WISE – Wireless Sound Detector

by

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Dissertation submitted in partial fulfilment of
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CERTIFICATION OF APPROVAL

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Approved by,

(Norshuhani Zamin)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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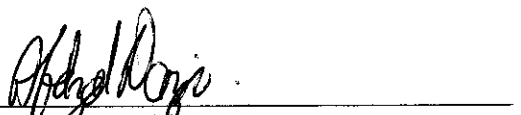
CERTIFICATION OF ORIGINALITY

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.



AFDZAL NAZRI
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11th April 2008

ABSTRACT

'WISE – WIRELESS SOUND DETECTOR'

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A switch that can turn on and off based on surrounding sound is proposed in this report. Not any sound can activate the switch but only high frequency of voice can trigger the switch. If the sound cannot be detected because of the distance or the surrounding noise, a wireless device will be used to transmit a modulated signal that carries a high pitch sound. The signal received will then be processed by the circuit to trigger any electrical equipment. A good frequency band must be chosen so that no electrical noise that can interferes the wireless signal and the quality of the signal transmitted must be good. The developed prototype can be applied as home security applications or application to help some people, for example small children or disable people to switch on the light and also to give a warning.

Keywords: Sound activated, wireless transmission, high pitch detector

ACKNOWLEDGEMENT

Alhamdullilah, with the capabilities given by Allah Taala to me, this project successfully done on time.

Thank you so much to my supervisor, Puan Norshuhani for her excellent guidance courage, and support from day one I involved in this project.

Thank you for my friends that gave me ideas on how to improve my project and all the support given.

Afdzal Nazri
8535, Information Communication Technology

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Abbreviations

FM	Frequency Modulation
HF	High Frequency
MHz	Megahertz
GHz	Gigahertz
MW	Medium Wave
VHF	Very High Frequency
UHF	Ultrahigh Frequency
SHF	Super High Frequency
EHF	Extremely High Frequency
PCB	Printed Circuit Board
IC	Integrated Circuit
SMS	Short Messaging System
GSM	Global System for Mobile

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wireless communication is a way to send information to other party without to use a physical medium such as copper or fibre optic that is has to be connected physically. Instead, using an air as a medium of transmission, will help to eliminate the cost and barriers that occupied by the wired transmission system. The distances involved may be short (a few meters as in television remote control) or very long (thousands or even millions of kilometres for radio communications).

In this project, a wireless transmission will be used to send a high pitch sound using a stable 27 MHz frequency modulation. This band was chosen as it can be used and seldom be occupied by other band. A crystal is embedded in the circuit to obtain an exact 27 MHz of frequency. There will be transmitter that will only transmit the sound using 27MHz frequency and the wave will be captured by the receiver. There is another circuit that detect the sound produced and will activate the relay. This relay soon will be connected to any electronic or electrical device and will be used to switch on or off the device.

This system can be use for home security where the system will be trigger by detecting sound made by intruders or to help small children of disable people to switch on light as the wall switch will not be reached by these people.

1.2 Problem Statement

- Switch is too high or far

We can see that for convinence, electrical switches being install high on the walls. This can be a burden for disable people that using a wheel chair to reach on the switch in order to switch on or off the electrical equipment. This device also can be use by small children when they are not tall enough to switch on the lights in corridor or stairs light.

- Sound detection fire alarm

Whenever fire alarm rings, some one has to phone the firemen and this procedure will consume time. By using this device, whenever the alarm bell ring for emergency, it will trigger and send signal to to fire station wirelessly.

- Frequency Modulation being occupied by to many stations

For the device to operate efficiently, Frequency Modulation (FM) was not used. Instead a dedicated frequency, 27 MHz will be use to transmit the signal. This is because that FM frequency already being occupied with radio stations that may interferes the signal quality.

1.3 Objective and Scope of Study

The main objectives of this project are:

- To transmit wireless signal using dedicated frequency (27 MHz)
- To trigger another system once the signal received
- To enable the electrical device response only to high pitch sound

Study Scope:

The signal will be using 27MHz high frequency where not being occupied. Only certain sound frequency with the right amplitude of sound will be detected by the device.

The study will be on the wireless signal that use air as a medium of transmission. With the signal propogate in a frequenc that is not being occupy by any other signal, a good quality signal will be received and later will change to a high amplitude signal. As for the sound recognition, only a certain level of frequency will trigger the switch. The switch will later be use to on or off any electrical device.

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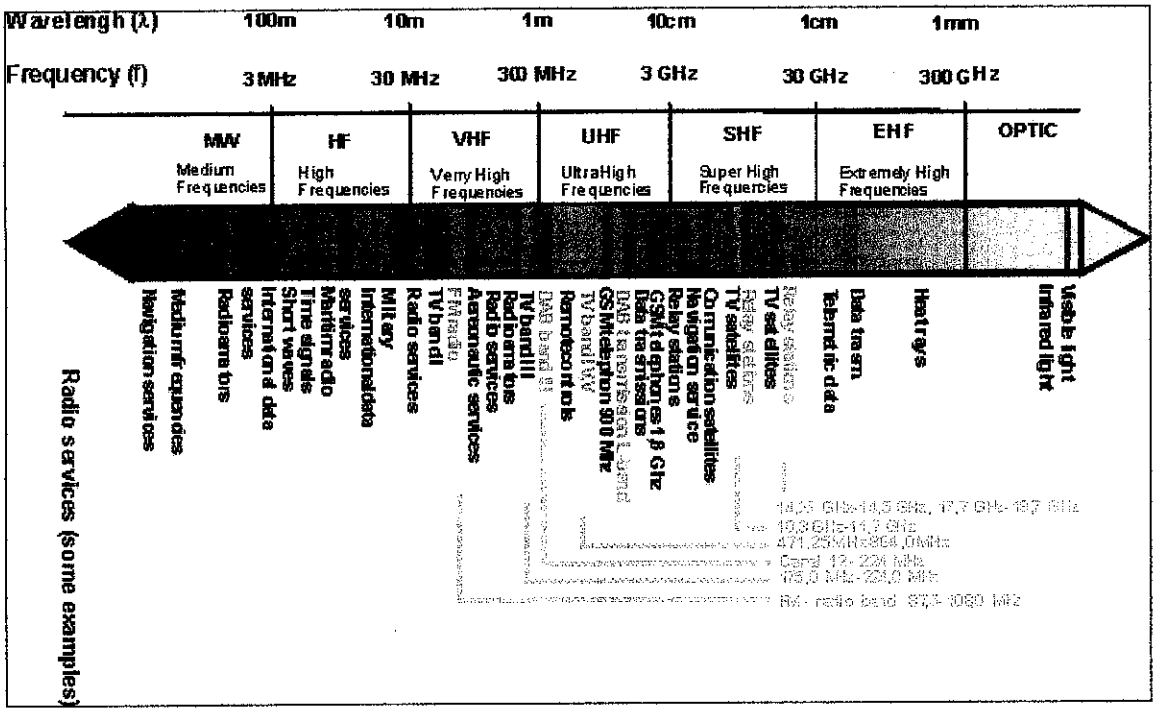


Figure 1.1 Frequency Spectrum

This project can be done in 32 weeks of time based on the objective stated.

CHAPTER 2

LITERATURE REVIEW

2.1 Wireless Communication

An information that is being transmit using air as a medium is being called wireless communication. By using the electromagnetic wave to encapsulate the signal, it can be transferred to another destination that is miles away from the transmitter. In this world, the electromagnetic wave is from 3MHz up to 300GHz. There are protocols inside this wave spectrum that ease the transmission procedure. Each of the protocol occupies certain bandwidth inside the frequency spectrum. Wireless internet occupies 2.4 GHz frequency while for Frequency Modulation (FM) radio takes 88 MHz to 108 MHz.

As for in this project, the frequency of 27 MHz will be used in order to transmit the sound wirelessly for around 100 meters apart between the transmitter and the receiver. In the frequency spectrum, this range of frequency is in the High Frequency (HF) area. Using this band to transmit the sound signal does not require special license.

2.2 High Sound Pitch Detection

The sensations of frequencies are commonly referred to as the pitch of a sound. A high pitch sound corresponds to a high frequency and a low pitch sound corresponds to a low frequency. Many people are capable of detecting a difference in frequency between two separate sounds which is as little as 2 Hz.

When two sounds with a frequency difference of greater than 7 Hz are played simultaneously, most people are capable of detecting the presence of a complex wave pattern resulting from the interference and superposition of the two sound waves.

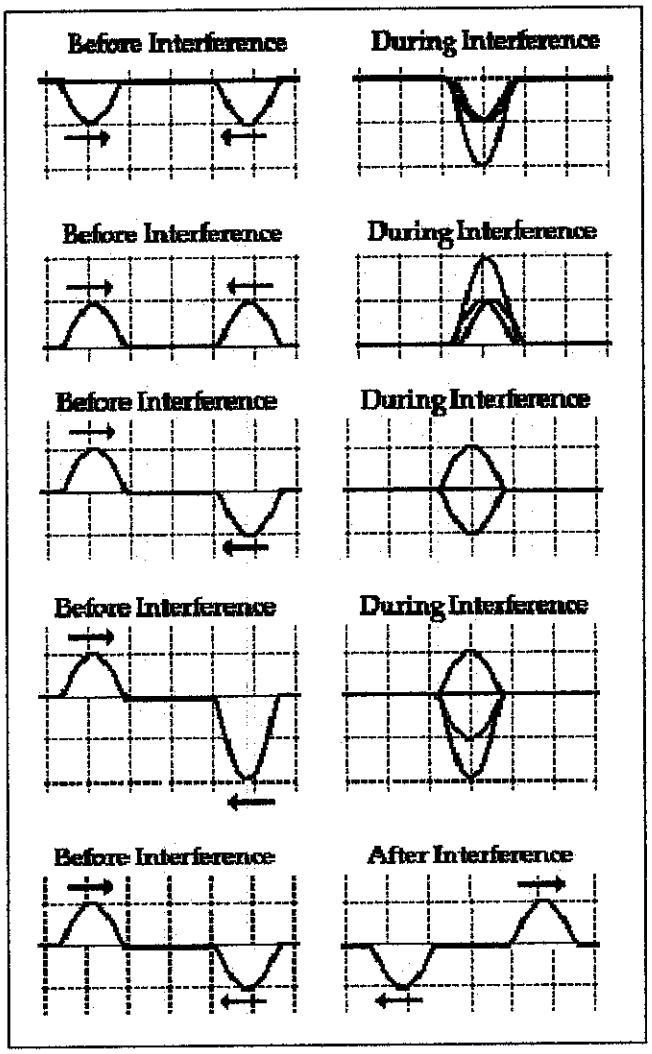


Figure 2.1 Sound Interference Waveform

Wave interference is the phenomenon which occurs when two waves meet while travelling along the same medium. When two waves interfere, the resulting displacement of the medium at any location is the algebraic sum of the displacements of the individual waves at that same location. All object has their own nature frequency each natural frequency which an object or instrument produces has its own characteristic vibration patterns. These patterns are only created within the object or instrument at specific frequencies of vibration; these frequencies are known as harmonic frequencies, or merely harmonics. At any frequency other than a harmonic frequency, the resulting disturbance of the medium is irregular and non-repeating. [1]

2.3 Signal booster

In this project, two antennas were used to amplify and to get a good quality of the transmission signal. By using a 1 meter antenna, the transmitter and the receiver can be further apart. Not only that, the noise can be eliminated once antenna is attached to the circuit.

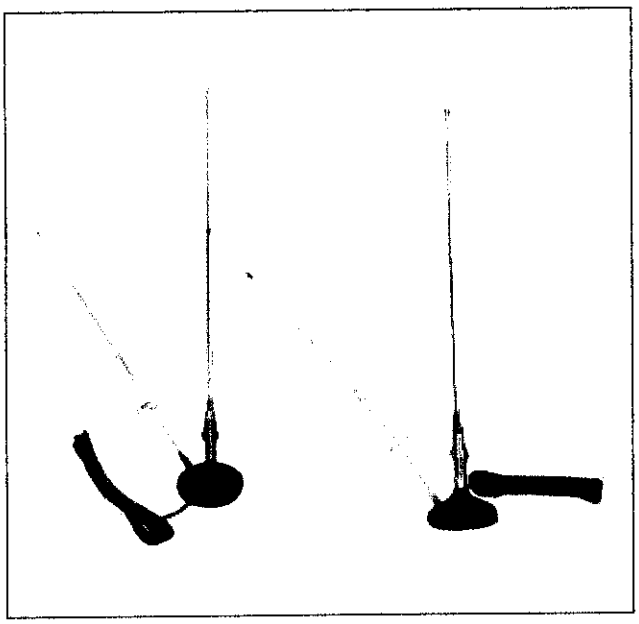


Figure 2.2: Antenna booster

Every antenna and every antenna feed-line have a characteristic impedance, or opposition to electrical current. In an ideal situation, the impedances of line and antenna match perfectly, and 100 percent of the electrical energy sent to the antenna is converted to radio energy and radiated into the atmosphere. In a less than ideal case, when the impedances aren't perfectly matched, some of the electrical energy sent to the antenna won't be converted to radio energy, but will be reflected back down the feed-line. The energy reflecting back from the antenna causes standing waves of electrical energy in the feed-line. (An example of standing waves outside the electronics world is found in river rapids. When water passes around and between boulders it may form a wave that doesn't go up or down the river, it just stays in one place. That is a standing wave of water.) The ratio of highest voltage on the line to lowest is the standing wave ratio. In the perfectly matched system, the SWR is 1:1. [2]

2.4 Sound capturing

Small microphone (such as the common condenser microphones) would result in the least disturbance of the sound field environment. [3] After receiving a sound, microphones produce a continues time electric signal, as in figure 2.1.

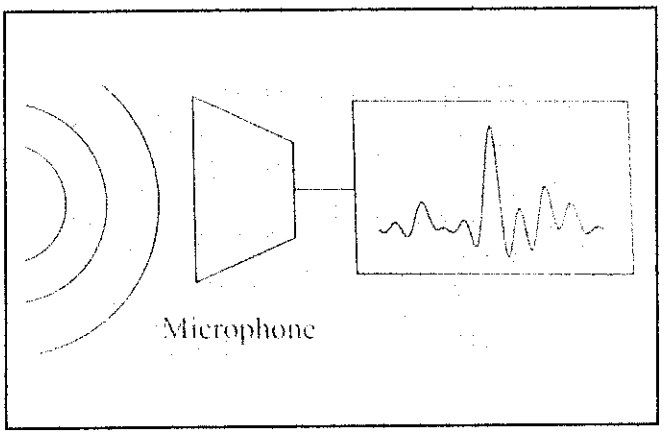


Figure 2.3: Time electric signal

In addition to background noise, reverberation is another major barrier for sound detection especially in a hands-free setting, where the microphone is placed further away from the speaker. Reverberation is caused by sound reflections by an enclosure such as walls of a room. Once an acoustic sound is emitted by a speaker in a room, the acoustic waves travel in all directions. Some of the waves travel directly to the microphone. The other waves hit the various surfaces of the room (such as wall, ceiling, floor) and parts of the waves are reflected. The reflected waves can also reach the microphone sometime later. As a result, the microphone receives multiple copies of the same sound with various amplitude and time delays. Mathematically, reverberations can e models as the impulse response between the source and the receiver. Reverberation time refers to the duration of this impulse response. A commonly used definition for reverberation time is T_{60}, which is defined as the time it takes for a sound to reduce to 60dB below its original level. [3]

Room impulse response in a rectangular enclosure can be simulated efficiently using the image method technique [4]. A typical room impulse response obtained using the image method with intra-sample interpolation is shown in figure 2.2. In this case, assumed that the walls, floor and ceiling having the same reflection coefficient.

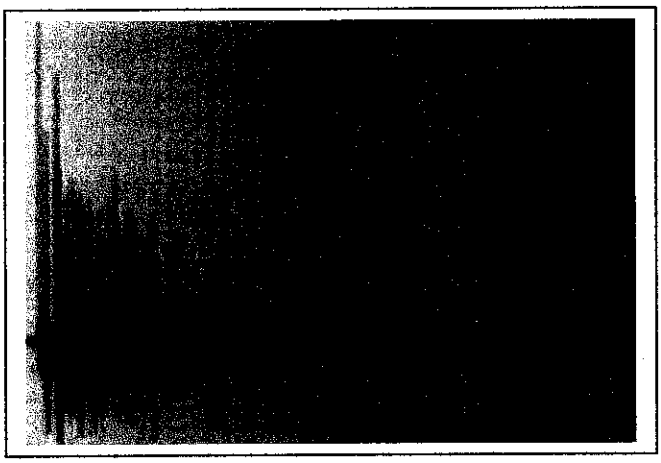


Figure 2.4: A simulated room impulse response using the image method with intra-sample interpolation (Room size 6m X 6m X 2.5m)

CHAPTER 3

METHODOLOGY

Methodology Before any planning are made, investigation were done to make sure that the product tat going to be built are feasible to be delivered on time within the knowledge capabilities. Analysis is made to before making planning for the modules. This is where the study about the feasibility was done, to ensure a quality prototype can be made.

After several modules being design, every single module was developed to make a single prototype. The prototypes were tested thoroughly on every component to ensure the functions working properly as desired. If any components are found not working correctly, the components or module will be redesign.

Soon, all of the module will go for final integration and final testing and benchmark will be done in order to finalize the project.

This methodology is the combination of modules development, prototyping and spiral development model. Each of this methodology has its own benefits and weakness thus by combining them all, making complements to each other.

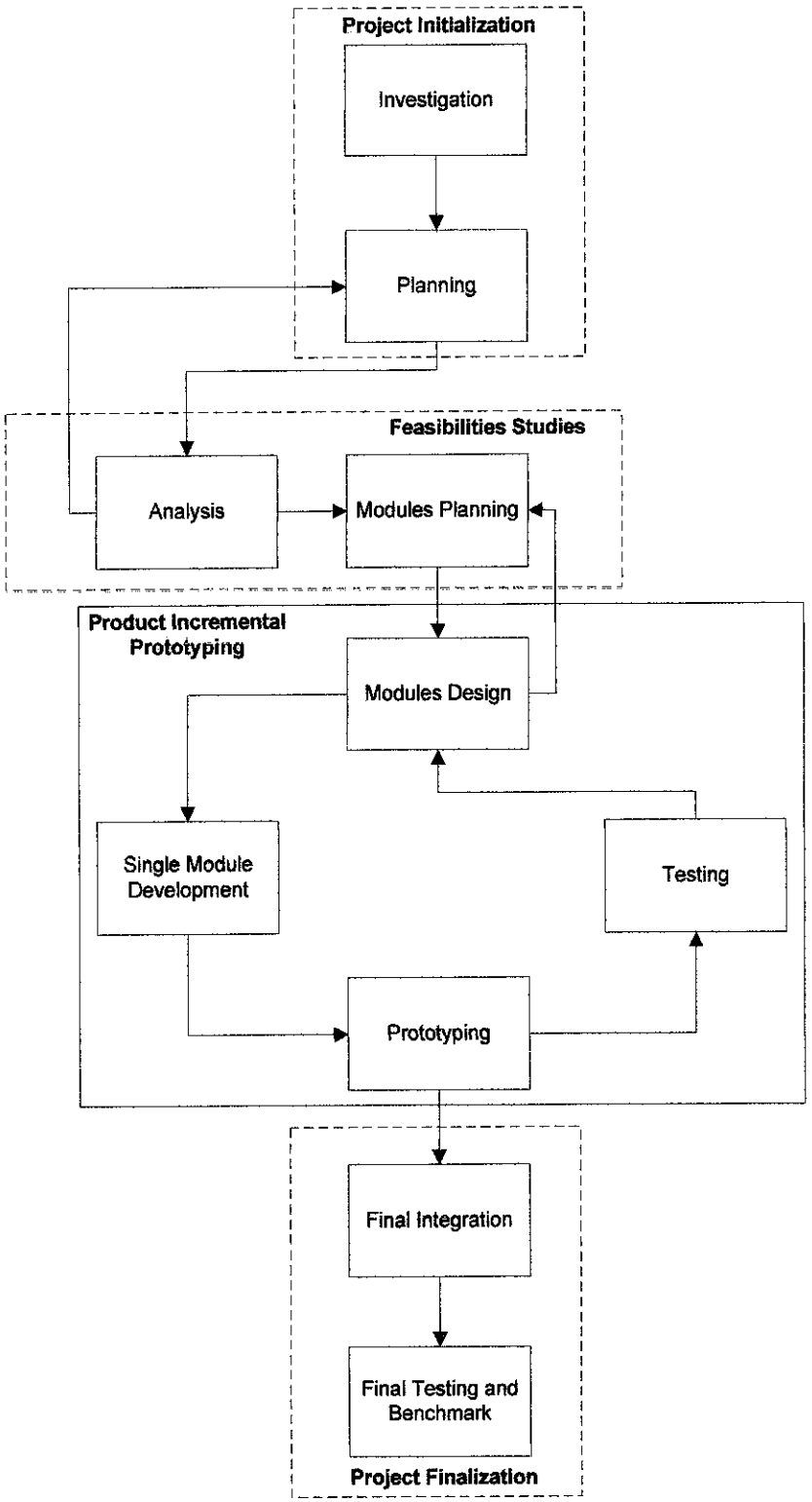
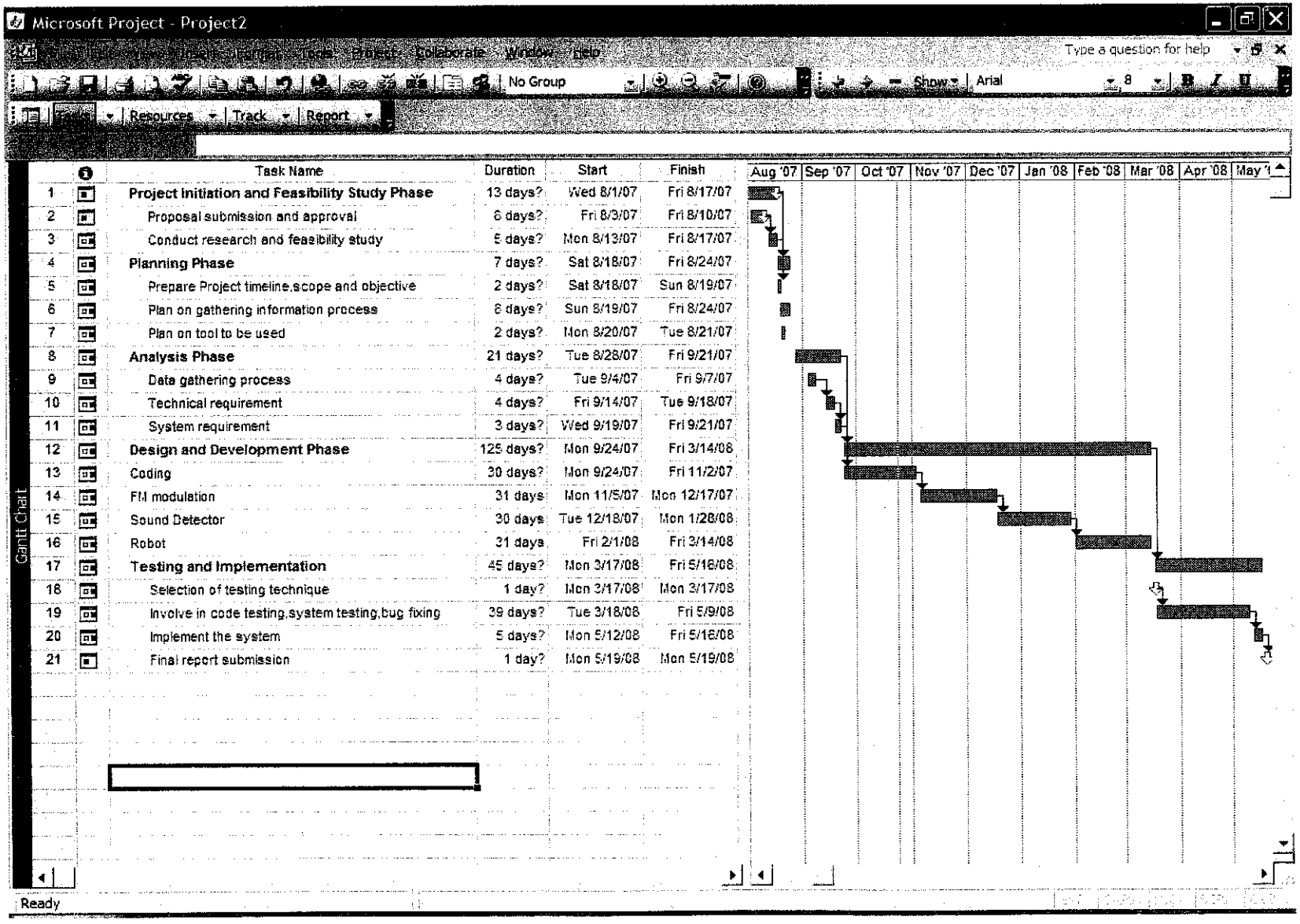


Figure 3.1: Methodology Diagram

3.1 Gantt Chart



	Task Name	Duration	Start	Finish
1	**Project Initiation and Feasibility Study Phase**	13 days?	Wed 8/1/07	Fri 8/17/07
2	Proposal submission and approval	8 days?	Fri 8/3/07	Fri 8/10/07
3	Conduct research and feasibility study	5 days?	Mon 8/13/07	Fri 8/17/07
4	**Planning Phase**	7 days?	Sat 8/18/07	Fri 8/24/07
5	Prepare Project timeline,scope and objective	2 days?	Sat 8/18/07	Sun 8/19/07
6	Plan on gathering information process	6 days?	Sun 8/19/07	Fri 8/24/07
7	Plan on tool to be used	2 days?	Mon 8/20/07	Tue 8/21/07
8	**Analysis Phase**	21 days?	Tue 8/28/07	Fri 9/21/07
9	Data gathering process	4 days?	Tue 9/4/07	Fri 9/7/07
10	Technical requirement	4 days?	Fri 9/14/07	Tue 9/18/07
11	System requirement	3 days?	Wed 9/19/07	Fri 9/21/07
12	**Design and Development Phase**	125 days?	Mon 9/24/07	Fri 3/14/08
13	Coding	30 days?	Mon 9/24/07	Fri 11/2/07
14	FM modulation	31 days	Mon 11/5/07	Mon 12/17/07
15	Sound Detector	30 days	Tue 12/18/07	Mon 1/28/08
16	Robot	31 days	Fri 2/1/08	Fri 3/14/08
17	**Testing and Implementation**	45 days?	Mon 3/17/08	Fri 5/16/08
18	Selection of testing technique	1 day?	Mon 3/17/08	Mon 3/17/08
19	Involve in code testing,system testing,bug fixing	39 days?	Tue 3/18/08	Fri 5/9/08
20	Implement the system	5 days?	Mon 5/12/08	Fri 5/16/08
21	Final report submission	1 day?	Mon 5/19/08	Mon 5/19/08

Figure 3.2: Gantt chart

3.2 Tools required

3.2.1 Oscilloscope

This hardware will be use measure on the right amplitude that needs to trigger the detector. The waveform also was being measured using oscilloscope in order to get the real wave form.

3.2.2 Soldering Iron

As this project will be build from scratch, all the electronic components will be solder on the PCB board or Vero board. All the components will be connected based on the schematic design of the circuit.

3.2.3 Project board

Project board was used to check the circuit that it works well before being soldered onto the Printed Circuit Board (PCB). Each of the components, especially Integrated Circuit (IC) MC14013BC and LM358 were tested on the project board first. Soldering process on the PCB was done once all the components verified.

CHAPTER 4

RESULT AND DISCUSSION

Whenever a high frequency sound such as clapping was detected by the microphone in the detector circuit, the signal will be passed to the amplifier IC. After amplification was made, the signal then was passed to the another IC that will detect the high frequency sound as that is the type of sound that will trigger the transistor. Soon, after the right sound detected, a small voltage was supplied to the transistor and will switch on the relay

As for the wireless transmitter and receiver, each input signal will be modulated into 27 MHz frequency signal. The receiver that is always on standby will take any signal that is in 27 MHz frequency and will change the signal back into sound captured by the receiver.

To make sure that the signal quality that being transmitted is good, antenna must be used. A good antenna that will boost the signal quality and the distance between the transmitter and receiver can be made further.

In application wise, this project will help the disable people to switch on electrical equipment such as lamp or fan in a room by just clapping. As for small children, they can clap their hand to switch on the light as the switch will be very high for these small children to reach. For security purpose, whenever the fire alarm strikes and made noise, this will trigger the device when the signal is being sent to the fire station wirelessly and this will surely eliminate a lot of time for someone to make the emergency call.

4.1 Circuit Theory

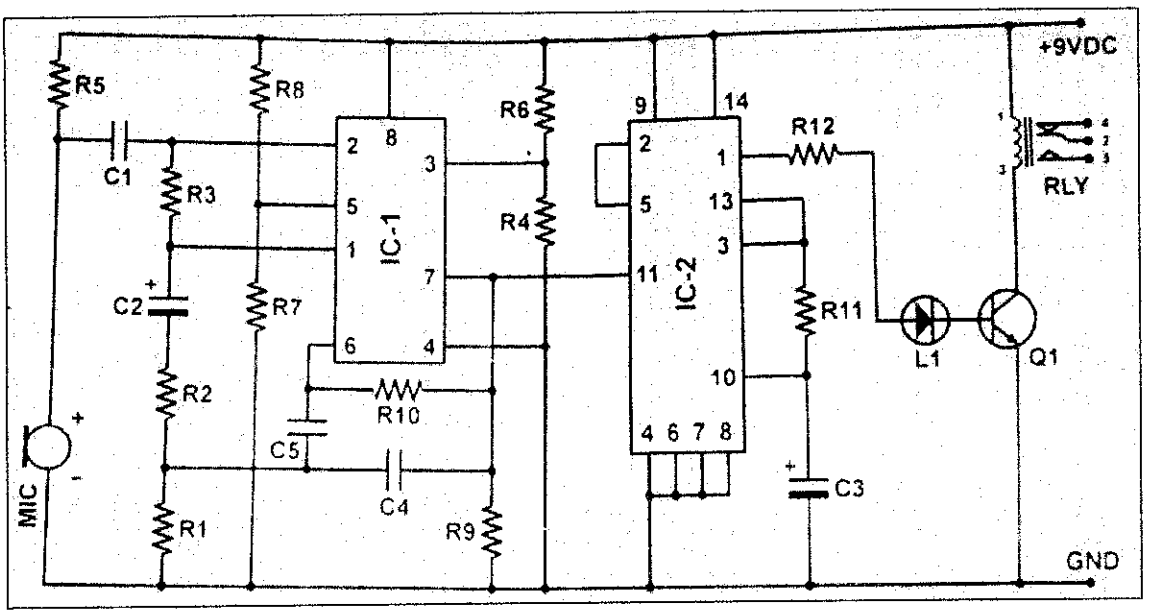


Figure 4.1: Sound detector circuit (Refer to Appendix A for the components value)

Figure 4.1 shows the sound detector circuit consist of IC-1which is the amplifier IC (Integrated Chip) and IC-2, the D-flip-flop IC. Once a sound detected by the microphone IC-1 will process either the sound captured is high or low frequency. If it is a low frequency, no output will be send to IC-2 through pin 7 of IC-1.

If there is a high frequency detected, pin 7 in IC-1 will send a HIGH signal (1) to pin 11 in IC-2. Next, IC-2 will process the signal as this is D flip flop. When the signal being processed, output at pin 1 of IC-2 will be HIGH and trigger Q1, the transistor. L1, the LED will act as an indicator and safety component in order to make only one flow of current direction. This is to prevent no current from Q1 to enter pin 1 and create malfunction to the circuit system.

Q1 acts as a switch. Whenever there is a current flowing to base of Q1, the transistor will be in ON state, giving a current flow from collector to the emitter. Once this happened, relay (RLY) will activate and trigger another system that being connected to the circuit.

4.2 Clapping Distance

Tests were done to see how far the circuit can detect the clapping. As near as 10 centimetres, usual human voice was used as an input to the microphone but the circuit does not triggered. This shows that low frequency voice will not trigger the circuit. Next, a distance of 100 centimetres was made a human voice again was used and still the circuit intelligently ignore the voice sound and the circuit remain OFF state.

As for a clap sound, the circuit can detect the sound as far as 10 meters away. The distance can be more in a room as the sound will reflects from walls to the microphone. A test was also done in a corridor to see the effect on how the distance can be further. In a corridor, surrounds by concrete wall, the clapping sound can be detected as far as 20 meters with a quiet surrounding.

In a noisy surrounding, with people chatting and radio switched on, the circuit still remain in OFF state and changed to ON state when a clap sound detected. This clap sound, which has a high frequency sound, was made 5 metres away from the microphone. This shows that the circuit is intelligent enough to differentiate which sound that is high and low pitch.

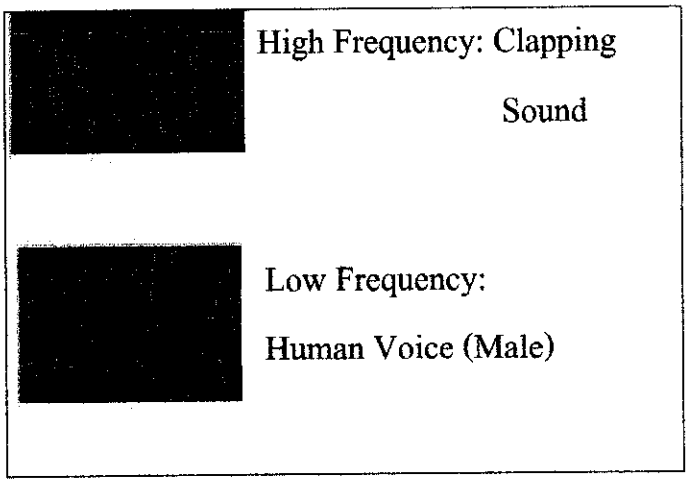


Figure 4.2: High and low frequency sound

4.3 Wireless Device

The wireless device was used to send the clapping sound to the sound detector whenever the detector is far away to detect the high pitch sound. This wireless device uses a dedicated 27 MHz High Frequency band to transmit the sound using air.

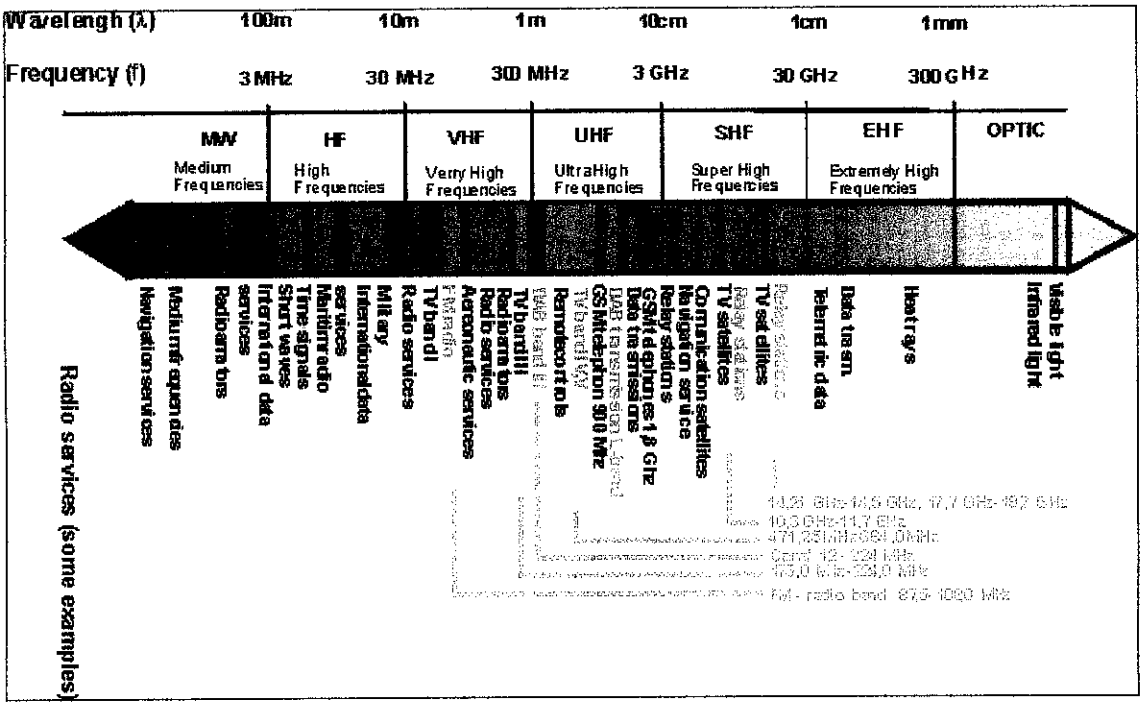


Figure 4.3: Radio Frequency Spectrum

There is also a small button located on board to produce to high pitch sound and transmit to the receiver. Antenna used in the circuit to eliminate the noise and to make the transmission distance further. To get a dedicated purely and uninterrupted modulation signal, a crystal being used. This crystal is to make sure that the oscillation of the modulation frequency is stable at only 27MHz. This frequency was selected because several experiments were done to carry the high pitch sound in Frequency Modulation (FM) technique. Because of so many radio stations occupy in the FM band, the transmission using FM was changed to High Frequency (HF) modulation technique

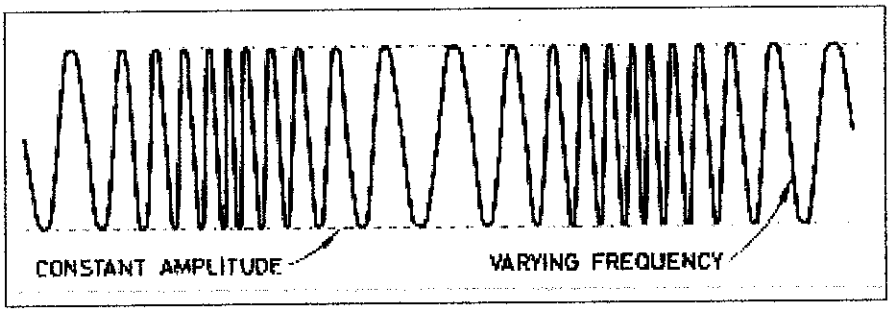


Figure 4.4: Frequency Modulation Technique Waveform

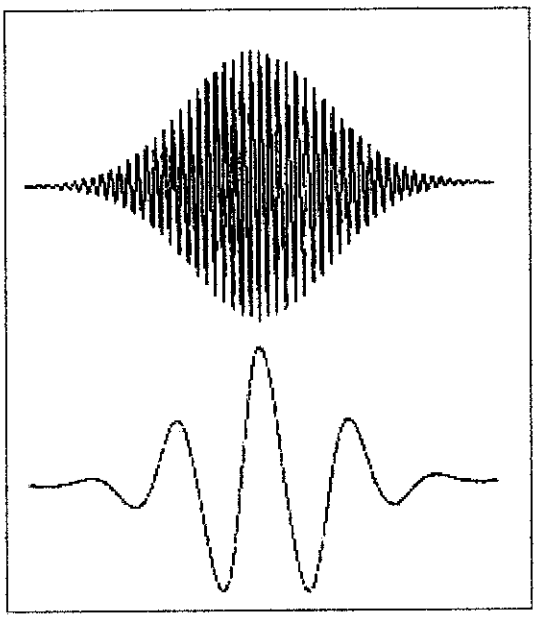


Figure 4.5: High Frequency (Top) and

Low Frequency (Below) waveform

4.4 Limitations

Several limitations were detected from this project. Theoretically, the transmission power can only transmit up to 100 to 150 metres, by using the right antenna and a good power source. As the distance go further, more noise will be detected and a false triggering will be made. To overcome this, a good and clean signal without noise must be obtained. In order to do that, the transmitter and the receiver must be in the range and a good antenna must be use.

The circuit is intelligent enough to eliminate high and low sound pitch. This made the circuit cannot trigger another circuit that produce high pitch sound such as an electric motor. Electric motors that create a high pitch sound that will make the sound detector back in OFF state. This makes this circuit does not suitable to trigger a robot or a blender, that use electric motor as the engine.

CHAPTER 5

CONCLUSION AND RECOMENDATION

5.1 Sound Detection

The sound detection of the device makes it intelligent while eliminating the unwanted noise so that the device will not confuse with the undesirable sound. By using the High Frequency wave signal, any strike sound made internally can be separated from the transmission signal. The detection must be good enough to take only the sound that being transmitted wirelessly from the transmitter.

5.2 Project Application

Imagine a disable person that on a wheel chair who tries to switch on the light but unfortunately, the switch is too high on the wall. He just can clap his hand and the switch can turn on. This application also applies to small children and patient on the hospital bed where switch is too far from them.

This circuit also can be integrated with fire fighting system where if the bell sound, which is in high pitch sound, the sound can be captured by the transmitter. This sound will be sent to the receiver wirelessly and trigger the sound detector. The sound detector will later send alarm signal to the fire station.

5.3 Future Works

With a good planning and knowledge, the objective of this project can be archive. However, there should be an improvement work later. The system should be able to send SMS using the GSM network. This can be done probably using a GSM modem.

Better transmission signal should be made possible so that the range of the transmission can be higher. The study on how to make more powerful signal transmission must be done as the signal distort as the transmitter move far away from the receiver.

The sound detector must be intelligent enough to eliminate the unwanted noise an only detects on the high pitch sound. In order to do that, a better microphone must be used The integrated chip that can eliminate and detect which one is unwanted noise must be integrate with the circuit.

Appendix A

<table>
<tr><td>RESISTOR</td><td>INTEGRATED CHIP (IC)</td></tr>
<tr><td rowspan="8">R1 = 100 Ω
R2 = 10 KΩ
R3 = 180 KΩ
R4 = 6.8 KΩ
R5 = 10 KΩ
R6 = 8.2 KΩ
R7 = 6.8 KΩ
R8 = 10 KΩ
R9 = 10 KΩ
R10 = 100 KΩ
R11 = 100 KΩ
R12 = 100 Ω</td><td>IC-1 = 358 (8 PIN)
IC-2 = 4013 (14 PIN)</td></tr>
<tr><td>TRANSISTOR</td></tr>
<tr><td>Q1 = 9013</td></tr>
<tr><td>CAPACITOR</td></tr>
<tr><td>C1 = 0.1 µF
C2 = 1 µF
C3 = 10 µF
C4 = 0.01 µF (103)
C5 = 0.01 µF (103)</td></tr>
<tr><td>OTHER ITEMS</td></tr>
<tr><td>L1 = LED
MIC = MICROPHONE
RLY = RELAY 6V ~ 9V DC</td></tr>
</table>

References

[1] Dr. David Gerhard., 1995, " Pitch Extraction and Fundamental Frequency: History and Current Techniques," *University of Regina Journal*

[2] How does a CB radio antenna work? 30 March 2008 <http://electronics.howstuffworks.com/question490.htm>

[3] Parham Aarabi. 2006, *Phase-Based Speech Processing,* London, World Scientific

[4] J. B. Allen and D.A. Berkeley. Image methods for efficient simulating small room acoustics. *Journal of Acoustic Society of America,* 65