# NAVIGATION COAT USING ULTRASONIC SENSORS FOR BLIND PERSON

By

HANIFF BIN HASAN

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

# CERTIFICATION OF APPROVAL

**NAVIGATION COAT USING**
**ULTRASONIC SENSORS FOR BLIND PERSON**

by

Haniff Bin Hasan

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

_____________________________

Puan Salina Bt Mohmad
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

December 2010

# CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Haniff Bin Hasan

# ABSTRACT

This documentation presents the research on navigation coat using ultrasonic sensors as a navigation tool for blind person. The difficulties for blind person to navigate without the help of navigation tool have led this research to be conducted. Basically the project are about designing, constructing and fabricating a navigation coat using ultrasonic sensors as a navigation tool for the blind person. The ultrasonic sensors will detect obstacles surrounding the blind person in $270^0$ angle in certain length of distance and give indication to the blind person indicating the location of the obstacle. The significant of this project is to help the blind person to detect and be aware of obstacles surround them thus reducing the difficulties to navigate themselves.

# ACKNOWLEDGEMENT

First of all, my utmost gratitude to Allah SWT for his uncountable graces upon me and a blessing for upon the successful of this project within the time allocate.

I would thank my supervisor, Puan Salina Bt Mohmad, for the support and constant guidance during the execution of the project. The kindness and patience shown is highly appreciated.

Then I would like thank the technicians that always there to help especially during the project troubleshooting session. The comment and suggestion given is appreciated.

Last but not least, many thanks to my family and friends who supported me morally, physically and financially during the whole project. And not to forget, my thanks to those that are not been mentioned here but provide support and help in any ways directly or indirectly.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1
# INTRODUCTION

## 1.1 Background of study

This project is about navigation coat using ultrasonic sensors as navigation tool for blind person. Ultrasonic sensor also known as transducer is divided into two which are the transmitter and the receiver. The transmitter's function is to transmit the ultrasonic wave, while the receiver will receive the reflected ultrasonic wave. The principle of the sensors is that the transmitter transmits ultrasonic wave and the wave will travels through air. Once the wave detects an obstacle, the wave will be reflected in the opposite direction. The receiver will then receive the reflected wave. The output of the receiver will then be send to an indicator to tell the location of the detected obstacle. According to this principle, the obstacles in the surrounding can be detected.

To achieve the detection angle of $270^0$, a certain number of ultrasonic sensors will be attached on the coat. The number of sensors that will be used depends of the angle of detection of an ultrasonic sensor. Thus knowing the angle of detection, the sensors will be attached on the coat at certain points of the coat – both of the shoulder and at the back of the coat. The coat is considered as a navigation coat because it can detects obstacles and tells the user the location of the coat with the help from the ultrasonic sensors.

## 1.2 Problem statements

Blind person is one of the unfortunate people in the world. Blindness can be defined as lack of vision. Blindness can be categorized into two categories that are partial blindness and complete blindness. Partial blindness means a person have limited vision while complete blindness means totally no vision. Upon to their incapability of seeing, they have to depend in their other senses such as sense of smelling, sense of hearing and sense of touching. Apart from that, additional navigation tools such as cane and guide dog are used as their assistant in walking especially. With the advancement of technology, other navigation tools using sensors are being developed.

Apparently, most of these navigation tools only focus on detecting obstacles in the front of the impaired, neglecting the obstacles from the back and sides of the impaired. Thus, a navigation tool that uses ultrasonic sensors can be designed to detect obstacles within certain range of distance in $270^0$ perimeter. A suitable implementation of this navigation tools is by a coat which can be wear anytime and anywhere that is cheaper than other navigation tools available.

## 1.3 Objectives and Scope of study

There are two main objectives of the project. The objectives are to construct a workable circuit that can transmit and receive the ultrasonic sound and give indication such as vibration or light or sound at specific points at the coat; and to fabricate a workable coat which use ultrasonic sensor that can detects $270^0$ angle of obstacles within certain range of distance.

The scope of study of this project is to design and test the ultrasonic sensor circuit. The ultrasonic sensors will then be analyzed on the area of detection and the distance that the obstacles that can be detected. The total area of detection that can be covered by the ultrasonic sensor should be at least $270^0$ angle since that is on of the objective. The distance of obstacle that can be detected by an ultrasonic sensor that should be appropriate to the blind person. When the ultrasonic sensors circuit had been finalized, the circuit will be implemented at the coat. The points that the sensors will be put on are on both of the shoulders and back of the coat. These points are specified so that the sensors can detect obstacles in $270^0$ angle. Indicators such as vibrator or buzzer will be the output of the circuit where it will tell the blind person the location of the obstacles.

# CHAPTER 2

# LITERATURE REVIEW / THEORY

## 2.1 Navigation Tools

There are many navigation tools that have been used or developed for the blind person. The traditional or commonly used navigation tools are the cane and the guided dog. Early on, a navigation tools such as NavBelt had been invented using acoustic cue that can tell the user the location of the obstacles. The advancement of technology also enhances people to invent new tools that can be used by the blind person such as Ultracane and Electronic Eyes. These navigation tools are actually use sensors such as ultrasonic sensor and computer chip. The Ultracane uses ultrasonic sensor that will detect obstacle in the designated perimeter that the sensor can detect and subsequently give signal or warning to the user that there are obstacle nearby. Meanwhile the Electronic Eyes is an intrinsic device that been implement in the brain – a virtual eye. Furthermore, many navigation tools have been developed and invented using ultrasonic sensor, for examples, shoes, hat, and belt. Addition to that, a more sophisticated navigation tool called electronic eyes for the blind person has also been invented.

### *2.1.1 Cane*

Cane is a commonly used navigation tools by the blind person. It is because of the price – cheap - , and can be easily obtained. The constraint of using cane is that the user has to point out the cane forward and sideways to detect any obstacle. It can only detect obstacle limited to the direction of the cane pointing and limited detection of distance at most about 2 feet.

Figure 1 : Cane

### *2.1.2 Guide dog*

Dog is one of the man best friend. A trained dog can be used to guide people especially the blind person. On the other side, the maintenance of taking care of the dog can be very costly. The dog’s maintenance includes the food, home, hygiene, training course and etc. Owning a guided dog can cost a lot.

Figure 2 : Guide dog

### *2.1.3 NavBelt [1]*

A navigation tools named NavBelt is basically a belt with sensors and being combine with audio device. It is one of the most early navigation tools that have been invented. The NavBelt can detect up to $120^0$ of perimeter. It operates with the help of audio system which is fabricated like a bag pack that the user has to carry around. Thus it will slow the travel time of the user and the weight can cause injury too.

Figure 3 : NavBelt [1]

### *2.1.4 Ultracane [2]*

Ultracane is actually a modified cane that has been installed with ultrasonic sensors. Number of sensors is installed on the Ultracane, so Ultracane can detect obstacle which located in many direction far ahead. It also can detect obstacle at the head height. The user is been acknowledge by vibration when there are obstacles.

Figure 4 : Ultracane [2]

### *2.1.5 Electronic eyes [3]*

It is the most sophisticated navigation tools that have been invented. It is actually an artificial eye that is installed in the brain. This is surely a magnificent and remarkable invention as blind person can actually see things in front of them. The risk is that, the device is intrinsic and the operational procedures are costly and dangerous. Plus, the cost to earn the electronics eyes will of course expensive.

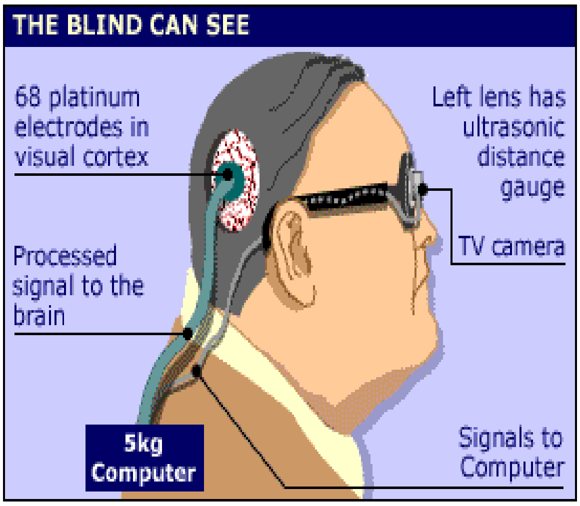



Figure 5 : Electronic eyes [3]

## 2.2 Ultrasonic sensor

Ultrasonic sensor is a device that works on the principle similar to radar or sonar which evaluates the transmitting and receiving of sound wave. Ultrasonic sensor generates high frequency sound waves and evaluates the echo which is then received back by the sensor (see Figure 6). Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

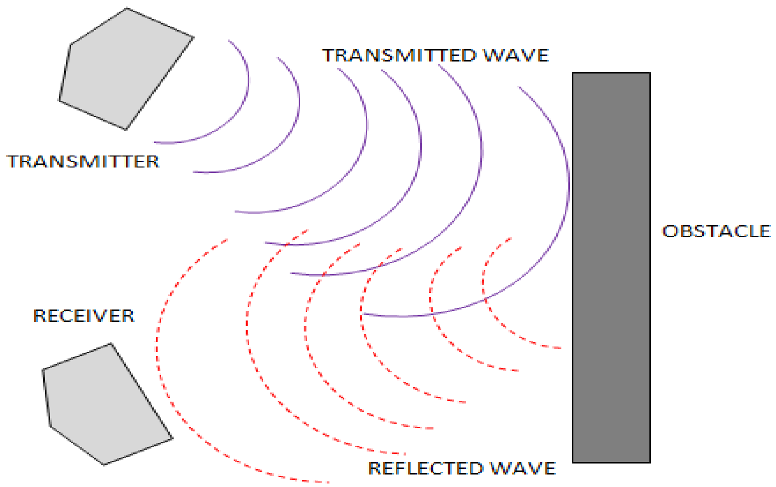



Figure 6 : The principle of ultrasonic sensor

There are several advantages of using ultrasonic sensor. The advantages are [4]:

i. It has long range detection (from 0.2m up to 6m)
ii. It has a broad are of detection ( more than 30 degree angle, depends on the sensor)
iii. It can detect almost all material composition. The target material can be clear, solid, liquid, porous, soft and wood.
iv. The sensor are not affected by dust, dirt or high moisture environment

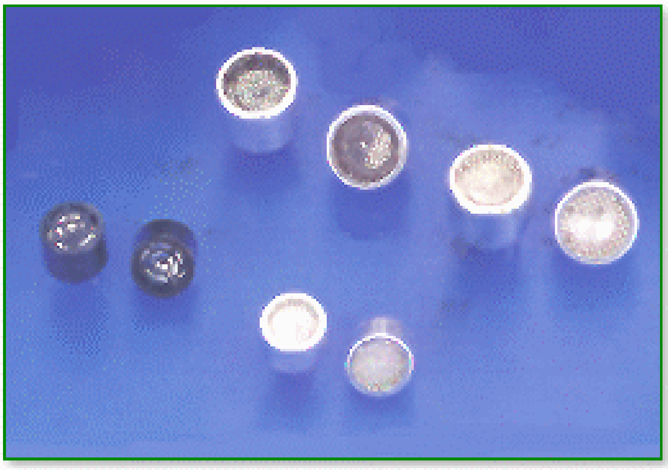


Figure 7 : Ultrasonic sensor [5]

Figure 7 shows the transmitter and receiver of several types of ultrasonic sensors. The ultrasonic sensors are classified to its operating frequency, transmitter sound pressure level, receiver sensitivity and beam angle.

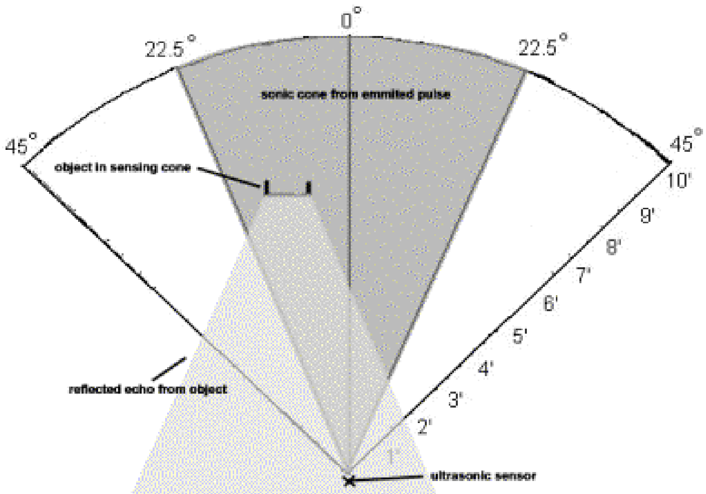



Figure 8 : The area of detection of an ultrasonic sensor

Figure 8 shows the area of detection of an ultrasonic sensor pair. Assuming that the transmitted wave form the transmitter has a $45^0$ angle coverage, any obstacle that in the coverage area will be detected. The transmitted wave will be reflected once it detects an obstacle. The reflected wave will travel in the opposite direction and towards the receiver

# CHAPTER 3

# METHODOLOGY

## 3.1 Procedure identification

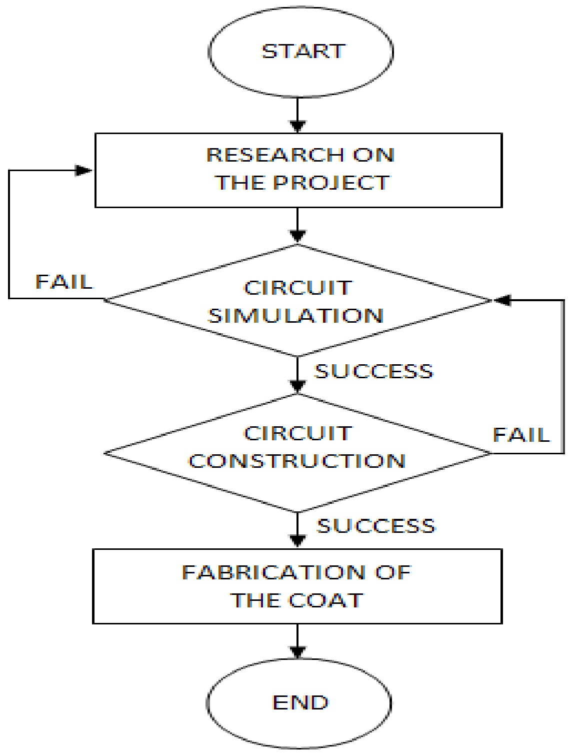



Figure 9 : Flow chart diagram

The project is divided into four parts. Part 1 is the research part which involves the brainstorming and gathering information about the project. Part 2 is the circuit simulation part which the circuit is designed and simulated to achieve the requirement. Part 3 is the circuit construction part which involves the construction of the circuit on the breadboard and the PCB. Finally Part 4 is the fabrication of the coat part which the process of attaching the circuit to the coat.

### 3.2 Definition of $270^0$ angle detection

For this project, the navigation coat helps the blind person to detect obstacles within $270^0$ angle starting form $45^0$ angle from his right side until $45^0$ angle from his left side. The definition of $270^0$ angle detection is illustrated in Figure 10.

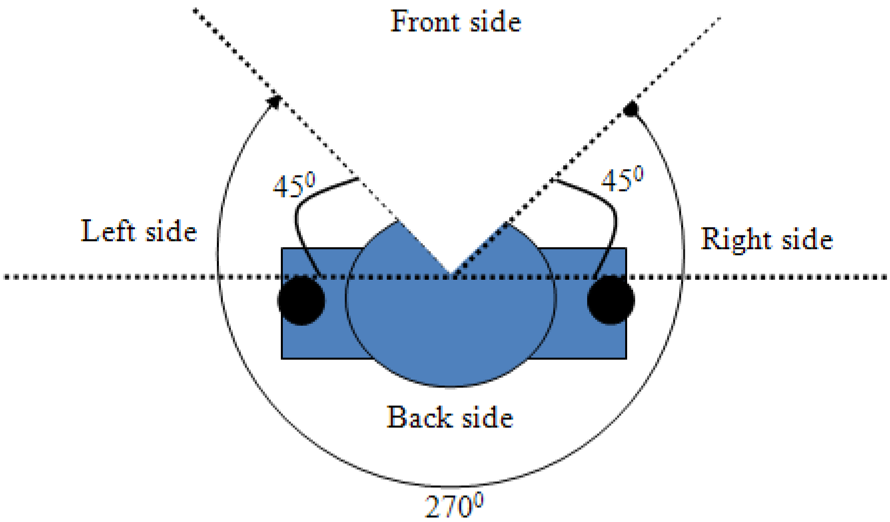



Figure 10 : Definition of $270^0$ angle detection

### 3.3 Coat with sensors

From the navigation tools that have been developed and invented, a coat based design is not yet been implemented. So after much consideration, it is most suitable to design a coat using ultrasonic sensor to detect obstacles. The coat will be design to detect obstacle within certain range of distance in $270^0$ perimeter. Coat is being chosen rather that other thing is due to several factors:

i. The coat can be worn anytime and anywhere
ii. The size and width of the coat is wide enough for installing certain numbers of ultrasonic sensor
iii. The circuit can be hidden in the inner side of the coat

### 3.4 Layout of coat with ultrasonic sensors

**Back view** **Plan view** **Side view**

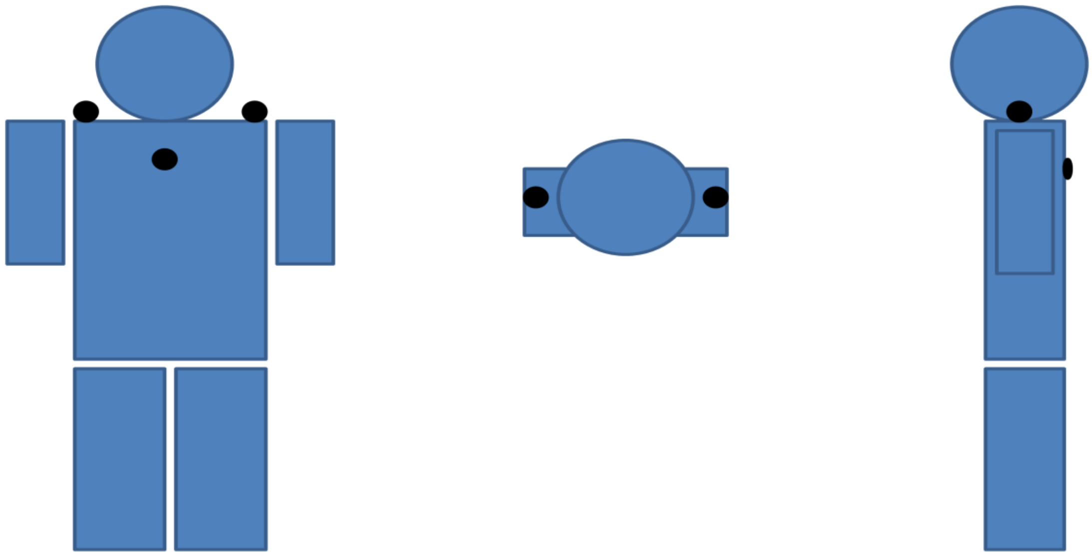


Figure 11 : The location of ultrasonic sensor at the coat

The sensors will be located at both of the shoulder and at the back of the coat as shown in Figure 11. From Figure 8, a sensor area of detection can go up to $45^0$ angle. Therefore to obtain $270^0$ angle of detection, the number of sensors to be used are 3 pair – one pair each at the point determined. The number of sensors is calculated as in Figure 12.

$$X = \frac{270^0}{45^0}$$

$$X = 6 \text{ sensors}$$

$$X = \frac{6 \text{ sensors}}{2}$$

$$X = 3 \text{ pairs of sensors}$$

Figure 12 : The calculation of number of sensors

### 3.5 Ultrasonic sensor - 400ST160 and 400SR160

After some research and cost analysis, the suitable ultrasonic sensors for the project are transmitter 400ST160 and receiver 400SR160. The sensors are used because of its operating frequency, its diameter and the beam angle. The operating frequency is 40 kHz. The operating frequency is chose to be 40 kHz frequency because the frequency will be generated by a 40 kHz crystal oscillator. The diameter of the sensors is 16 mm which is large among other sensor model which logically will have a greater area of detection coverage. The beam angle of the transmitter is about $45^0$ wide. More details on the sensor are shown in Appendix A.

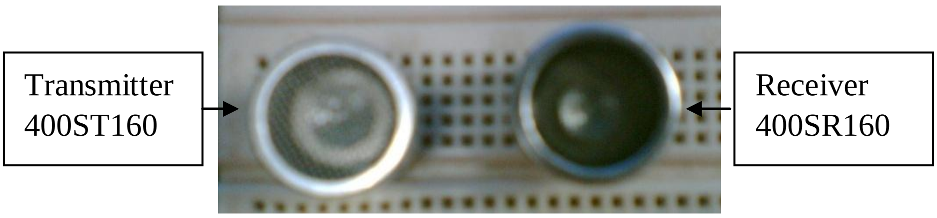



Figure 13 : Transmitter 400ST160 and receiver 400SR160

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Circuit schematic diagram

After several research and simulations on several circuit design, the finalize circuit schematic diagram is shown as Figure 14. The components that are used in the circuit are stated in Table 1.

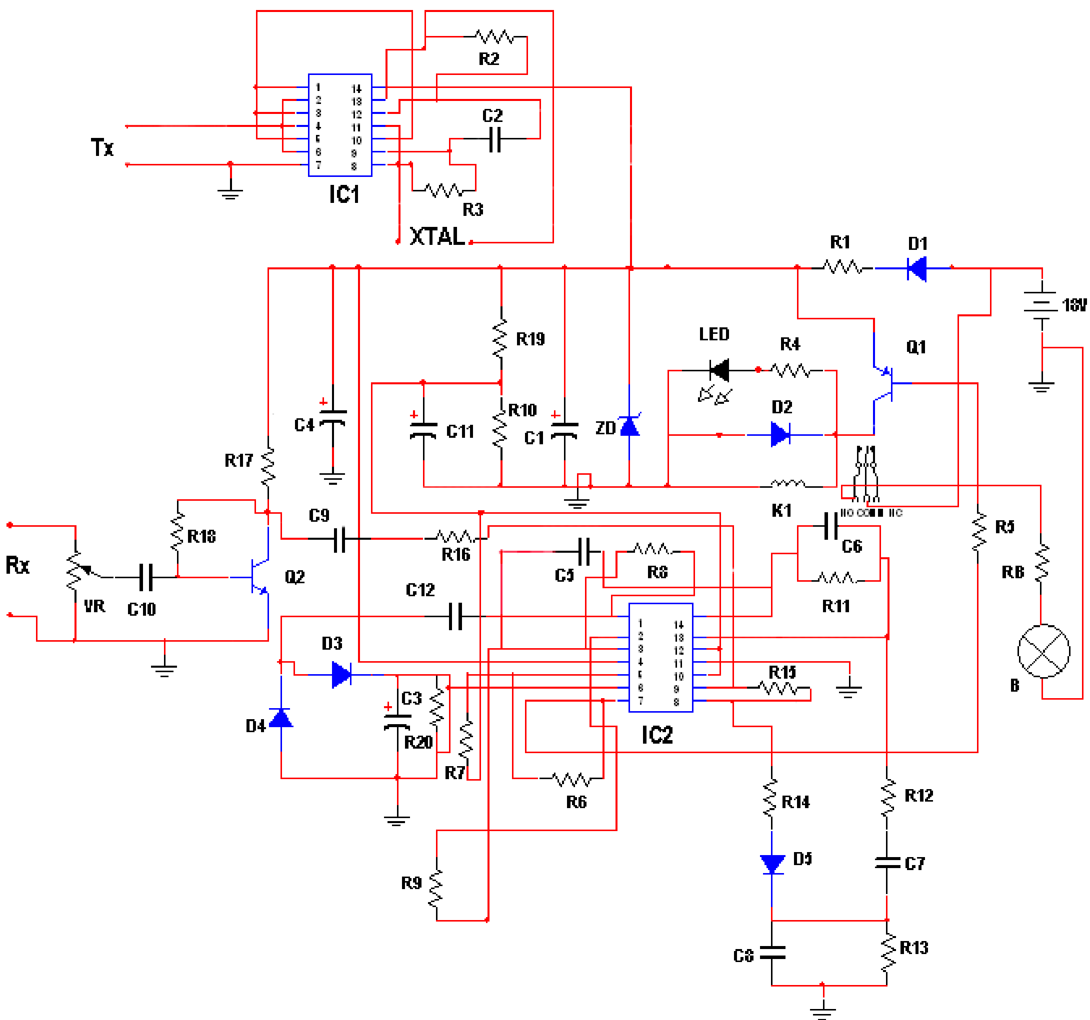



Figure 14 : The circuit schematic diagram

Table 1 : The components used in the circuit

| Component | | Value |
|---|---|---|
| Resistor | R1 | 33 Ω |
| | R2,R3,R20 | 1 MΩ |
| | R4 | 1 kΩ |
| | R5,R10 | 6.8 kΩ |
| | R6,R8,R11,R18 | 2.2 MΩ |
| | R7,R9,R13 | 470 kΩ |
| | R12,R14,R16,R17,R19 | 10 kΩ |
| | R15 | 100 kΩ |
| | RB | Depends for the pitching of buzzer |
| Capacitor<br>- electrolytic | C1 | 470 uF |
| | C3 | 1 uF |
| | C4 | 4.7 uF |
| | C11 | 10 uF |
| Capacitor<br>- ceramic | C2,C9,C10 | 0.001 uF |
| | C5 | 0.01 uF |
| | C6 | 33 pF |
| | C7,C8,C12 | 0.1 uF |
| Hex inverters<br>- CMOS 4069 | IC1 | - |
| Quad operational amplifiers<br>- TL 084 | IC2 | - |
| General purpose PNP transistor<br>- 2SA 1015 | Q1 | - |
| General purpose NPN transistor<br>- 2SC 1815 | Q2 | - |
| Rectifier diode<br>- 1N 4001 | D1,D2 | - |
| General purpose switching diode<br>- 1N 4148 | D3,D4,D5 | - |
| Zener diode | ZD | - |
| Trimmer pot | VR | 10 kΩ |
| Miniature relay<br>- Coil = DC 12V | K1 | 12 V |
| Light emitting diode | LED | - |
| Tuning fork crystal | XTAL | 40 kHz |
| Ultrasonic transmitter | Tx | - |
| Ultrasonic receiver | Rx | - |
| Buzzer | B | - |

### 4.2 Circuit construction

From the circuit schematic diagram, the circuit is constructed on the beardboard. After a few testing and promising results, the circuit is constructed on the printed circuit board (PCB). The constructed circuit on PCB is shown in Figure 15.

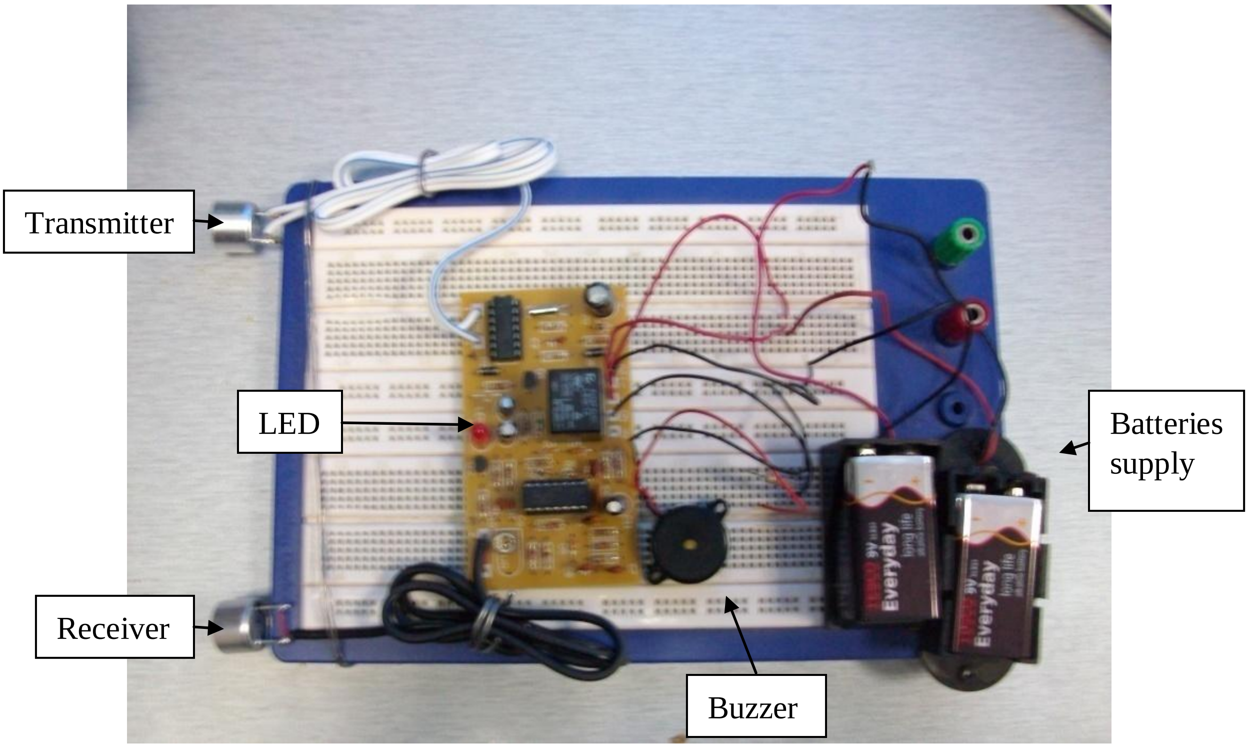



Figure 15 Circuit construction

### 4.3 Circuit operation

The circuit operation can be divided into three main parts which are the transmitter signal generation part, the amplifying receiver signal part and the output part. Basically, the component IC1 (hex inverters) is used to transfer the signal from the XTAL (40 kHz crystal) to the ultrasonic transmitter. The 40 kHz crystal is used because the ultrasonic sensor will only operate in 40 kHz frequency wave signal. The function of IC2 (quad amplifier operational) is to amplify the signal received by the ultrasonic receiver since the signal received is very small. This signal is then amplified to certain value so that it can trigger the miniature relay coil (K1) when an obstacle is detected. When the relay is triggered, the buzzer will be activated thus indicating that there is an obstacle nearby.

## 4.4 Circuit analysis

Some experiment is done on the circuit to see the behavior of the ultrasonic sensors. Form the experiment, there are several factors that affects the behavior of the sensors. The results of the experiment are as shown in Table 2.

Table 2 : The behavior of the ultrasonic sensors

| Factor | Description |
|---|---|
| The distance between the transmitter and receiver sensors | The closer the distance, the farther the distance range of detection |
| The direction of the sensors are facing | Both sensors must face directly forward in order to maximize the area of detection |
| The obstacle shape | The shape of obstacle will determine the direction of the reflected wave |
| The value of trimmer pot (VR) | The value will determine the sensitivity of the sensors |

The circuit is then tested to see whether it achieved the objectives of the circuit. The circuit results are as shown in Table 3.

Table 3 : The circuit result

| Parameter | Description |
|---|---|
| Obstacles material | The circuit managed to detect solid obstacle such as wall, door and human being |
| Range of distance | The sensors can detects up to 2 meter long, but adjustment is made on VR and the distance between sensors so that the maximum range of distance of 1meter. |
| Degree angle of detection | The maximum degree angle that the sensor can detect is about $30^0$ and it depends on the distance between the obstacle and the sensors. |

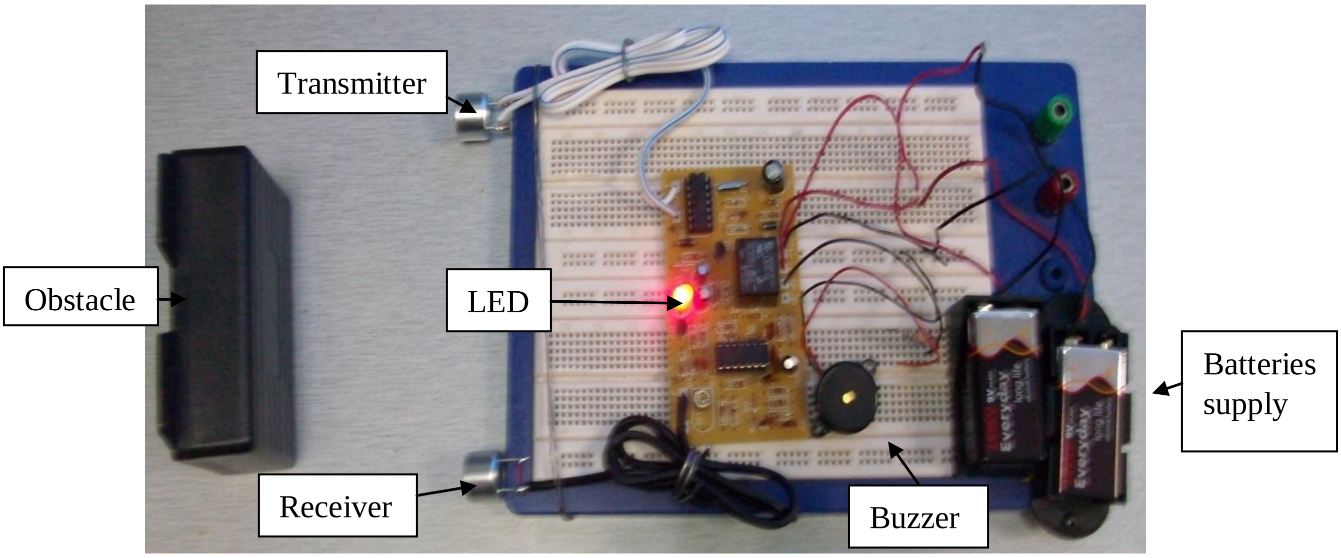



Figure 16 : The circuit is activated when obstacle is detected

Figure 16 shows that the circuit is activated when an obstacle is detected. The indicator LED will be turned on and the buzzer will be triggered when an obstacle is detected.

### 4.5 Coat fabrication

The coat is then fabricated with the circuit is been put at the inner side of the coat. The seen components at the outer layer of the coat are the transmitter, receiver, LED and the buzzer. The complete coat is as shown in Figure 17.


Figure 17 : The navigation coat using ultrasonic sensors

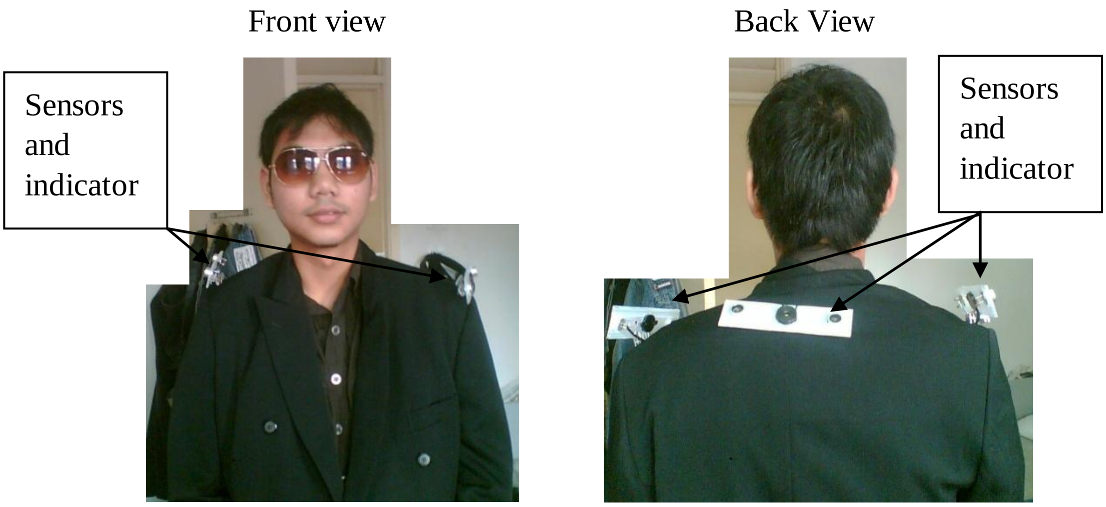



Figure 18 : A user wearing the navigation coat

Figure 18 shows the user wearing the coat and the location of each sensors and indicator. The sensors are located at three specific points which are both shoulder and back of the coat.

## 4.6 Coat analysis

The coat has been tested to detect the obstacle. The results of the test are as shown in Figure 19 and Table 4.


Figure 19 : The indicator (LED) turn on when it detects wall

Table 4 : Detection range of sensors

| Sensors location | Distance detected | Area coverage detected |
|---|---|---|
| Right side | Less than 1 meter | Around $60^0$ |
| Back side | Less than 1 meter | Around $60^0$ |
| Left side | Less than 1 meter | Around $60^0$ |

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

This navigation coat using ultrasonic sensors is found to be able to detect obstacle in 1 meter range. The blind person needs also to use the sense of hearing to determine the location of the obstacle since buzzer is used as the indicator. From the coat, the blind person can determine the location of the obstacle according to the sound of the buzzer located at specific point on the coat thus helping them to navigate.

## 5.2 Recommendation

Improvement can be made on the navigation coat which can help the blind person to navigate more smoothly. Some improvement that can be made is by equipping the navigation coat with voice system which can tell the blind person the distance of the obstacle. The system can also tell the blind person which direction to turn and help the blind person to avoid obstacle. The improvement should help the blind person to navigate them and for the better of mankind.

# REFERENCES

[1] http://www-personal.umich.edu/~johannb/navbelt.htm

[2] http://www.ultracane.com/

[3] http://www.sabah.org.my/shsb/electronic_eye.htm

[4] http://www.migatron.com/overview.htm

[5] http://www.ctdco.com.tw/ultrasonic_sensor.htm

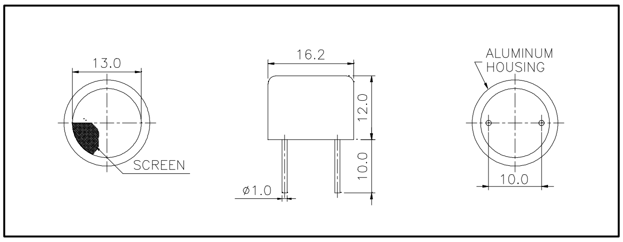
# APPENDICES

# APPENDIX A

# ULTRASONIC SENSOR DATASHEET

# Air Ultrasonic Ceramic Transducers 400ST/R160

**Dimensions:** dimensions are in mm




## Specification

| | |
|---|---|
| **400ST160** | Transmitter |
| **400SR160** | Receiver |
| **Center Frequency** | 40.0±1.0Khz |
| **Bandwidth** (-6dB) 400ST160 | 2.0Khz |
| 400SR160 | 2.5Khz |
| **Transmitting Sound Pressure Level**<br>at 40.0Khz; 0dB re 0.0002µbar per 10Vrms at 30cm | 120dB min. |
| **Receiving Sensitivity**<br>at 40.0Khz 0dB = 1 volt/µbar | -65dB min. |
| **Capacitance** at 1Khz ±20% | 2400 pF |
| **Max. Driving Voltage** (cont.) | 20Vrms |
| **Total Beam Angle** -6dB | 55° typical |
| **Operation Temperature** | -30 to 80°C |
| **Storage Temperature** | -40 to 85°C |

All specification taken typical at 25°C
Closer frequency tolerance can be supplied upon request.

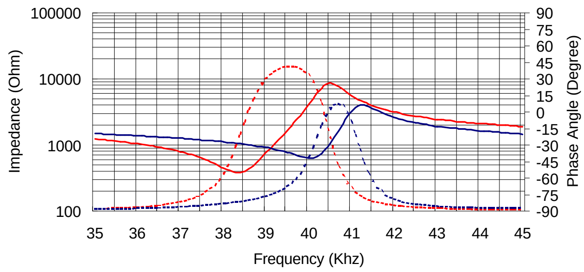
Models available:

| | | |
|---|---|---|
| 1 | 400ST/R160 | Aluminum Housing |
| 2 | 400ST/R16B | Black Al. Housing |
| 2 | 400ST/R10P | Plastic Housing |
| 3 | 400ST/R16F | Al. Housing w/Solid Grid |

## Impedance/Phase Angle vs. Frequency

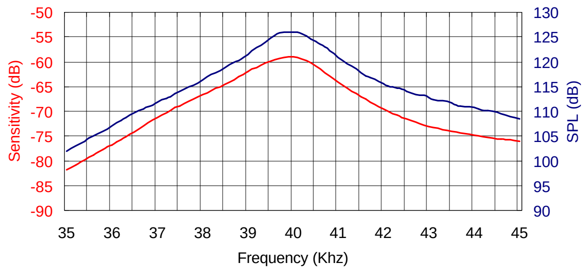
Tested under 1Vrms Oscillation Level

400SR160 Impedance
400SR160 Phase
400ST160 Impedance
400ST160 Phase

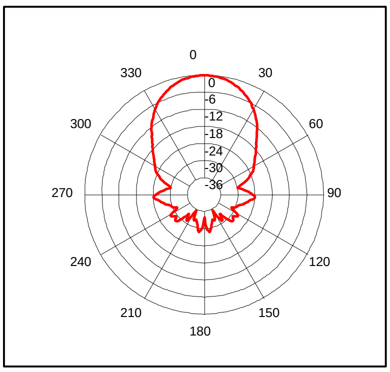



## Sensitivity/Sound Pressure Level

Tested under 10Vrms @30cm

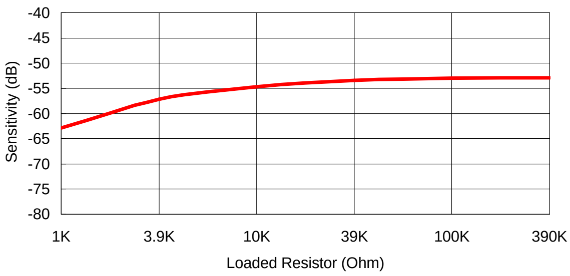



**Beam Angle:** Tested at 40.0Khz frequency

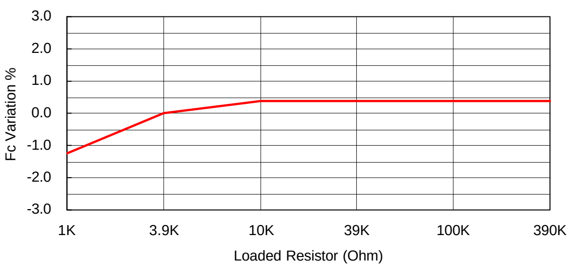


## 400SR160 Receiver

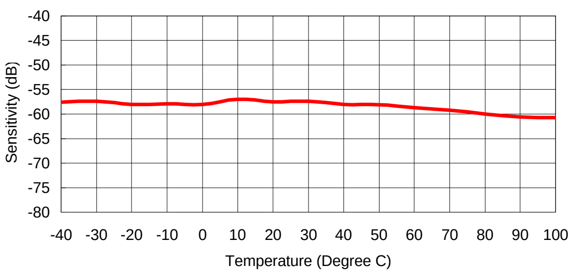
### Sensitivity Variation vs. Loaded Resistor



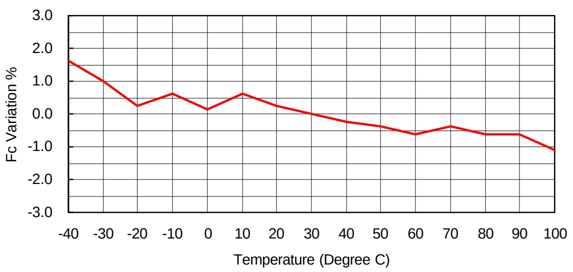

### Center Frequency Shift vs. Loaded Resistor




### Sensitivity Variation vs. Temperature

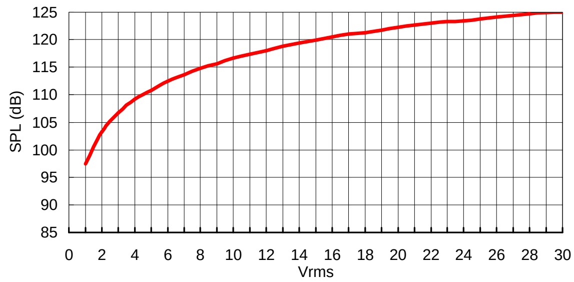



### Center Frequency Shift vs. Temperature

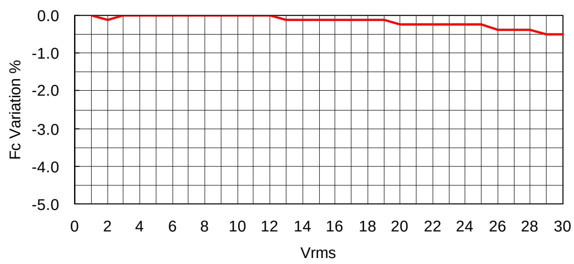



## 400ST160 Transmitter

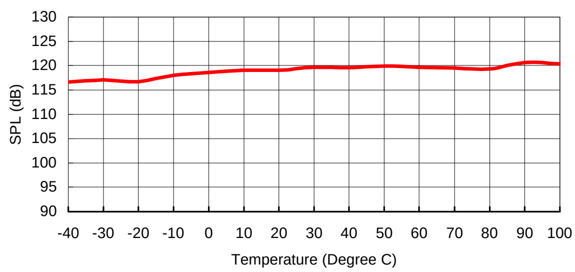
### SPL Variation vs. Driving Voltage




### Center Frequency Shift vs. Driving Voltage




### SPL Variation vs. Temperature




### Center Frequency Shift vs. Temperature