. They can be produced in gasses (including air), liquids and solids. Magnetostrictive transducers use the inverse magnetostrictive effect to convert magnetic energy into ultrasonic energy. This is accomplished by applying a strong alternating magnetic field to certain metals, alloys and ferrites.

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.

The piezoelectric effect was first studied by Pierre Curie around 1880. He found that asymmetrical crystals such as quartz and Rochelle salt (potassium sodium tartrate) generate an electric charge when mechanical pressure is applied. Conversely, mechanical vibrations are obtained by applying electrical oscillations.

2.4. Ultrasonic Distance Measurement – Polariod 6500 Sonar Ranging Module

A common technique in robotics for proximity detection is time-of-flight measurement (TOF) [3]. This is often accomplished using the Senscomp 6500 ultrasonic ranging module and an appropriate transducer. There are other options but the Senscomp modules are very popular because of their ease of interfacing and relatively low cost. Sonar Ranging is one of the most common forms of distance measurement used in Mobile Robotics and a variety of other applications. The principle is simple to understand, a speaker (Transducer) is used to emit a short burst of sound (Ping). The sound wave travels through the air and reflects off a target back to the Transducer (Echo). By measuring the Time of Flight between Ping and Echo detection, one can calculate the distance between the target and transducer.

The Polaroid Corporation has developed the 6500 Sonar Ranging board and a series of Transducers which makes Sonar Ranging very simple. Interfacing to the 6500 Board is straightforward. The only hardware requirement is the ability to measure the Time of Flight which can usually be handled by a host Microcontroller or a simple clock and counter circuit.

2.4.1. Specification of Polaroid 6500 Sonar Ranging Module

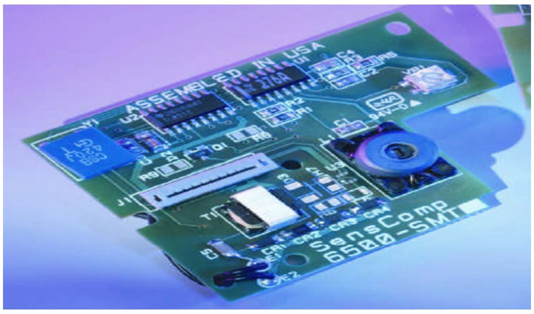
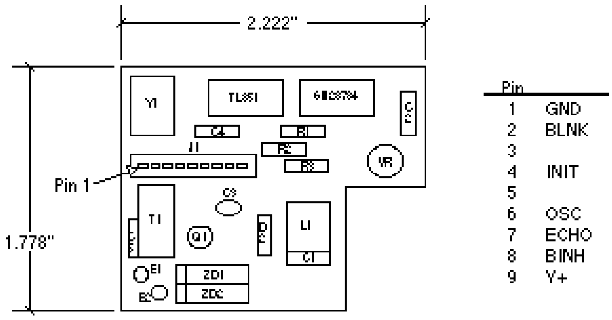


Figure 2.1: Polaroid 6500 Sonar Ranging Module.

2.4.2. Features of Polaroid 6500 Sonar Ranging Module



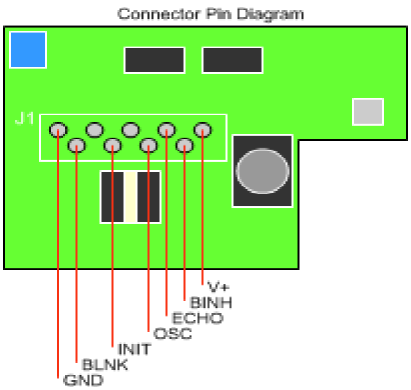


Figure 2.2: Connector Pin Diagram.

The 6500 Series is an economical sonar ranging module that can drive all the Polaroid electrostatic transducers with no additional interface. This module, with a simple interface, is able to measure distances from 6 inches to 35 feet [3]. The typical absolute accuracy is (+-) 1% of the reading over the entire range.

This module has an external blanking input that allows selective echo exclusion for operation on a multiple-echo mode. The module is able to differentiate echoes from objects that are only three inches apart. The digitally controlled-gain, variable bandwidth amplifier minimizes noise and side-lobe detection in sonar applications.

The module has an accurate ceramic-resonator-controlled 420-kHz time base generator. An output based on the 420 kHz time base is provided for external use. The sonar transmit output is 16 cycles at a frequency of 49.4 kHz.

The 6500 Series module operates over a DC power supply range of 4.5 volts to 6.8 volts (5 volts nominal) and is characterized for operation from 0° C to 40° C.

Voltage from any pin to ground (see NOTE 1)	7 V
Voltage from any pin except XDCR (see NOTE 1)to V_{CC}	-7 to 0.5 V
Operating free-air temperature range	0° C to 40° C
Storage temperature range	-40° C to 85° C

NOTE 1: The XDCR pin may be driven from -1 volt to 400 volts typical with respect to ground

Table 2.1: Absolute Maximum Ratings over Operating Free-air temperature range.

		MIN	MAX	UNIT
Supply Voltage, Vcc		4.5	6.8	V
High-level Input Voltage, VIH	BLNK, BINH, INIT	2.1		V
Low-level Input Voltage, VIL	BLNK, BINH, INIT		0.6	V
ECHO and OSC Output Voltage			6.8	V
Delay Time, Power Up to INIT High		5		ms
Recycle Period		80		ms
Operating Free-air Temperature, T_A		0	40	°C

Table 2.2: Recommended Operating Conditions.

PARAMETER		TEST COND.	MIN	TYP	MAX	UNIT
Imput Current	BLNK, BINH, INIT	$V_I = 2.1$ V			1	mA
High-level Output Current, I_{OH}	ECHO, OSC	$V_{OH} = 5.5$V			100	µA
Low-level Output Voltage, V_{OL},	ECHO, OSC	$I_{OL} = 1.6$ mA			0.4	V
Transducer Bias Voltage		$T_A = 25°$ C		200		V
Transducer Output Voltage (peak to peak)		$T_A = 25°$ C		400		V
No. of Cycles for XDCR Output to Reach 400V		C = 500 pF			7	
Internal Blanking Interval				2.38†		ms
XMIT Drive Signal Duration				1.1†		ms
Frequency During 16-pulse Transmit Period	OSC output			49.4†		kHz
	XMIT output			49.4†		kHz
Frequency After 16-pulse Transmit Period	OSC output			93.3†		kHz
	XMIT output			0		kHz
Supply Current, Icc	During transmit period				2000	mA
	After transmit period				100	mA

Table 2.3: Electrical Characteristics over Recommended Ranges of Supply Voltage and Operating Free-Air Temperature.

2.4.3. Theory Of Operation

The basic principal of operation for sonar ranging is the same no matter what system is being used [3]. The sensing is initiated by first creating a sonic ping at a specific frequency. In the case of this module, the ping is roughly 16 high-to-low transitions between +200v and -200v. These transitions are fed to the transducer at around 50 kHz. For reference, the human ear can hear sounds in roughly the 20 Hz to 20 kHz range. As this chirp falls well out of the range of human hearing, the ping is not audible. Sometimes you can hear the transducer click as the chirp is sent.

The chirp moves radically away from the transducer through the air at approximately 343.2 m/s, the speed of sound. This is roughly 0.9ms/foot. This speed is only slightly affected by humidity and virtually not affected at all by pressure and therefore is almost independent of altitude. Since the chirp is spreading out radically, the signal strength as the chirp moves farther from the transducer is reduced by $1/d^2$. This means that the maximum measuring distance drops off rapidly at the extreme maximum of the sensor.

When the chirp reaches an object, it is reflected in varying degrees dependent on the shape, orientation, and surface properties of the reflecting surface. The ranging system is capable of detecting amazingly small obstacles such as a flower stem at several meters.

This reflected chirp then travels back towards the transducer, again at the speed of sound. The transducer is especially sensitive to noises around 50 kHz like the chirp. As the reflected signal hits the transducer, a voltage is created which is fed to a stepped-gain amplifier.

Since the signal decreases in strength with distance at an inverse squared proportion, the gain of the amplifier is increased exponentially ($\sim d^2$). This helps give the best sensitivity across the range of the detector which is roughly 2 feet to 35 feet.

Once the ranging module "sees" enough cycles of the reflected signal, it changes its ECHO output to reflect the received reflected signal or echo. All that is