DESIGN AND DEVELOPMENT OF NOISE DETECTOR AT HANGAR AIRCRAFT TRAINING ORGANISATION

NORSIAH BINTI SUKARDY

FACULTY OF ENGINEERING

UNIVERSITY OF MALAYA

KUALA LUMPUR

2018

DESIGN AND DEVELOPMENT OF NOISE DETECTOR AT HANGAR AIRCRAFT TRAINING ORGANISATION

NORSIAH BINTI SUKARDY

FACULTY OF ENGINEERING

UNIVERSITY OF MALAYA

KUALA LUMPUR

2018

UNIVERSITI OF MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **NORSIAH BINTI SUKARDY**

Matric No: **KQD 160025**

Name of Degree: **MASTER OF ENGINEERING (SAFETY, HEALTH AND ENVIRONMENT)**

Title of Project Paper/Research/ Report/Dissertation/Thesis ("this Work"):

DESIGN & DEVELOPMENT OF NOISE DETECTOR AT HANGAR TRAINING ORGANISATION

Field of Study: Safety

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;

(2) This Work is original;

(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;

(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;

(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;

(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date:

Subscribed and solemnly declared before:

Witness's Signature Date:

Name:

Designation:

ABSTRACT

Hearing problem is one of the most common disabilities among personnel at hangar. They are exposure to high noise from the aircraft engine, ground power unit (gpu), auxiliary power unit (apu), machinery, towing vehicles and rivet machine. Many of the posts have high noise levels, and particular ratings have high exposure. These are especially for the peak level of sound emission. If results of higher risk can be identified, then prevention precaution can be focused. Duty as technician, skill students, instructors, engineers and pilot ratings are at high risk for hearing loss, this study looked at medical hearing test records for nearly 100,000 enlisted AM personnel over the period of 2004 to 2017. Investigation on these matter have been done by doing analysis and study through survey and questionnaires . Collection of questionnaires from five (5) major hangar in Selangor are used to investigate the underlying hearing impairment. The design and development of Prototype Noise Detector has been created to assess the effect of this invention to reduce early hearing problems. Excessive hearing senses may persist and other problems due to noise can be overcome.

ABSTRAK

Masalah pendengaran adalah salah satu kecacatan yang paling membimbangkan di kalangan kakitangan di hangar. Mereka terdedah kepada kebisingan tinggi dari enjin pesawat, unit kuasa darat (gpu), unit kuasa tambahan (apu), jentera, kenderaan menunda dan mesin rivet. Banyak sumber bunyi mempunyai tahap bunyi yang tinggi, dan penilaian tertentu mempunyai pendedahan yang tinggi. Ini adalah terutamanya untuk tahap puncak pelepasan bunyi. Keputusan risiko lebih tinggi dapat dikenalpasti, maka langkah pencegahan dapat difokuskan. Tugas sebagai juruteknik, pelajar kemahiran, tenaga pengajar, jurutera dan pekerja perintis berisiko tinggi dalam mengalami permasalahan dan kehilangan pendengaran. Kajian membuktikan rekod ujian pendengaran perubatan untuk hampir 100,000 anggota AM terdaftar dalam tempoh 2004 hingga 2017. Siasatan terhadap beberapa kajian telah dilakukan dengan kaedah soal selidik yang dikumpul dari lima (5) hangar utama di Selangor. Soalan analisa terhadap kerosakan pendengaran terhadap para pekerja jelas terbukti. Pembangunan prototaip pengesan bunyi ini telah dibuat untuk menilai kesan hingar dan pemberitahua untuk mengurangkan masalah pendengaran pada peringkat awal. Pendedahan terhadap bunyi bising dan hingar yang berlebihan malah berlarutan akan memberi masalah dan kerosakan kekal dalam tempoh pendek atau jangka panjang.

ACKNOWLEGMENTS

In the Name of Allah, the Most Merciful, the Most Compassionate all praise be to Allah, the Lord of the worlds; and prayers and peace be upon Muhamad SAW, His servant and messenger.

First and foremost, I must acknowledge my limitless thanks to Allah, the Ever - Magnificent; the Ever -Thankful, for His help and bless. I am totally sure that this work would have never become truth, without His guidance. I owe a deep debt of gratitude to University Of Malaya for giving me an opportunity to complete this work.

I am grateful to some people, who worked hard with me from the beginning until the completion of the present research particularly my supervisor Associate Professor Dr. Siti Zawiah Binti Md Dawal, who has been always generous during all phases of the research, I highly appreciate the efforts expended by her.

I would like to take this opportunity to say warm thanks to all my beloved friends, who have been so supportive along the way of doing my research report. I also would like to express my wholehearted thanks to my family for their generous support they provided me throughout my entire life and particularly through the process of pursuing the master degree. Because of their unconditional love and prayers, I have the chance to complete this research.

I owe profound gratitude to my husband, Muhamad Nordin Bin Suleiman and my two beloved sons Muhammad Akmal and Muhammad Nabil, for their understanding and constant encouragement, limitless giving and great sacrifice helped me to accomplish my research. Without their support, this study would not have been possible. Last but not least, hopefully this research would bring mutual benefits to all of us.

TABLE OF CONTENTS

CHAPTER 3 : METHODOLOGY

CHAPTER 4: RESULTS AND ANALYSIS

CHAPTER 5: DISCUSSION

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS & ABBREVIATION

AC	:	Alternating Current
AFTO	:	Aircraft Training Organisation
AM	:	Aircraft Maintenance
AMO	:	Aircraft Maintenance Organization
APU	:	Auxiliary Power Unit
DB	:	Decibel
DB SPL	:	Decibel Sound Pressure Level
DC	:	Direct Current
GND	:	Grounding
GPU	:	Ground Power Unit
HPF	:	High Power Field
HSE	:	Health Safety Executive
ISO	:	International Organization For Standardization
LED	:	Light Emitting Diode
NIHL	:	Noise-Induced Hearing Loss
NIOSH	:	National Institute For Occupational Safety And Health
OSHA	:	Occupational Safety And Health Act
PEL	:	Permissible Exposure Limit
PPE	:	Personal Protective Equipment
QFD	:	Quality Function Deployment
REL	:	Recommended Exposure Limit
RMAF	:	Royal Malaysian Air Force

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Overview

Organisation is defined as a unit of people that is structured and managed to meet the need of collective goals. Organisation has a management structure that coordinates between different activities and fellows, dividing roles, responsibilities, and authority to carry out different tasks. Communication in organisation is important to coordinate the roles, responsibilities , and tasks of different levels until finally reaching a collective decision to accomplish the goals.

This study is to assess the noise exposure and hearing threshold of the personnel at Aircraft maintenance hangar. This is the strategy to improve the quality and reliability of aircraft works at hangar.

High noise levels are experienced in aerodrome and within their surroundings, as revealed in previous studies (Cohen et al.,2008). Characteristic hearing loss or Noise induced hearing loss (NHIL) which results from exposure to noise for excessive duration and intensity (Ballenger, J.J. Editor,1985). This problem in active duty personnel has been documented in several studies. Most studies has been done on flight noise scenarios at airports (Smedje G,2011) and military airlines aerodrome. The great challenge here is to have an accurate result of status of hearing disability or hearing impairment among them.

NHL is a serious disease burden in aviation industry. Due to the nature of the profession, Hearing is a vital asset during tactical and survival training and exposure to loud noises during training are inevitable. Prevention is still the mainstay of treatment and workers need to be educated with regards to the use of hearing protection devices. The most important of these studies is to assist the personnel carrying out the work at the

hangar. It is well known that the hangar cannot be denied with any serious noise risk. A study (Smedje, G., et al. 2011). also found that Engineering control on the early warning must be identified and reviewed to be implementing as a way of addressing the dangers of noise and loss problems in the long run.

Hangar is one of the places that produces noise. Hangar attendance are exposed to noise as a routine part of their jobs. This noise various come from aircraft engines during ground run, landing, towing, ground power unit (GPU) or from high-speed air flow over the fuselage and others machinery and tools.. The amount of noise transmitted by the source depends largely on the source of two factors, the type of aircraft engine and its speed and machine equipment. Each source causes complex noise. It consists of various sources: engines, air entrances and exhaust, transmission, tires form road surfaces, drill machines, riveting, casing machines and others. Moreover, (A. Garcia. (2001) the direction of these resources is dependent on other variables such as speed and operating mod. It is essential to find the significant sources of this hearing loss or impairment and then investigate ways to reverse this trend.

The Health and Safety Executive (HSE), noise levels above 105dB (decibels) can damage hearing if endured for more than 15 minutes each week. However, lower levels such as between 80dB and 90dB will cause permanent damage to your hearing if anyone is exposed to them for a few hours every day. Here are a few daily examples that could relate to sound pollution found at hangar. Sound is measured in decibels (dB). Occupational noise exposure can be followed up directly by personal test or indirectly by area test (Atzeri, S., Cocco, P.L., 2004). Exposure to noise workplace has a number of acute and chronic effects on human (Koh, D. J. (1998) and (Ingle S.T., B. P. 2005).

Thus, this research is to investigate current practices and the impact of noise to attendance workers and finally to suggest control measures that can be applied to reduce or eliminate hearing impairment.

1.1 Problem Statement

There are many employees, students and instructors in range 18 years to 51 years carry out their works at hangar every day. By norms hangar is the severe noisy area. Work continue in hangar can cause them to fatigue, exhausted, discomfort and worse scenario may harm their health such as hearing problem. Understanding the concept of hearing sensitivity is vital and the best method to mitigate hearing impairment from the early stage (Atzeri, S., Cocco, P.L., 2004).

Based on an existing AFTO Hangar, a control equipment is not attached or mounted at hangar in order to alert crews. Some researchers only discovered on hearing impairment of the aviation personnel after test and medical check-up. If found problem then the patient will be provided with a mobile detector by putting on at their wrist. From the result will produce consequence step of hearing status and ability. Noise detector the dosimeter to see what the average level of radiation or noise has been exposed.

Previous research in Aviation industry found that younger employees were prone to face with hearing problem compared to their counterparts (Smedje, G., et al. 2011). They are being exposed to noise environment since working as a technical workers in hangar. The noise environment in which the aircraft maintenance engineer works can vary considerably. For instance, the airport ramp or apron area is clearly noise, due to running aircraft engines or auxiliary power units (APUs), moving vehicles and so on. The hangar area is noisy, usually due to the use of various tools during aircraft maintenance. When working in noisy environment, may affect their health especially hear. If the level of noise is too high, it may damage hearing sense such as 85 dB and above. A user friendly noise detector is needed in order alerting them the current level of noise. Therefore can mitigate the hearing impairment at early stage. Therefore, it is vital to identify method or device

that could detect high noise level in the environment earlier that could cause impairment and damage hearing.

Studies have shown that youth aged 18 years to 40 years old aircraft technicians and mechanics in a Swedish airlines suffer from hearing loss and less awareness of the risk of deafness. They are often exposed to extremely noisy conditions. Compared to those not exposed to such a condition (Costa, S., Arezes, P., 2012).

Advisable exposure limit (REL) from National Institute of Occupational Safety and Health (NIOSH) is 85 dB (A) for occupational noise exposure for 8 hours average sound pressure level NIOSH. (1998). Criteria for a Recommended Standard.

1.2 Objectives

The objectives of this project are:

i. To determine noise level feature at AM Hangar.

ii. To design the detector based on noise level.

iii. To validate the ability of a prototype in solving the hearing impairment in AM Hangar.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter will discuss and summarise the topic which contains the information gathered to gain knowledge and ideas in completing the project. The first part of this chapter compares the current notification system applied by reviewing the approach used in the system, the components, and the technical requirement of the system. The second part contains analysis of technologies or components related to the devices development.

Information from NIOSH USA, a person exposed to persistent noise is exposed to hearing hazard it is very dangerous and not good to the senses of hearing and can cause permanent damage (Uimonen, SM-T. 1998) The duties of maintaining a plane are one of the highest contributors in the sense of hearing as this task is exposed to the sound of a high level. In ensuring that a very important task in laying the trust so that it is safe to fly can even land perfectly. Advantage of good and earnest work done by the professional is sure to involve unnecessary exposure to maintenance. The task of implementing complex skills activities includes cleaning, diagnosing, recovery, testing and conversion of certain parts and equipment, so there is no hang on the environment that is extremely noisy.

The findings also show that airplane staff who will be equipped with tracking devices are able to educate them on a very noisy environment. This benchmark will enable them to reduce hearing loss among newly-started staff at the hangar. In short, raising awareness about the risks that can affect their hearing senses. Cleared information by Health and Safety Executive (HSE), sound levels exceeding 105 dB (decibels) may cause hearing loss if exposed to more than 15 minutes per week. However lower levels between

80 dB to 90 dB may also cause permanent damage to your hearing if the individual is exposed to noise for a few hours per day. Here are some daily exposure on hangers that can be linked to noise pollution and routine sound problems are the sound of Forklift equipment (90 dB), Drill (98 dB), 7 meter distance truck (95 dB - 100 dB) and Chainsaw 115 dB - 120 dB). Obviously it can add to the noise of the workplace besides the sound of the existing airplane.

2.1 Existing Methods

2.1.1 Sound Level Detector / Controller

Figure 2.1.1.1: Noise Controller

This device continuously measures of noise levels in a specified area and activates (or deactivates) an electrical signalling device when a specified noise exceeds the limit level. Buzzers and light are triggered once reach danger limit. It will not generate signal or notification before certain range before reaching the Permission Limit (PEL) (Smedje, G., et al. 2011).

2.2 Applied system and research

Based on the research that has been done, there are some previous studies which are related to this project. Two systems were chosen in order to understand more about the system operation and development.

2.1.1 Conventional System

Examinations and studies of noise among staff working on hangars after a certain period of time clearly indicate problems with their hearing ability. Hearing tests on employees' thresholds at airlines and aerodrome hangers. This study is nothing but aims to improve the quality and reliability of aircraft work on hangar especially among students, teachers and permanent workers in their own hangar. There are other views in research papers that focus more on just having to do a health examination after a year or two or more. But some staff also did not conduct any direct checks. With obstacles and initiatives to prevent it being taken lightly. Inspection of the audiogram method proves a very significant hearing effect when compared to those who are not exposed to sound (Atzeri, S., Cocco, P.L., 2004). With surveys and analysis among them in 5 hangars in Subang, Selangor can cause this paper to meet the target. To minimize the problem and the effective hearing loss of an effective sound sensor should be installed in the hangar. This method can increase awareness, security and reduce their problems. Indeed, consciousness and safety practices are indirectly conceived. Here's a questionnaire, indicating the exact scenario applies in AMO and AFTO hangars.

2.3 Component of proposed system

Referring to the previous reviews of the applied detector, a few main components of the device have been identified. These include a microphone, a resistor components, three (3) LED , a buzzer, and a switch. In this chapter, the theories about the components are explained and discussed to assist the readers in their understanding about the proposed device.

2.4 Noise Detector

Sound detectors are a special instrument designed to respond to sounds by taking into account the human ear capability, and the suitability of human attitudes in performing hangar tasks. The main purpose of measuring the sound pressure level and informing the environment spontaneously while in the hangar. There are several types of sound meter system available. Various differences but each system will consist of circuit processors, microphones and reading meters. Microphone converts sound signals to electrical signals together. The choice of tools and components with appropriate and accurate in providing reliability to the effects and steps should be taken if the lights and alarms sound. The electrical signals generated by the microphone are too low and small, so the preamplifier needs to be added in order for the effective process to be produced(Atzeri, S., Cocco, P.L., 2004). Signal received and processed electrified. It is easier to build a different electronic sensitivity than the human ear's natural frequency, thus replicating the same contour will be produced for an easy-to-assessable way of presenting. This has produced three different international standard features called "GREEN", "ORANGE" and "RED". Level dB, which means that the sound level is measured A-weighted) Signals showing healthy, cautious and third hazards to work with db are not ideal can be found in the output socket, in the form of AC or DC, connections

to external sensors such as recording equipment level and tape to prepare records and then process to the next level.

The sound sensor circuit is produced, using microcontroller, Arduino board, to turn on LED light after sound is detected. Microphone is used to act as a sound interpreter received to record the unit level that has been determined according to human ear capability. Amplifier is used to amplify, receive, and generate electricity signals. If we connect the output signal from the microphone directly to the Arduino pin, the board cannot detect any very low signal. Accepted signals need to be amplified first for use by Arduino. Hence connect the microphone to the amplifier, amplify the signal, and then connect the amplification signal to the Arduino.

In the construction of this circuit, it has been using the microphone and connecting it to the audio amplifier to get a stronger and precise signal. The IC amplifier used is the popular IC LM386. This will help the Arduino gain readings that allow for more accurate, accurate and credible results. At the red LED it will produce warning sound.

2.5 Nature of Noise-Induced Hearing Loss

Generally, noise-induced hearing loss (NHL) is a major preventable disease. It causes by an acute continuously long-term exposure to high pressure sound level higher than 75–85 dB. Table 2.5.1 shows the term and description of sound pressure.

Table 2.5.1 : Glossary of terms used

Terms	Description
Sound pressure level (SPL)	The unit of sound wave pressure level measurement is the decibel (dB SPL)
dB Scale	To measure sound pressure level at logarithmic scalar.
dB	To measure high frequency noise
L_{Aeq}	Average Level at certain period.

Research in Aviation industry, proved that younger employees had more faced with hearing problem compared to others workers. They are exposed to noise environment since been involved in technical works in hangar. The noise environment in which the aircraft maintenance engineer works can vary considerably. For instance, the airport ramp or apron area is clearly noise, due to running aircraft engines or auxiliary power units (APUs), moving vehicles and so on. The hangar area is noisy, usually due to the use of various tools during aircraft maintenance. When working in noisy environment, may affect their health especially hear. If the level of noise is too high, it may damage hearing sense such as 85 DB and above Atzeri, S., Cocco, P.L., 2004). A user friendly noise detector is needed in order alerting them the current level of noise.

Based on previous research, some data and info can be applied as a reference. Hearing problems and hearing loss are considered health problems, These problems can lead to security issues in the workplace and ultimately invite a disaster (Smedje, G., et al. 2011).. The Occupational Safety and Health Administration sets limits on how decibels of employees can be disclosed on an average basis of 8 hours a day. The limits of exposure allowed by OSHA are 90 A-weighted decibels (dB) for 8 hours. However, if noise increases by 5 dB, the amount of time exposed to noise levels is reduced to 50 percent.

For example, an employee may be exposed to 87 dB for 8 hours, if the noise level increases to 92 dB, the employee can only be exposed to the source for 4 hours only.

The Table 2.5.2 shows the limitation and tolerance for human if in continous and intermittent noise at hangar.

Table 2.5.2 : Limits of Tolerance For Continuous and Intermittent Noise

Noise Level (dB)	Maximum Exposure Permitted
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours 30 min
90	4 hours
91	3 hours 30 min
92	3 hours
93	2 hours 30 min
94	2 hours
95	1 hour 45 min
98	1 hour 15 min
100	1 hour
102	45 min
104	35 min
105	30 min
106	25 min
108	20 min
110	15 min

Thus the objective of this study is to determine the important of noise detector at hangar to alert and mitigate hearing problem on aircraft personnel (Atzeri, S., Cocco, P.L., 2004).

Table 2.5.3 shows the levels of noise in AFTO and AMO hangar and the effect to human hearing.

Table 2.5.3 : Examples Noise Levels

Noise Source	dB Level	dB Effect
Jet take off outdoor	150	Eardrum rupture
Aircraft carrier deck	140	Eardrum rupture
Military jet aircraft take off	130	Eardrum rupture
Thunderclap, chain saw, oxygen torch 121 dB	120	Painful 32 times as loud as 70 dB
Turbo fan aircraft at ground 200ft	118	Average human pain threshold 16 times as loud as 70 dB
Riveting machine	110	Average human pain threshold 16 times as loud as 70 dB
Helicopter at 100 ft	100	8 times as loud as 70 dB. Serious damage possible in 8 hr exposure
Boeing aircraft or DC aircraft before landing	90	4 times as loud as 70 dB likely damage in 8 hour exposure
Propeller plane flyover outdoor	88	2 times as loud as dB possible damage in 8 hour exposure

2017 IAC ACOUSTIC A Division of Sound. Controlling Noise Every Environment

Meanwhile, table 2.5.4 below provides the average L eg by individual opearation.

Table : 2.5.4 : Average L eg Workshops individual operations

Operation	L eg (dBA)
Riveting 1	93.4 + - 1.9
Air compressor	92.6 + - 3.0
Combo	92.4 + - 1.7

Air conditioner	91.4 + - 1.4
ule	91.3 + - 5.3
APU exhaust	90.8 + - 5.4
Idle engine	90.5 + - 2.2
APU run	90.2 + - 2.9
Ground Power Unit	89.3 + - 1.5

Average, aircraft maintenance operation is very high and most workers (89.5%) are exposed to sound level at 85 dB. Frequency analysis of sound pressure level indicates that donations of octave groups 1, 2 and 4 kHz to the overall noise level is high. Audiograms of inspected workers show significant hearing impairment against workers who are not exposed to noise. Various information is collected about its nature and sound sources, and their effects related to exposure time. However, investigators should continue to determine where method, where the level of sound pressure, and at what scale the sound will cause hearing loss (Miyakita, T., Ueda, A., 1997). Studies show that hearing disorders in aircraft maintenance workers are found to be fast in the first 20 years employment, followed by a deceleration rate for the next 10 years and rate increase over the last 10 years (Gidikova, P G, 2007).

Two hundred workers aged 22 to 58 years and worked for 1 year to 36 years were selected for hearing exams to the above mentioned discovery. All employees checked are men. Some criteria for hearing loss are used for analysis. Some these criteria are reported, such as 25 dB hearing threshold as the average of all frequencies. The classification of hearing loss level was performed as mild (25-40 dB), moderate (41-55 dB), moderately severe (56-70 dB), severe (71-90 dB) and profound (>90 dB) (Ologe, F.E., B.A., 2008) and (Ologe, F.E.,.G., 2006.).

CHAPTER 3

METHODOLOGY

3.0 Project Development Overview

This chapter elaborates the approach in developing the proposed notification system. The design approach is divided into two phases. The initial phase involves defining the problem, doing background research through literature review and survey, specifying the requirement, and finally evaluating and choosing the ideal solution for the best design concept.

From the selected design concept, the model of this project is developed and undergoes some testing to ensure that it satisfies the highlighted objectives. This step is involved in the second phase of the project development. Figure 3.1.1 shows the flow process of the project development.

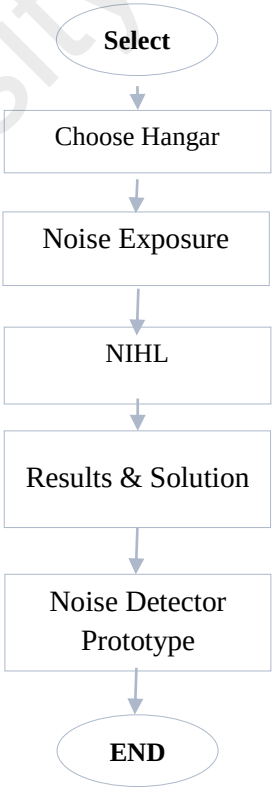


Figure 3.1: Project Research Flow Plan

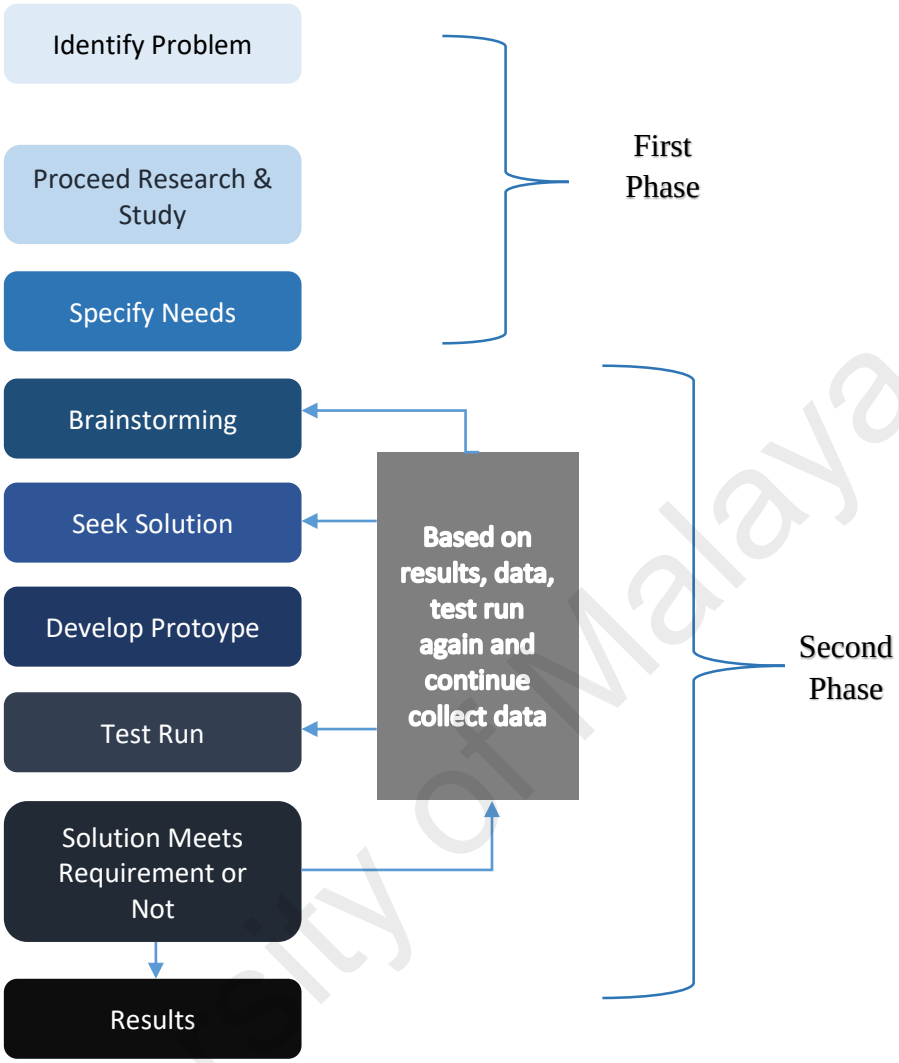


Figure 3.2 : Project development process flow actual

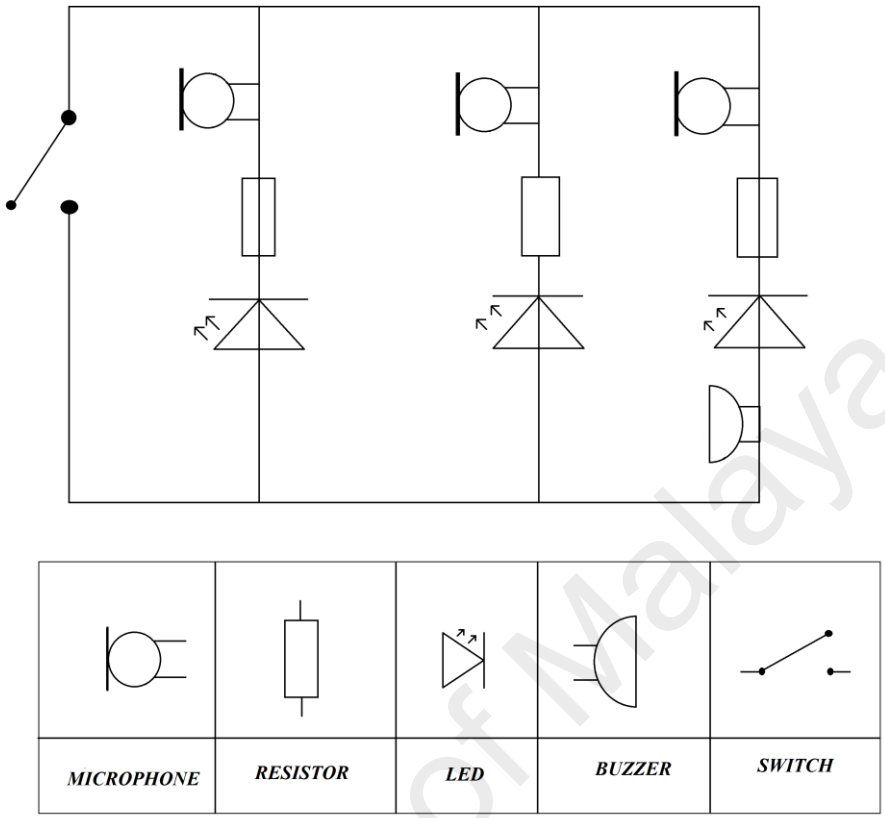


Figure 3.2.1 Components needed

In this assessment, to explain some of the methods of building this sound sensor circuit in generating a simple prototype. Sound and noise detectors, some may have known, is a circuit capable of detecting sounds, such as talking, clapping, or screaming. machines and others. This sound receipt data will be sent and processed by tracking circuits, then in the circuit, processing such as turning on LED lights and alarming for as a warning step.

3.3 Design Requirement and Functional Requirement

Figure 3.3.1 shows the design and functional requirement that are needed for the prototype.

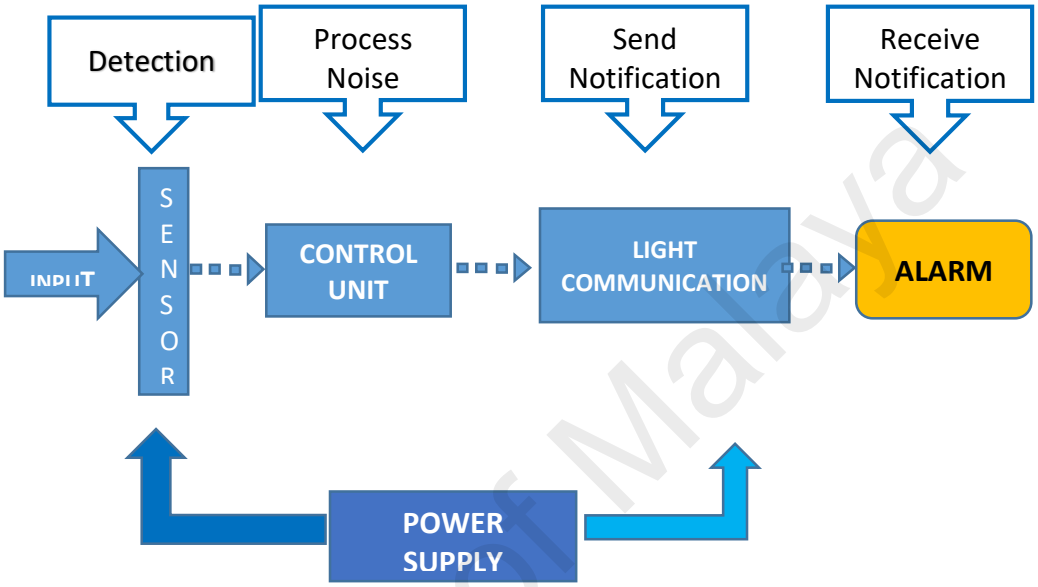


Figure 3.3.1 : Design requirement

The noise level meter detector is an instrument designed to respond to any sound with the same calculation as the human ear capability.

3.4 Three LED notification involved:

1) Green – dB range (0 dB – 45 dB)
2) Orange – dB range (46 dB – 79 dB)
3) Red – dB range (80 dB above)

Figures 3.4.1 and 3.4.2 show the side view and front view of the Noise Detector prototype

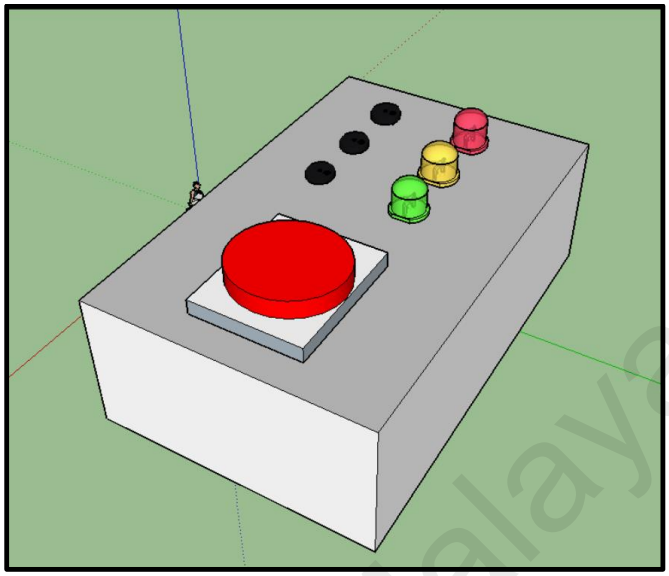


Figure 3.4.1 : Side view "Prototype of Noise Detector"

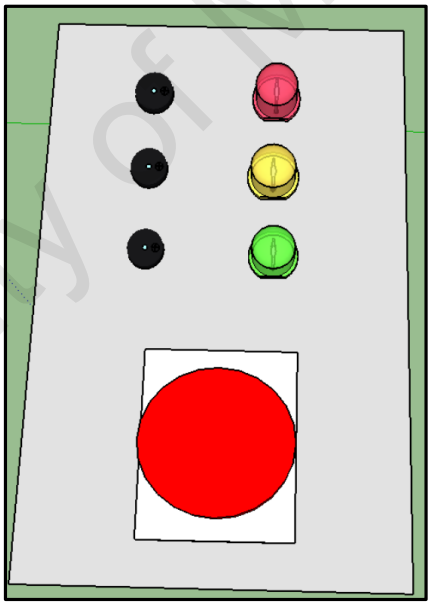


Figure 3.4.2 : Front view "Prototype of Noise Detector"

The notification of this noise detector device should able to perform these functions:

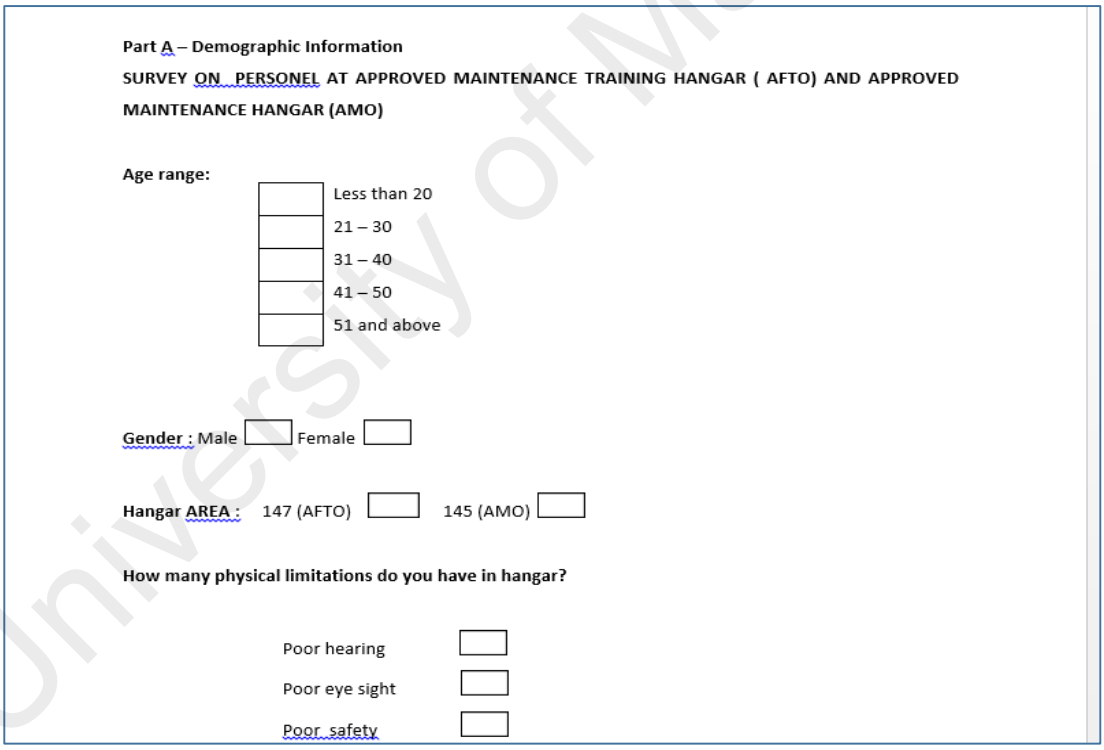
1) Detects the noise at surrounding area in hangar.
2) LED notification is sent to notify users.
3) Sends and receives noise notification in real-time basis.
4) Able to save the sound notification to alarm if reach limit.

3.5 Survey

This research was conducted to obtain feedback and information from AM personnel related to the use of the current notification system for noise detector. Findings of this survey were expected to assist in designing a prototype according to their needs.

3.5.1 Questionnaire Structure

a) Part A - The survey focuses on age, gender, place of hangar and type of disability of the respondents.



Part A – Demographic Information

SURVEY ON PERSONEL AT APPROVED MAINTENANCE TRAINING HANGAR (AFTO) AND APPROVED MAINTENANCE HANGAR (AMO)

Age range:

- ☐ Less than 20
- ☐ 21 – 30
- ☐ 31 – 40
- ☐ 41 – 50
- ☐ 51 and above

Gender : Male ☐ Female ☐

Hangar AREA : 147 (AFTO) ☐ 145 (AMO) ☐

How many physical limitations do you have in hangar?

- Poor hearing ☐
- Poor eye sight ☐
- Poor safety ☐

Figure 3.5.1 : Part A Questionnaire

b) Part B and Part C- The questionnaire focuses on noise makes them less focus and fatigue. It is important to their job scope. According to the survey, majority of the respondents' agreed to have engineering tools to detect noise level.

Part B – Initial Information of Your Workplace Environment

No.	ITEMS / QUESTIONNAIRES	SCALAR 1-NO 2- NOT SURE 3-YES			
		1	2	3	COMMENTS
A	TOOLs				
1	Do you know the noise level of the tools ?				
2	Do you know how many hours per week using the tool?				
3	Can you control the level sound of tools?				
4	Are all appliances and utensils conveniently and safely?				
5	Have you experienced hear pain while working for a long time using the tools?				
6	Have you ever felt tired and needing to stop while using the tool?				

Part C – Initial Information about PPE

B	HEARING PROTECTORS	1	2	3	COMMENTS
1	Do know the right PPE to use while carrying task as below: • Rivet • APU • Engine Ground Run				

Figure 3.5.2 : Part B and Part C Questionnaire

c) Part C, D, E, F and G - The questionnaire focuses on the characteristics of the current status and what kind of noise and experience was faced currently.

Part D – Sound Alert

C	ENGINE OF AIRCRAFT	1	2	3	COMMENTS
1	Do you alert when aircraft engine is running so loud?				
2	While working at the hangar, would it be easier to know the noise level?				
3	Have you ever experienced body pain while working with running engine on the ground?				

Part E – Hearing Status

D	HEARING	1	2	3	COMMENTS
1	Are the environment convenience and comfortable?				
2	Is there any adequate equipment to help you prevent from deafness?				
3	Do you realize that noise can cause problem to your hearing?				
4	Do know the limit of human hearing				
5	What you can do to prevent from hearing problem?				
6	Do you understand the causes of hearing loss				
7	Do you have trouble hearing in places where a lot of people are talking at once				

Figure 3.5.3 : Part D and Part E Questionnaire

Part F – Problem Faced

E	HANGAR WORK : Do you ever experienced	1	2	3	COMMENTS
1	Strain on hear due to noisy environment				
2	Difficult to work due to hearing health				
3	Frequently changing position difficult to hear				
4	Work seems heavy to perform alone				
5	Early onset of fatigue				
6	Become breathless very soon				
7	Weakness diminished working capacity				
8	Frequent headaches during skilled work				
9	Do not feel strong enough to work				
10	Physical handicap restricts hearing				
11	Know the danger of noise				
12	Do you have ringing, roaring or hissing in your ears?				

Part G – Conclusion

F	CONCLUSION	1	2	3	COMMENTS
1	Do you need a noise alarm to be triggered when exceed warning and danger?				
2	Do you keep commonly ignore about noise level?				
3	Do you think noise detector in hangar is practical?				

Figure 3.5.4 : Part F and Part G Questionnaire

d) Part H – The Questionnaire focuses on design requirement and user requirement.

Part H - Desired features

19. What are the important features to consider in the development of a notification system?

No	Design criteria	Very important	Important	Moderate	Less important	Not important
A	Real time					
B	Time saving					
C	Safety and security					
D	Works anywhere (able to switch type of notification)					
E	Reliability					
F	Stable system (intermittency)					
G	Privacy					

Your cooperation is highly appreciated.

Thank you very much for your time, effort and kindness to fill out this survey form.

Figure 3.5.5 : Part H Questionnaire

3.6 Analysis

From the survey, personnel's requirements were recognized and were then intake into the method of Quality Function Deployment (QFD). The requirements were transferred into design requirement of the suggested engineering hardware. The design concept was developed based on the important and primary needs. The detailed findings and data of analysis are illustrated in Chapter 4. The figure 3.6.1 shows the status of hearing cases at selected AM Hangar in Subang.

3.7 Hardware Development and Hardware Architecture

The entire circuit complex. The block diagram makes the circuit easy to understand. The circuit is divided in several blocks. The function of each block is discussed below. The figure 3.7.1 shows the blocks diagram of Noise Detector.

a) Microphone takes the voice signal as input.

b) HPF is used for noise reduction purpose.

c) Amplifier amplifies the signal 100 times.

d) Peak detector hold the signal for a few mille seconds

e) Comparator compares the signal voltage with a fixed reference voltage.

f) Comparator output activates the LED and alarm.

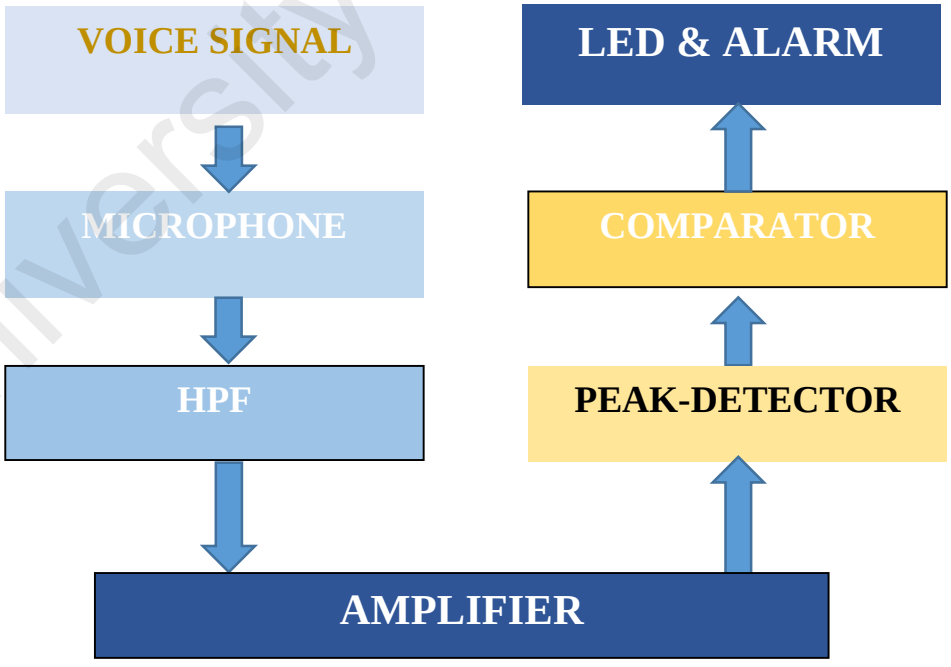


Figure 3.7.1 : Block Diagram Noise Detector

3.8 Equipment needed for setting

The noise signal will be captured after 5-10 seconds after transmitted is received into the noise detector to allow the sound to be captured and transferred clearly. The table 3.8.1 below shows the time taken for noise and notification received by the AM personnel.

Table 3.8.1: Time taken to trigger Noise Detector

Sample	Time Taken Interruption (Sec)	Distance (meter)
1	0.1 – 0.2	2 .0
2	0.I – 0.3	2.5
3	0.2 – 0.4	3.0
4	0.2 – 0.6	3.5
5	0.4 – 0.8	4.0
6	0.5 – 0.9	5.0
7	0.5 – 1.1	6.0
8	0.6 – 1.3	8.0

3.9 Demonstration Purpose at AM Hangar

At the beginning of a simple circuit demonstration was used to study the effects of noise on the hangar environment. However there are weaknesses in the location to be tested. Struck with machine and wall. It causes less sensitivity. Various techniques and methods were tried to overcome the problem. By reducing the barriers and placing higher detector equipment. The figure 3.9.1 shows Phase 1 installation of noise detector circuit.

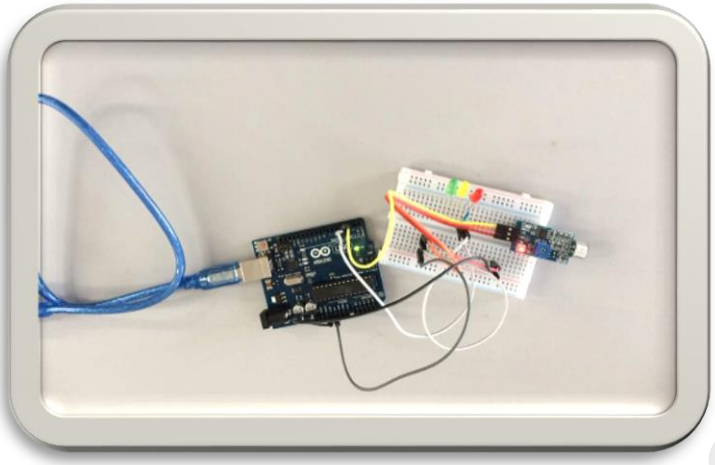


Figure 3.9.1:

Phase 1 install in the hangar for demonstration purpose

1) **Environment in AM Hangar.**

Figures 3.9.2 and 3.9.3 are the right view and left view of AFTO Hangar.

Figure 3.9.2 : Right of AM Hangar

Figure 3.9.3 : Left Side of AM Hangar

2) **Trial 1 placing 'Noise Detector"**

This location is not suitable for noise detector because it interferes in the hangar activity, although the location is best in receiving sound and noise. Figure 3.9.4 is the view of middle area of AM Hangar.

Figure 3.9.4: In The Middle Of AM Hangar And 3 Meter From Main Entrance

3) **2 selected point in AM Hangar.**

Figure 3.9.5 and 3.9.6 are the first and second testing points of noise detector in AM Hangar.

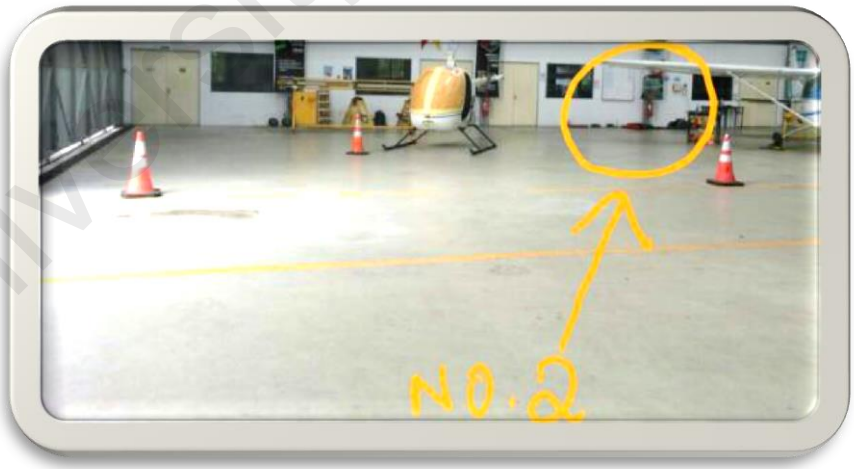


Figure 3.9.5 : Point 1 Of Noise Detector

Figure 3.9.6 : Point 2 Of Noise Detector

4) Point 3 is particularly suited for receiving noise due to no obstacle. Noisy reception is transmitted to the LED and the alarm can be more effective and notification will be accurate.

Findings of the survey were then analysed to choose the ideal solution for the best design concept and place Among the trainers requirement considered were real-time, time saving, auto notification, safety and security, system that can work everywhere, flexible, as well as reliable and stable system in terms of intermittency

CHAPTER 4

RESULTS AND ANALYSIS

4.0 Overview

This chapter mainly presents the findings obtained from the survey conducted and the results of the system that has been developed. The purpose of the study is to get users' feedback on specific characteristics needed in order to reduce the problems related to the users' hearing impairment. The results are used to assist in designing a competitive devices according to customer requirement. This chapter also focuses on functional testing of the completed module including application, selection, Sensor detection, and time-response.

4.1 Survey Findings

In the demographic part of the survey, it has been found that 20 % female and 70% male respondents took part in this survey. Majority of the respondents were between the age of 21 up to 52 years old and 49.1% of the respondents worked in the area of education, such as instructors. Figure 4.1.1 shows the problems at AM Hangar.

Table 4.1.1 : Problem Faced at Hangar

Physical Limitation	At Training Organisation Hangar			
	Male		Female	
Factor	70	%	20	%
Poor Hearing	50	71	7	35
Poor Eyesight	10	14	1	5
Poor Safety	30	43	0	0

Figure 4.1.2 shows the comparison number of respondents having NIHL symptom

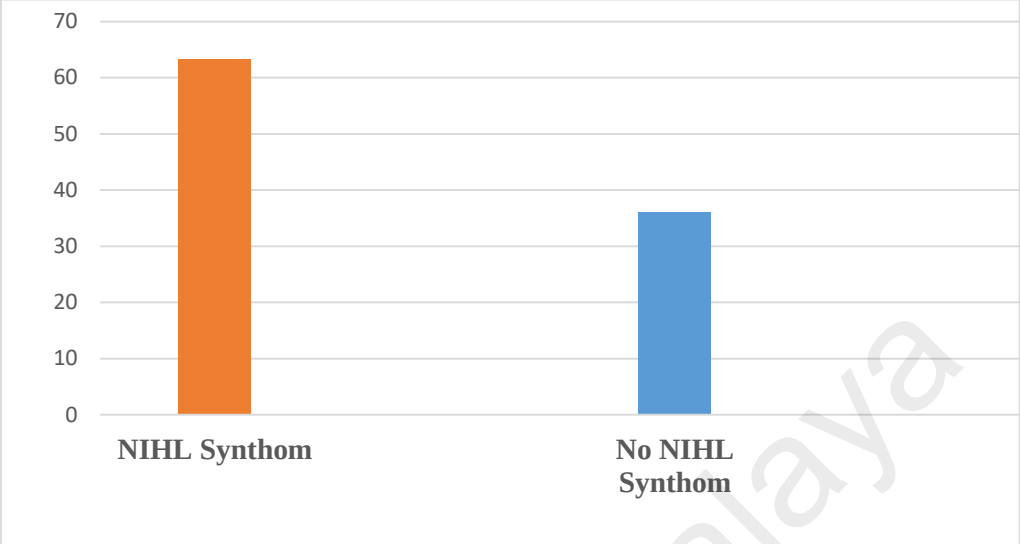


Figure 4.1.2: Comparison Number of Respondents After 3 years

This figure 4.1.3 shows the problem encountered and indentify to the users due to continuously exposure to the noise at hangar.

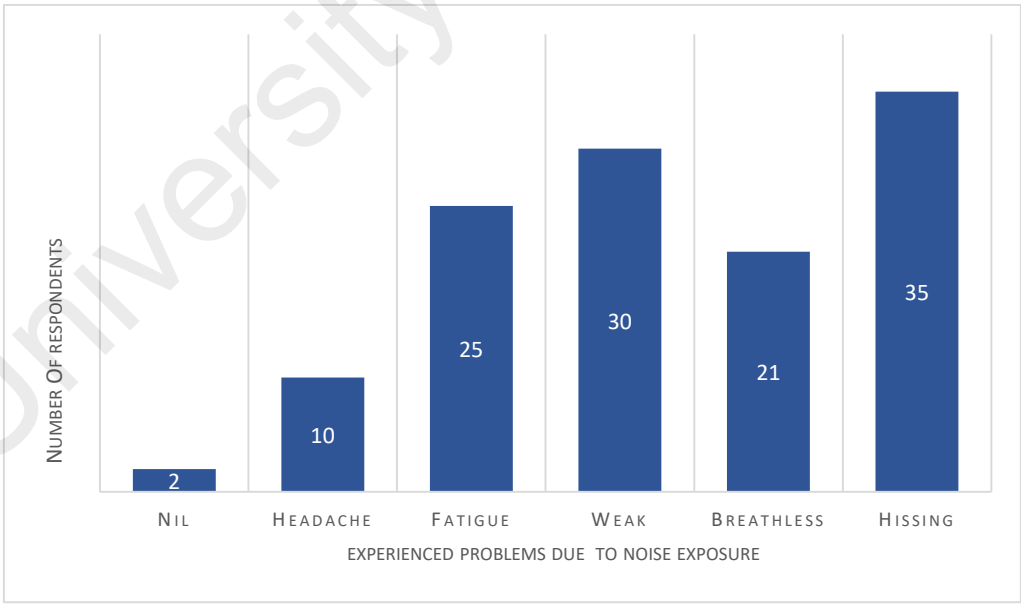


Figure 4.1.3: Impact of Noise

4.2 Respondents' feedback on the importance of notification LED and Alarm

In the figure 4.2.2.1 below presents the finding of the survey. The results hightlighted that 90.5% did not have any notification of their problem occur and due to that. 90% of the respondents have to do medical checked- up once they have sickness and hearing impairment. Only 10% of the users who had awareness and safety precaution upon high level of noise.

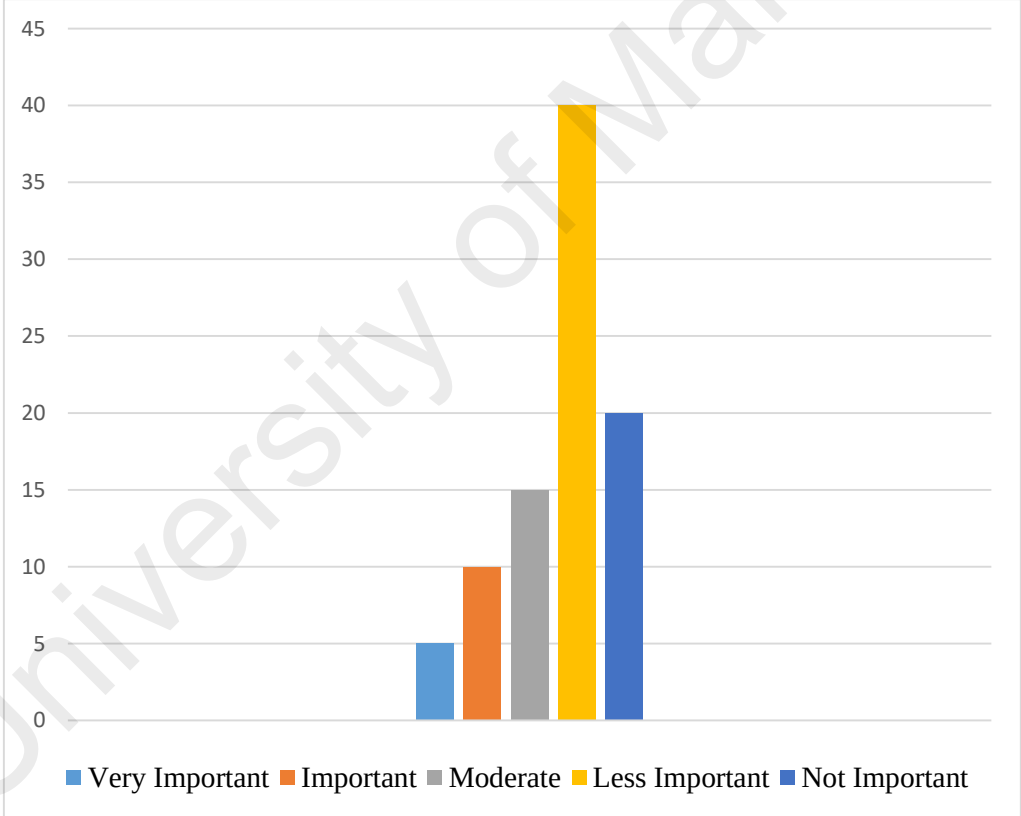


Figure 4.2.1: Level of notification impairment

Figure 4.2.2.below shows the problems commonly happened to the respondents who did not notice about surrounding area.

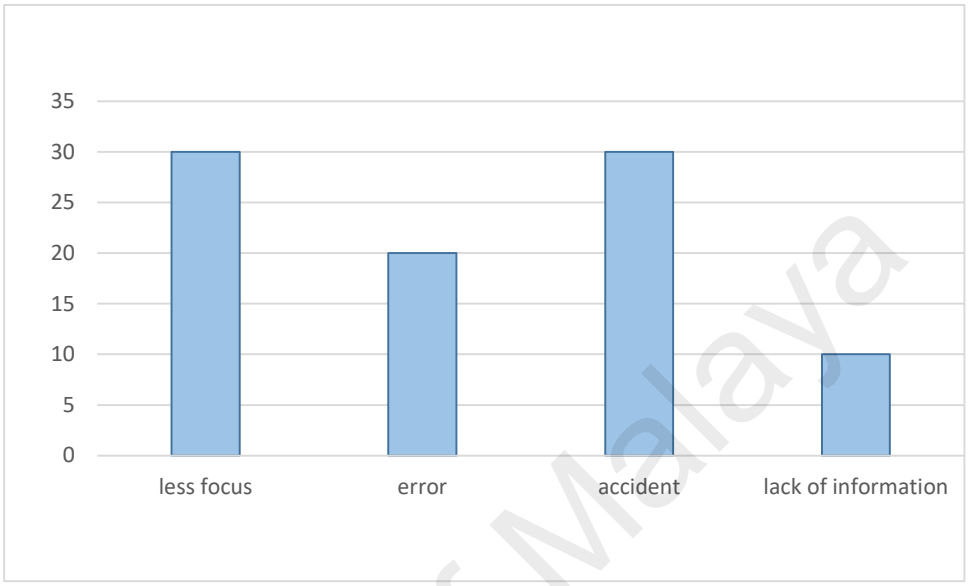


Figure 4.2.2 : Common consequences happen at noisy workplace

Figure 4.2.3 shows the finding by the respondents that agreed to have a notification or detector. In fact majority of the respondents often experienced with many problems relate to hearing problem.

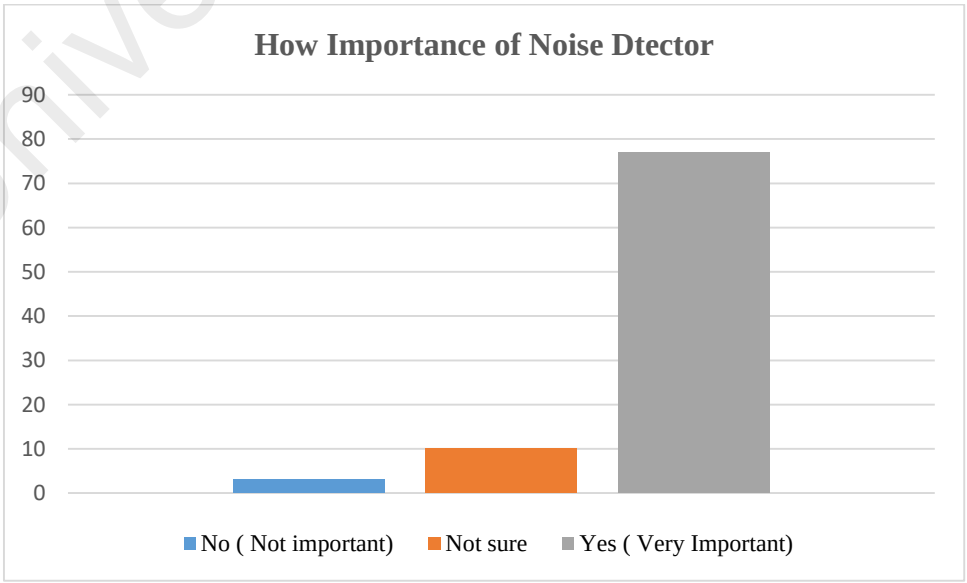


Figure 4.2.3 : Respondents feedback on the importance of noise notification device

4.3 Survey Analysis

4.3.1 Quality Function Deployment (QFD)

Structure of Quality Function Deployment (QFD) attached to identifying personnel's needs or request. By translating the data into precise and adequate plans to produce engineering device that meets the purpose.

Table 4.3.1.1 shows the essential elements to be taken into account as personnel's requirement to develop the noise detector. The requirement were then added as inputs into Quality Function Deployment (QFD) method to be considered as vital medium during development process. The identified personnel requirements for this detector are as stated below.

Table 4.3.1.1: Description of AM personnel requirement

No	Users Requirements	Description
A	Real time	The ability to send notification at the right time .
B	Time	The detector design with real time in which the personnel can alert.
C	Safety and security	The notification has accurate locking mechanism.
D	Works anywhere (able to switch type of notification)	Availability of area to send notification and user in the area can receive in the range of hangar area.
E	Reliability	The device must be consistent, accurate, good in performance and validated
F	Stable system (intermittency)	Stable and not easily disrupted or not intermittent.

4.4 Description Design Requirement

Table 4.4.1 shows the translating of needs into the design requirement to fulfil user's needs. From the literature review of the relevant current trend of the technologies, the table below shows the explanation of the design requirement.

Table 4.4.1 : Description of design requirement.

No	Design Requirement	Description
1	Control	Process of vibration and sound alertness from detector and interfacing with data to send the notification
2	Type of sensor	Functioning as detector that can detect high level of noise (dB).
3	Notification Alert	How the user will be notified – alarm and light
4	Notification Content	Green, Orange and Red –LED
5	Power Consumption	Energy supply to empower the whole works as required.

The graph figure 4.4.2 shows that 63% of the respondents are having hearing impairment and 37% of them normal.

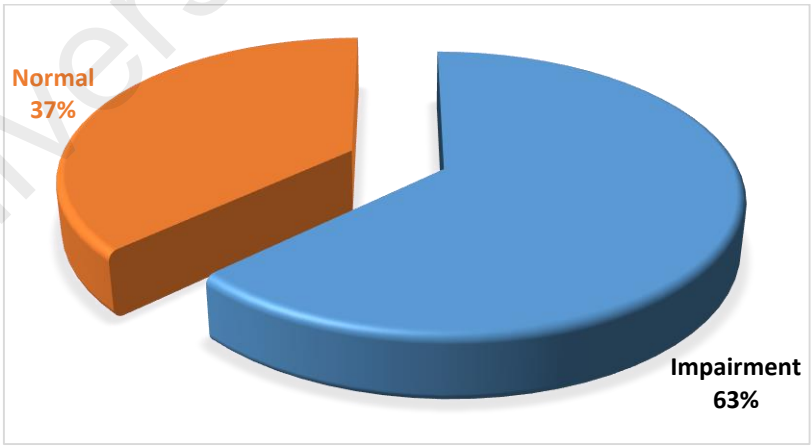


FIGURE 4.4.2 :Hearing Status Cases at AM Hangar

Figure 4.4.3 below shows Coverage Area Of Noise Detection in hangar after test-run.

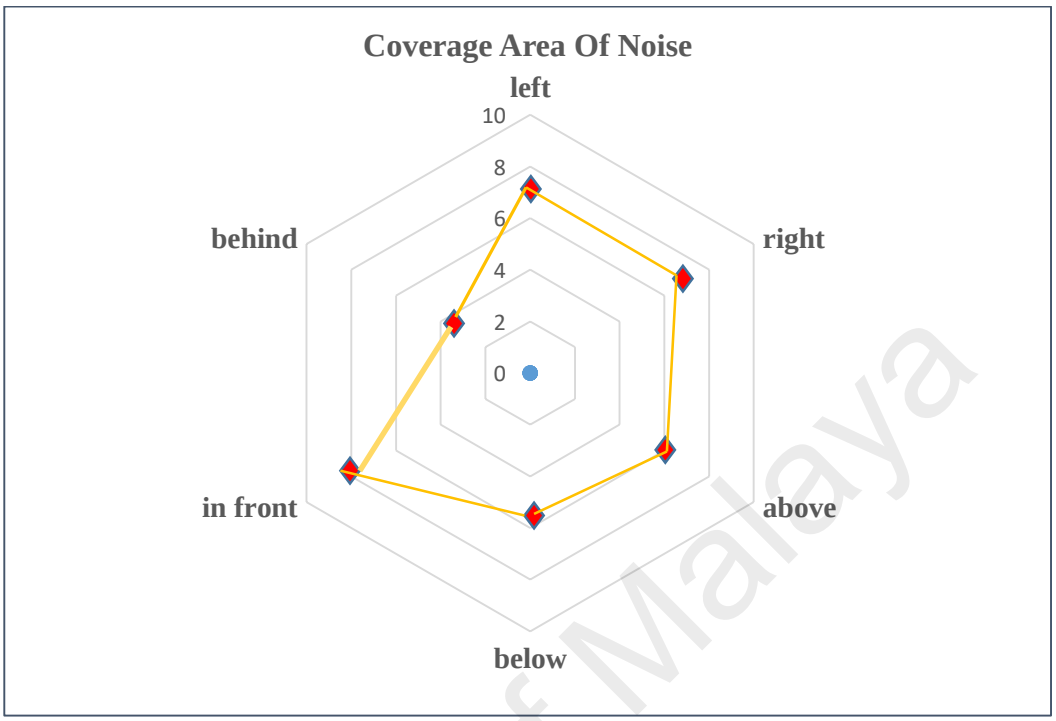


Figure 4.4.3: Coverage of Noise in metre

Figure 4.4.4 shows the performance of LED within 6 metre

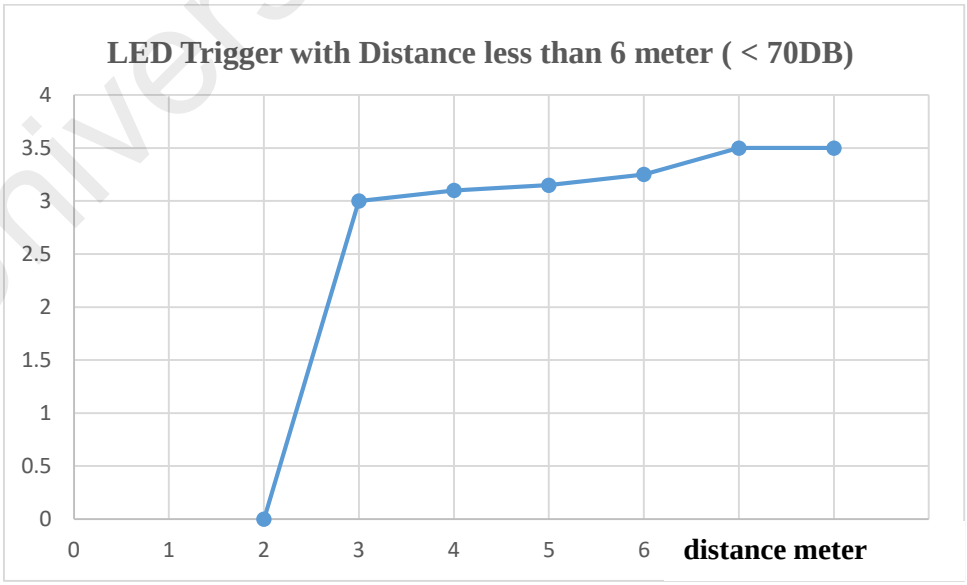


Figure 4.4.4: LED Performance in Distance Less 6 meter

Figure 4.4.3 shows the complete QFD development. Relation matrix between AM users requirement and design requirement was defined by three strength levels; strong (5), moderate (3),and weak (1).

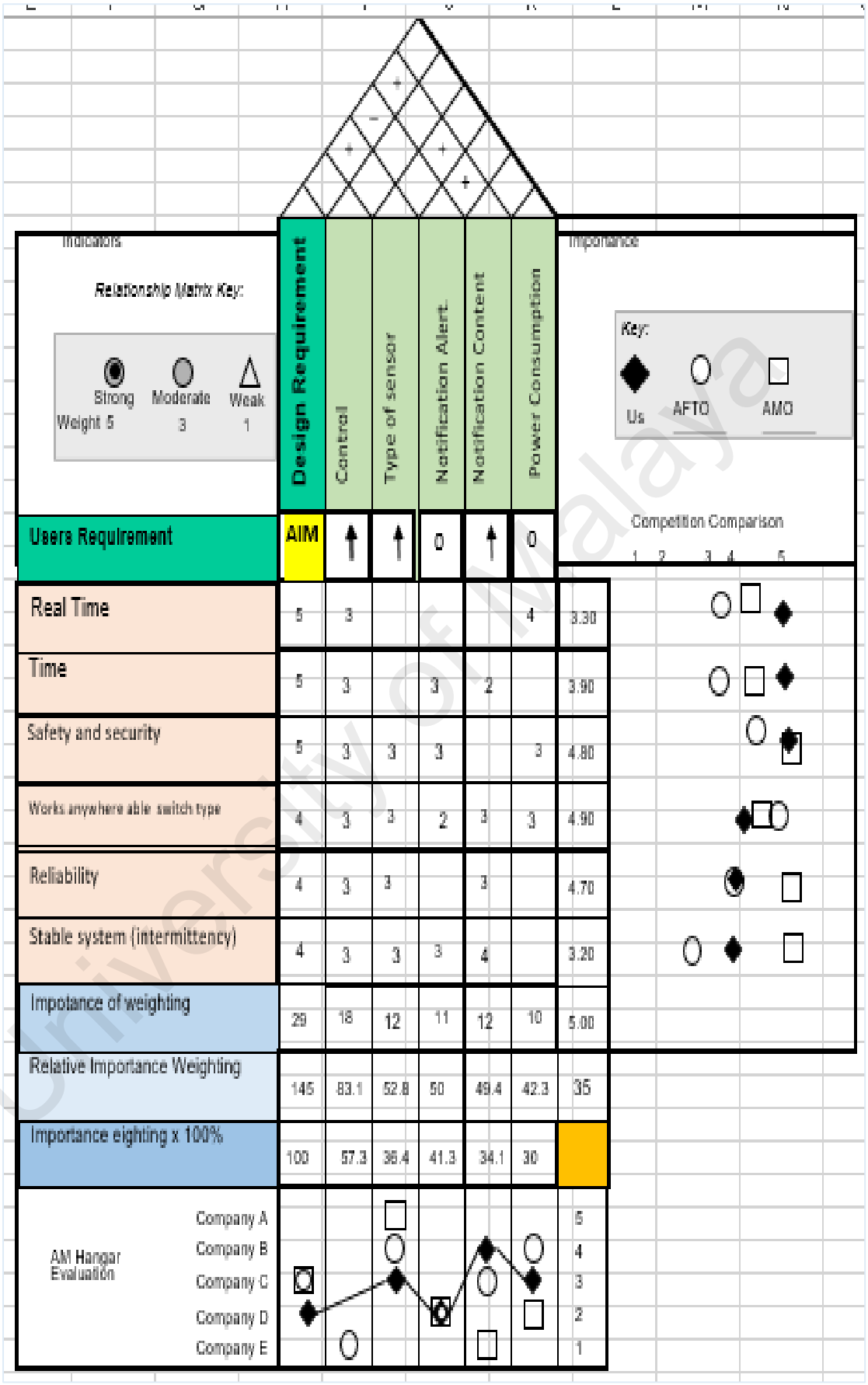


Figure 4.4.2.1 : Complete QFD

In this study, describes how the explainary variables were defined and determined and what data sets were used to obtain relevant information. The measurement of hearing loss from Institute of Aviation Medicine, Royal Malaysian Air Force (RMAF), obtained the data on time spent at different hangar in Selangor. Demographic data such as the age range, gender, position, experience data, physical limitation and area of hangar. This data set has information on the careers of individual who served in aircraft maintenance during the period of 2011 to 2017. Relevance to Industry, based on the analysis results, several suggestions are provided to aircraft maintenance staff to further improve line maintenance crews' safety and hearing impairment

4.5 Estimated Costing For The Noise Detector Device

The estimated cost for developing a single unit of this tool was around RM111.00. This estimation was based on the price of the components used as in Table 4.5.1. This cost did not include the extra cost such as human power and general workers for installation and usage of utilities of development.

Table 4.5.1 : Cost of item

Item	**Quantity**	**Cost(RM)/Item**
Resistor	3	9
Arduino	1	40
LED	3	6
Wire connector	12	36
USB connector	1	10
Circuit Board	1	10
Total		RM111.00

4.6 PINOUT DIAGRAM

Microphone condenser, resistors, capacitors and LM386 audio amplifier chips are very easy to buy and buy mills that sell electronic components. The LM386 will be connected to the microphone to get the best results.

4.6.1.The pin out diagram is shown below:

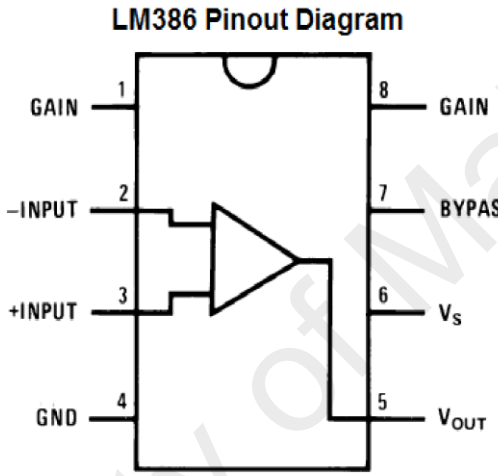


Figure 4.6.1 Pin Out Diagram

4.6.2 Pin Terminals

i. 1 and 8 Terminal: representing amplifier control. It is a capable terminal in accordance with the method obtained by using the resistors and capacitors in the terminal. This circuit, a 10μF capacitor will be placed between these terminals to take the highest voltage. The coordination ability can be made to select the desired value.

ii. 2 and 3 Terminals: represent signaling signals and taking sound from the terminal. This terminal is available at the required level. The condenser microphone will be connected to these terminals. Terminal 2 has minimal

negative input while Terminal 3 is a positive input. This circuit, terminal 3 will be connected to the positive microphone terminals and the negative microphone terminals are connected to terminal 2 and then connected to the earth.

iii. 4 -Terminal: GND (earth): negative voltage is a source of power or power supply.

iv. 5 -Terminal: amplifier on output. The terminal where the sound signal is increased for the output signal.

v. 6 - Terminal: the terminal will receive a positive DC voltage, the op amp can receive the power required to amplify the signal

vi. 7 - Terminal 7: This terminal is always open or connected to the ground. For perfect stability, the capacitors are added to the circuit. This can protect the swing chips to the amplifier.

4.7 Audio Amplifier

The pins in the LM386 represent all audio amplifiers installed on the circuit. Figure 4.7.1 below shows the amplifier Part of this circuit is illustrated as shown below:

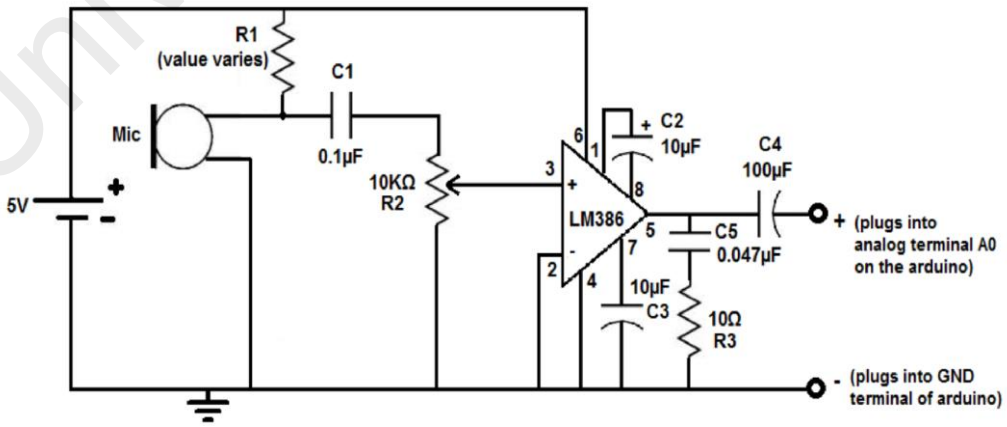


Figure 4.7.1 Audio Amplifier Circuit

i. R1: Is the resistor connected to the microphone to a positive voltage (+) aims to turn on the microphone. The microphone will not work fully if the desired power is not available. Because it requires complete power to act. Resistors vary in value to meet microphone requirements. Check the correct value for the microphone for the resistor.

ii. R2 : Potentiometer controls the volume of the sound.

iii. C2: Capacitors set the voltage obtained from LM386. Voltage output is 200 times the input. Maximum can be made by LM386. • C3: Capacitors are capable of increasing the LM386 amplifier and stabilizing the swing. • C4: Capacitates DC offset DC from LM386 output • C5: Flammable capacitors during release. The microphone changes the signal to the electric form. Then the electrical signal amplified by the LM386 IC to be delivered to the Arduino board

4.7.1 Advantages of Arduino for users compare to other systems

The advantages of Arduino :

a) Arduino boards are relatively inexpensive compared to other microcontroller platforms.
b) The Arduino Software (IDE) compatible runs on platform Windows.
c) The Arduino Software (IDE) is easy and simple, programming environment is user friendly.
d) The Arduino software is also published as open source tools and language programming.
e) It is easy to maintain and operate.
f) The Arduino system can be extended and integrated to enhance the feature in future.

Figure 4.7.2.1 shows the circuit of Arduino Hardware

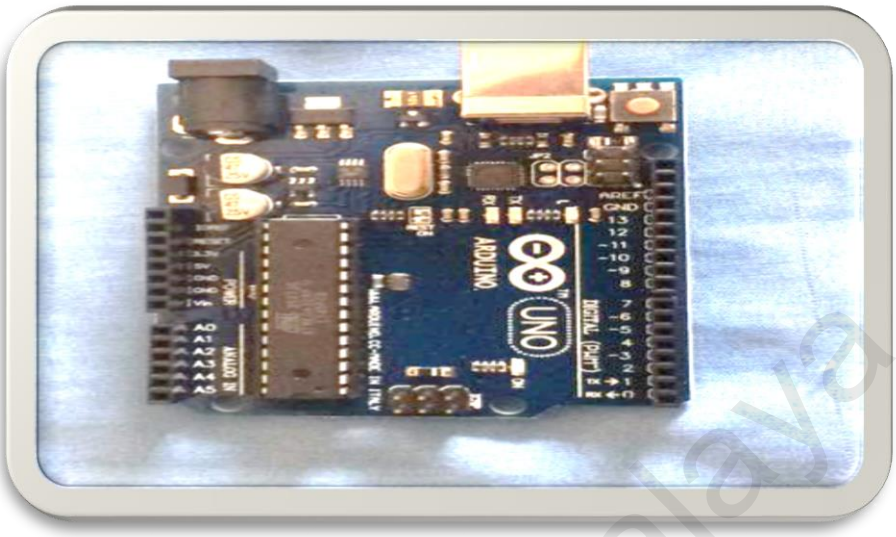


Figure 4.7.2.1 : Arduino Hardware

4.8 Discussion

All information and summary of the research are presented, and findings of the study are discussed and interpreted. Future recommendations for further research are included to suggest better improvements for this project. Findings of the survey were then analysed to choose the ideal solution for the best design concept. These requirements were then translated into design needs to satisfy the needs in reducing hearing impairment. Noise can have many negative impact in the workplace especially in hangar:

It can :

a. Annoying such as sudden sounds or constants loud noise.
b. Cause accidents by masking signals or messages.
c. Fatigue and may effect concentration in decision making.
d. Damage hearing either temporary or permanently.
e. Disturbing verbal communication between workers

4.8.1 Summary

The development of this project involved two stages which were concept development and engineering development. Concept development phase involved the process of defining the problem, studying background research through literature review, and conducting survey to specify the users' requirement.

4.8.2 Significant Contribution

All in all, commitment from the management and involvement from students and staff AM are the fundamentals of a smooth running industry. Both sides are responsible for the safety of others as well as their own. When a management team and employees are committed to their role, it will not only make the working place safe, but it will also be good for business in the long run. It is a good practical to all AM hangar in Malaysia to mitigate hearing impairment among personnel at AM hangar.

CHAPTER 5

CONCLUSSION

5.0 Summary and conclusion

It can be concluded that the research has met the objective that is to design out developed on device that can detect high level of noise at hangar. The device system will adequate user to give awareness of surrounding condition before exceed to harmful environment such as high noisy limit exceed the permissible exposure limit (PEL or OSHA PEL) . The primary focus of this study also was to determine how service at AM hangar affects hearing loss. The Medical records of individual hearing tests given by the personnel can give accurate data on hearing impairment. Producing noise detector or enforcing the wearing of hearing protection devices has the potential to reduce the number of workers who might have a potential hearing loss in their aviation careers by 18 percentage points (Costa, S., Arezes, P., 2012).

With all these important aspects brought to light, we can narrow down the important necessity that Aircraft Maintenance Hangar needs, as well as narrow down the proper actions that need to be taken to address the issues of hearing impairment or loss among workers due to noise. An observative safety officer should always be prepared to solve the problem such as these abiding by the legal requirement of Malaysia.

5.1 Future recommendations

Based on the findings of the study, a genuine recommended to be further explored by integrate the engineering control at hangar by adding noise detector system below the danger limit during working or carrying out duty at hangar. The data should be stored and give information the accumulate hours exposed to the noisy environment per day. Therefore the workers ease calculate the amount of danger exposure occurred daily by hours. To minimize the major hearing problems amongst them, effective sound detectors should be installed in the hangar to prevent to hearing impairment at early stage. Firstly, eradicate the source of noise. The source of noise could be from machinery with no maintenance. Hence, causing the machine to produce noises which may harm to the hearing.

Secondly, alternatively use quieter machinery instead of noisy machinery. Although quieter machinery may be costly as these machines would require higher maintenance, an employer's main priority is the employee's health and wellbeing. Personnel Protection Equipment (PPE) is designed to protect workers from various hazards. But when can only think of injuries and accidents that can happen at work, it may be overlooked in thinking of the importance of protecting our ears. Hearing loss is irreversible because it can destroy the inner hairy cell. Once the ability of hearing is damaged it incurable disease and gone forever. Therefore can mitigate the hearing impairment at early stage. With assist of sufficient noise detector may lead them to increase the work performance and decrease the hearing loss.

5.1.1 : There are some suggestions and recommendations from the outcome of this paper:

i. A detail research on the behaviour of workers at hangar help to identify the features needed to improve the system. Behaviour-based design can be used to make functional requirement design more reliable and precise.

ii. An early phase of this device has a lot of issues and bugs that require immediate attention. Inability to capture any noise are consecutively without time lapse. This hardware should be released to try under real conditions for testing and feedback.

iii. To enable this system to be portable and flexible, it requires the use of batteries that can provide a stable power.

5.2 Limitation of the study

The limitation of the duration of the completion of the project has resulted in the restriction of completing the disability. But some things should be stressed like the device was attached to the desk using sticky tape causing it easy to fall and may disturb the performance of the system. The module should be mounted strongly on the wall or on the proper place avoiding module falling so that the noise detector works accurately. The mounting and hooking technique should be applied for durability and strength.

REFERENCES

Cohen et al.,2008;Bafail and Noweir, 2004;El-Fadel, 2002;Amram and Brooks, (1996)

Ballenger, J.J. Editor. Diseases of the nose, throat, ear, head, and neck,13th ed. Leah & Febiger. Philadelphia.1985

Smedje G, Lundén M, Gärtner L, Lundgren H, Lindgren T. Hearing status among aircraft maintenance personnel in a commercial airline company. Noise Health 2011;13:364-70

Smedje, G., et al. (2011). "Hearing status among aircraft maintenance personnel in a commercial airline company." Noise and Health 13(54): 364.

A. Garcia. (2001). Environmental Urban Noise. Boston: WIT Press

Atzeri, S., Cocco, P.L., 2004. Assessment of occupational noise exposure: methodology, measurement error, evaluation criteria. Med. Lav. 95, 198e210

https://www.totalsafety.com/insights/the-importance-of-noise-protection-in-the-workplace/ **US** NIOSH researcher Dr. Amanda Azman.January 2017 study./11.45am/4 December

Koh, D. J. (1998). Occupational health in Singapore. International Archives of Occupational Environmental Health, 295-301

Ingle S.T., B. P. (2005). Noise Exposure and Hearing Loss among the Traffic Policemen Working at Busy Streets of Jalgoan Urban Centre. Transportation Research, 69-75.

Uimonen, S. M.-T. (1998). Hearing and Occupation. International Journel Circumpolar Health, 156-161.

New Tokyo International Airport Promotion Foundation, 118 Nakanodai, Higashi-Sanrizuka,286=0112, Narita –City, Japan

Department of Medical Sciences/Occupational and Environmental Medicine, Uppsala University, University Hospital, SE-751 85 Uppsala Sweden

Smedje G, Lundén M, Gärtner L, Lundgren H, Lindgren T. Hearing status among aircraft maintenance personnel in a commercial airline company. Noise Health 2011;13:364-7.

Lindgren T, Wieslander G, Dammström BG, Norbäck D. Hearing status among commercial pilots in a Swedish airline company. Int J Audiol 2008;47:515-9.

Costa, S., Arezes, P., 2012. Comparison between occupational noise measurement strategies: why is it important? Work. A J. Prev. Assess. Rehabil. 41, 2971e2973.

Occupational Noise Exposure. Cincinnati, US: US Dept. of Health and Human Services, Public Health Services, Center for Deasease Control and Prevention, National Institue for Occupational Safety and Health.

UTM Razak School of Engineering and Advanced Technology , Universiti Teknologi Malaysia, Malaysia (A.R.A.Aziz, S.A.Aziz, M.Z.Hassan)

Raynal M, Kossowski M, Job A (2006) Hearing in military pilots: one-time audiometry in pilots of fighters, transports, and helicopters. Aviat Space Environ Med 77(1):57–61

Smedje G, Lunden M, Gaertner L, Lundgren H, Lindgren T (2011) Hearing status among aircraft maintenance personnel in a commercial airline company. Noise Health 13(54):364–370

Kuronen P, Toppila E, Starck J, Paakkonen R, Sorri MJ (2004) Modelling the risk of noise-induced hearing loss among military pilots. Int J Audiol 43(2):79–84

NIOSH. (1998). Criteria for a Recommended Standard : Occupational Noise Exposure. Cincinnati, US: US Dept. of Health and Human Services, Public Health Services, Center for Deasease Control and Prevention, National Institue for Occupational Safety and Health.

Chen T.J., Chiang H.C. & Chen S.S. 1992. Effects of aircraft noise on hearing and auditory pathway function of airport employees. JOccup Med, 34, 613-619

Organization for Standardization I. 1984. Acoustics Threshold of hearing by air conduction as a function of age and sex for otologically normal persons: ISO Geneva

Miyakita, T., Ueda, A., 1997. Estimates of workers with noise-induced hearing lossand population at risk. Journal of Sound and Vibration 205, 441e449

Gidikova, P., Prakova, G., Ruev, P., Sandeva, G., 2007. Hearing impairment among workers occupationally exposed

Ologe, F.E., Olajide, T.G., Nwawolo, C.C., Oyejola, B.A., 2008. Deterioration of noiseinduced hearing loss among Ologe, F.E., Olajide, T.G., Nwawolo, C.C., Oyejola, B.A., 2008. Deterioration of noiseinduced hearing loss among

Ologe, F.E., Akande, T.M., Olajide, T.G., 2006. Occupational noise exposure and sensorineural hearing loss among workers of a steel rolling mill. European Archives of Otorhinolaryngology 263, 618e621.

Costa, S., Arezes, P., 2012. Comparison between occupational noise measurement strategies: why is it important? Work. A J. Prev. Assess. Rehabil. 41, 2971e2973

APPENDIX A

UNIVERSITI MALAYA
KUALA LUMPUR

Dear Respected Respondent,

Warm greetings. It would be highly appreciated if you could spend 5 to 10 minutes of time to fill out this questionnaire that is related to a study about the importance of noise detector at hangar.

In the era of information technology, the use of sensor or detector becomes the primary choice for communication because it is faster and more efficient compared to the conventional system. However, the use of ear plug and ear mouth is still essential and most probably the last solution in noisy hangar. Meanwhile, users often have a problem due to unavailability of a notification system to alert the personnel upon the danger level of noise in hangar. Findings of this survey are expected to assist the researcher in designing a system that notifies you the limit. Please be informed that all results of this survey will be used for academic purposes only and will be treated with confidentially with no specific individuals identified. Your help in completing and returning this questionnaire is very much appreciated.

Thank you

Regards,
NORSIAH BINTI SUKARDY
Master of Safety, Health & Environment Engineering.
Faculty of Engineering
University Of Malaya
norsiahns@siswa.um gov.my