FIRE EXTINGUISHER USING SOUND WAVES

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering

in

Electronics and Telecommunication

by

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CERTIFICATE

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This is to certify that the project entitled **Project Title** is a bonafide work of **Shaikh Zaid (16DET67),Mohammed Umer (16DET62),Solkar Abrar(16DET71), Patel Asfi (16DET63)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Department of Electronics and Telecommunication Engineering.

Supervisor	Examiner
Head of Department	Director

Project Report Approval for Bachelor of Engineering

This project entitled **"Fire Extinguisher Using Sound Waves"** by **Shaikh Zaid (16DET67),Mohammed Umer (16DET62),Solkar Abrar(16DET71), Patel Asfi (16DET63)** is approved for the degree of **Bachelor of Engineering in Electronics and Telecommunication**.

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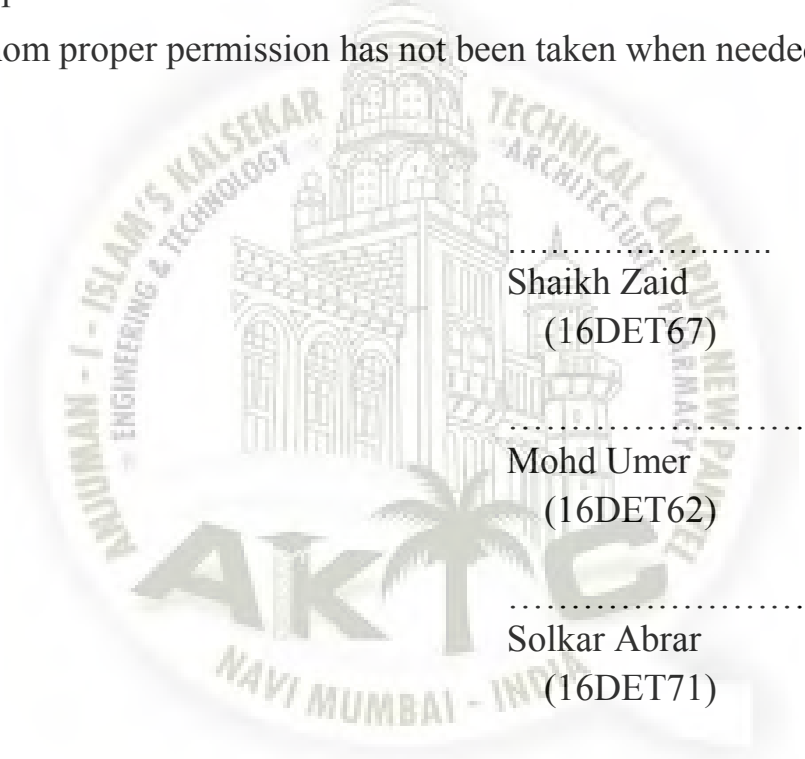

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Abstract

The fire extinguishing techniques used nowadays are having various drawbacks. The need for new fire extinguishing techniques is very important as fire accidents causes damages. This project demonstrates an idea of a developing device which can extinguish fire using sound. Traditional fire extinguishers, such as chemical foam or water, are used successfully but pose the threat of severely damaging indoor equipment, whereas an acoustic wave fire extinguisher would protect them from further damage caused by the fire. The low frequency acoustic waves produced from a subwoofer tend to extinguish the flames.

This project aims to analyze the effect of different frequencies of sound wave on flames and also to study the behavior of acoustic wave propagation in the collimator and surrounding environment. To find the range of frequencies within which fire extinguishes. Three different sources of flames were used with three different state of fuel (solid, liquid and gas). The converged collimator used to increase the air velocity output as compared to an ordinary collimator design. The variation of high and low pressure which is then coupled with high flow air velocity, causes disturbances in air-fuel ratio at the flame boundary, is one of the reason leading to flame extinction. In this project, the frequency range needed to suppress the flames is in between 30 to 95 Hz.

By hitting fire with the low-frequency sound waves in the 30 to 60 hertz range, the device separates oxygen from fuel. The pressure wave is going back and forth, and that agitates where the air is. That specific space is enough to keep the fire from reigniting.

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Chapter 1

Introduction

1.1 Project Overview

Fire extinguishers are trying to eradicate one of the elements in the pyramid (flame tetrahedron) in order to eliminate the flame. Fire fighting in an enclosed space has always been a problem, other than the accessibility for the fire fighter to access the place, accessing the water, carbon dioxide (CO2) or other fire extinguisher technology to the closed space is a major challenge. A compact independent and reliable fire extinguisher is required in order to overcome this problem. Space station and submarine are the main examples of the application that highly required new fire extinguisher technology that will be able to be used in a confined and very limited space.

Fire manipulation using sound was not a new technique. The interactions between sound and flames was first reported by John Leconte in 1858, who noted flames within an orchestral respond to beats within music. A German physicist, Heinrich Rubens in the1900s, showed the technique using a section of pipe with holes perforated along the top. One end was sealed off with a sound speaker connected; the other sealed off and attached with a gas supply. Subsequently, igniting the gas leaking from one of the openings and varying the sound frequency being emitted, the height of the flames could be manipulated, this effect is called Rubens tube.

The development of a portable fire extinguisher is initiated with the basic design approach. The key components includes a Tone generator, which generates the frequency waves between 30 to 90Hz. The Tone generator is interfaced with the subwoofer. These waves are amplified using power amplifier.

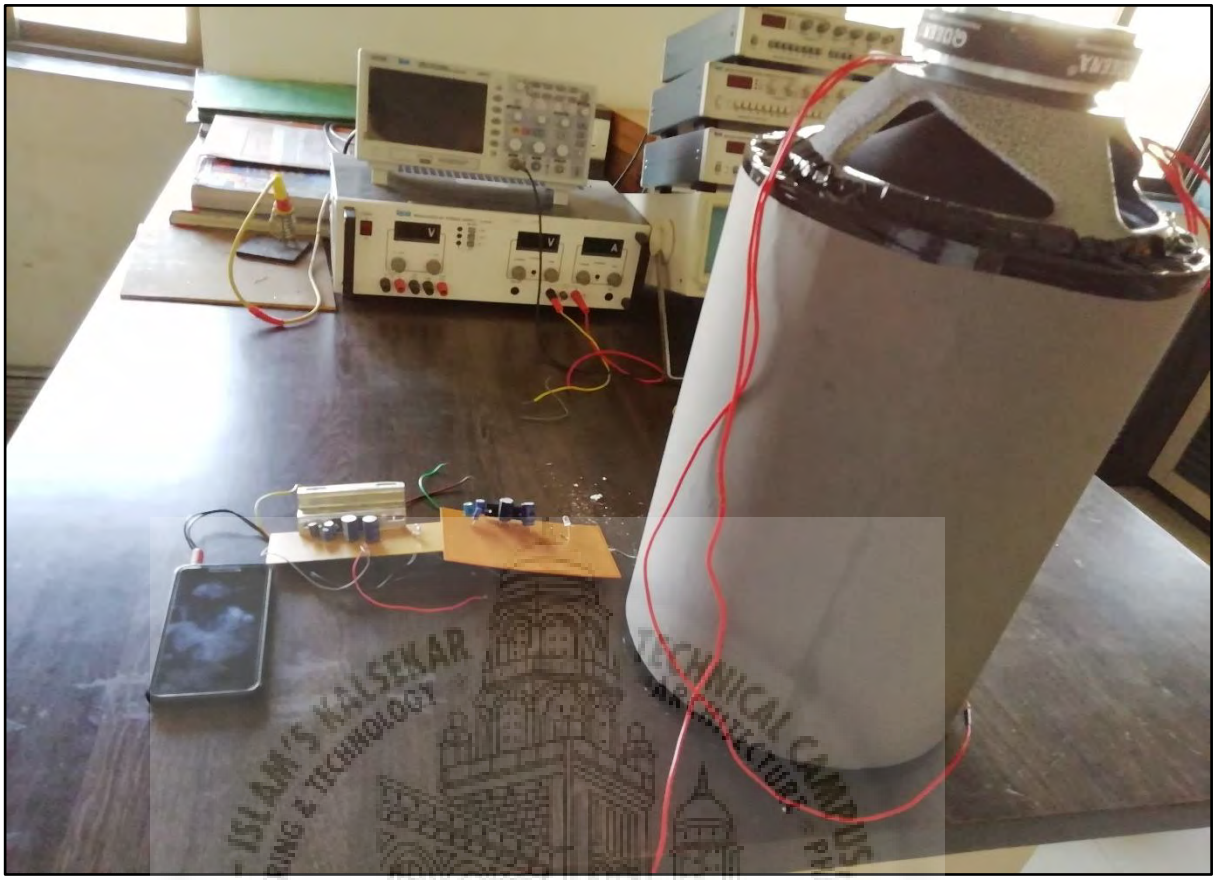


Fig 1.1 Wave Extinguisher

The development of a portable fire extinguisher is initiated with the basic design approach. The key components includes a Tone generator, which generates the frequency waves between 30 to 90Hz. The Tone generator is interfaced with the subwoofer. These waves are amplified using power amplifier. The generated sound waves are made to travel to the vortex tube. Subwoofer along with the vortex tube is designed to focus the sound waves in single direction and to produce extremely low frequencies used to extinguish the fire.

1.2 Introduction to Fire

Fire is a self-sustaining, chemical chain reaction with varying degrees of light and heat. Flame is the observable portion of the fire. Fires start when a flammable and/or a combustible material, in combination with an adequate quantity of an oxidizer for instance, oxygen gas is exposed to a source of heat or ambient temperature above the flash stage for the fuel/oxidizer mix, and is able to withstand a rate of rapid oxidation that produces a chain reaction. Fire is made up of four components Fuel, Oxygen Heat and Chemical Chain Reaction. This is normally called the fire tetrahedron.

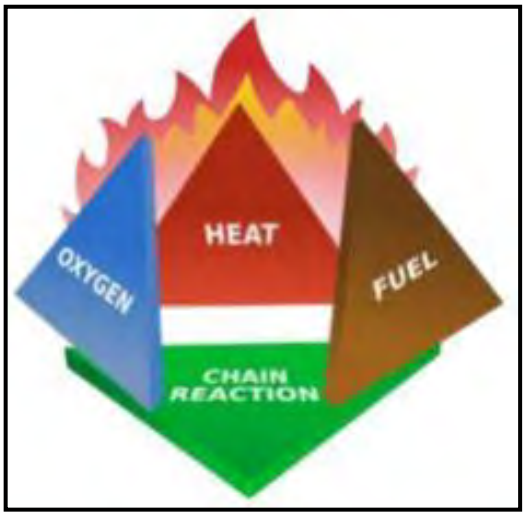


Fig.1.2 Flame Tetrahedron

Fire cannot exist if deprived of all of these elements in place and in the right proportions. Fire extinguishers are divided into five categories, based on different types of fires such as Class A, Class B, Class C, Class D, Class k.

Class A fires are fires in ordinary combustibles such as wood, paper, cloth, rubber, and many plastics.

Class B fires are fires in flammable liquids such as gasoline, petroleum greases, tars, oils, oil-based paints, solvents, alcohols. Class B fires also include flammable gases such as propane and butane. Class B fires do not include fires involving cooking oils and grease.

Class C fires are fires involving energized electrical equipment such as computers, servers,
motors, transformers, and appliances. Remove the power and the Class C fire becomes one of
the other classes of fire.

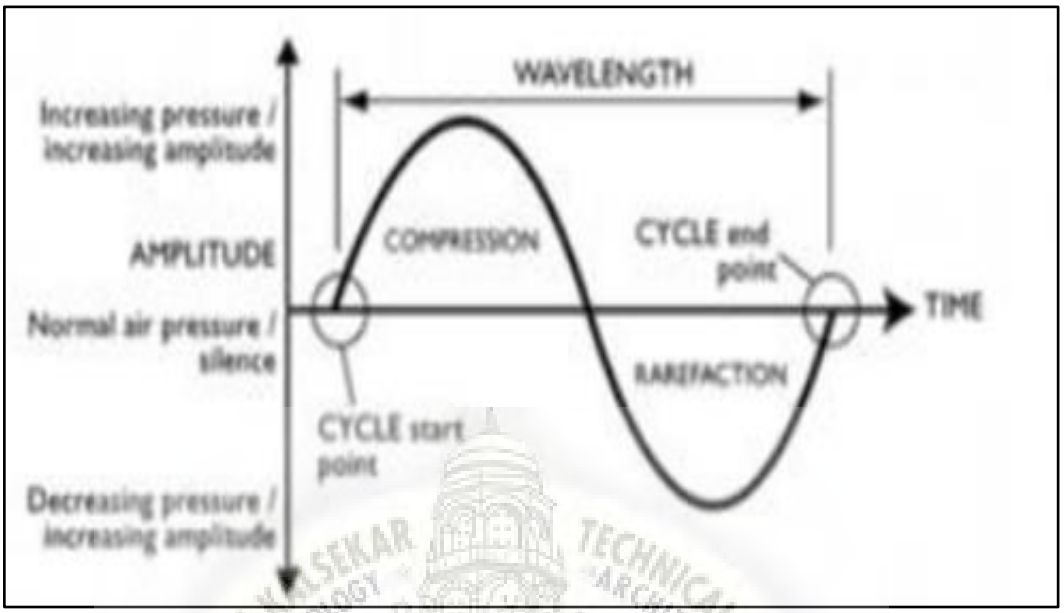
Class D fires are fires in combustible metals such as magnesium, titanium, zirconium, sodium,
lithium, and potassium.

Class K fires are fires in cooking oils and greases.

1.3 Sound Waves

Sound is a form of energy, just like electricity, heat or light. When you strike bell, it makes a loud ringing noise. Now instead of just listening to the bell, put your finger on the bell after you have struck it. Can you feel it shaking? This movement or shaking, i.e. the to and fro motion of the body is termed as Vibration. The sound moves through a medium by alternately contracting and expanding parts of the medium it is travelling through. This

compression and expansion creates a minute pressure difference that we perceive as sound. Sound is a vibration that propagates as a perceptible mechanical wave of pressure and



displacement, through a medium such as air or water.

Fig. 1.3: Sound Waves in Waveform Amplitude

Sound propagates through compressible media such as air, water and solids as longitudinal waves and also as a transverse waves (in solids). The sound waves are generated by a sound source, such as the vibrating diaphragm of a speaker. The sound source creates vibrations in the surrounding medium. As the source continues to vibrate the medium, the vibrations propagate away from the source at the speed of sound, thus forming the sound wave. At a fixed distance from the source, the pressure, velocity, and displacement of the medium vary in time. At an instant in time, the pressure, velocity, and displacement vary in space.

Chapter 2

Literature Survey

2.1 Conventional Fire Extinguishing Techniques

There are four common techniques used in extinguishing fires. Cooling down the burning material is the most common practice used to extinguish fire. Water is usually available and the best cooling agent to use particularly in fires involving solid materials. By vaporizing in contact with fire, water also mantles the fire, cutting off the oxygen supply. However, water should never be applied to fires involving hot cooking oil or fat because it can cause the fire to spread. Secondly, is thru excluding oxygen from the fire. Asphyxiating agents are substances used to extinguish a fire by cutting off the oxygen supply. Foam, which is the content of some fire extinguishers, can help to cool down and isolate the fuel surface from the air, reducing combustion and being able to resist wind and draught disruption. Nevertheless, foam should never be used on energized electrical equipment, because it is an electrical conductor. Other smothering agents include carbon dioxide, which is found in some fire extinguishers and is ideally used in electric equipment and sand, which is effective only on small burning areas. Another method of extinguishing a fire is to remove the fuel supply by switching off the electrical power, isolating the flow of flammable liquids or removing the solid fuel, such as wood or textiles. In woodland fires, a firebreak cut around the fire helps to isolated further fuel. In the case of gas fire, closing the main valve and cutting off the gas supply is the best way of extinguishing the fire. Flame inhibitors are substances that chemically react with the burning material, thus extinguishing the flames. Dry-chemical fire extinguishers work in this way, and can contain mono ammonium

phosphate, sodium and potassium bicarbonate and potassium chloride.

Vaporizing liquids also have a flame inhibiting action. Conversely, most of these substances have been phased out due to high levels of toxicity.

2.2 Types Of Sound waves

Sound is a vibration that propagates as a typically audible mechanical wave of Pressure and Displacement, through a medium such as gases, liquids and solids. Sound is pressure wave and Displacement caused in the medium through with particles will move in a random direction, and transferring the pressure from one particle to the another, hence this how sound travel in any medium. Sound can be travel in two forms they are:

1. **Longitudinal waves :** Longitudinal waves, also known as "l waves", are waves in which the displacement of the medium is in the same direction as, or the opposite direction to, the direction of travel of the wave. Mechanical longitudinal waves are also called compression waves, because they produce compression and rarefaction when traveling through a medium.

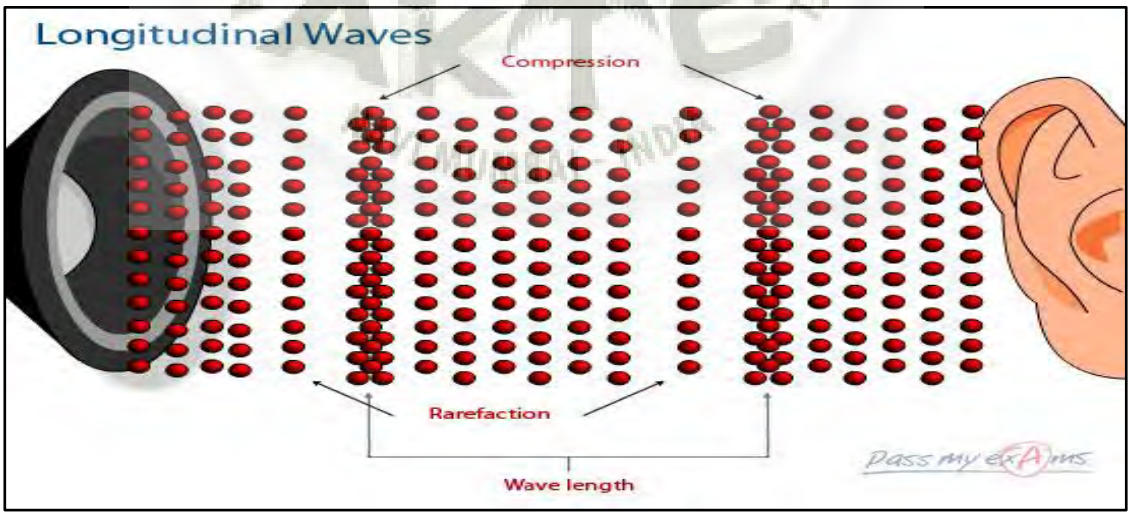


Fig. 2.1: **Longitudinal waves**

2.Transverse Wave: A transverse wave is a moving wave that consists of oscillations

occur- ring perpendicular (or right angled) to the direction of energy transfer. If a transverse wave is moving in the positive x-direction, its oscillations are in up and down directions that lie in the y–z plane. Light is an example of a transverse wave. With regard to transverse waves in matter, the displacement of the medium is perpendicular to the direction of propagation of the wave. A ripple in a pond and a wave on a string are easily visualized as transverse waves.

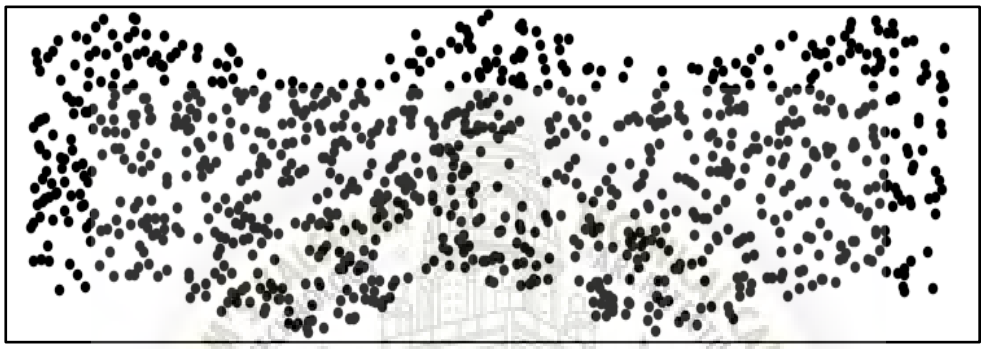


Fig 2.2 Transverse wave

Observation

Longitudinal waves are the most pressure waves and we can use these waves in our system. From Observations made above we can say that the particles of sound vibrates form one to next, can able to move the heating element from fire by creating a pressure in the area, but here there is a key point to remember that sound wave of any frequency may not vibrate the particles such that they can cause fire to put off. There are particular ranges of frequencies which can only extinguish fire.

2.3 Hypothesis of sound as fire extinguishers

Sound waves are produced by variation in the pressure of a medium The energy from the vibration producer moves to air particles in a pattern of high and low pressure zones .Acoustics increases the air velocity fire is thinned and higher fuel vaporization widens the flame .Flames are extinguished because the sound waves change the air pressure A decrease

in pressure can lead to a decrease in temperature If the maximum and minimum pressures caused by a sound wave are different enough, the flame will go out.

2.4 Problem Statement

Current method of firefighting using has significant drawbacks such as toxic to humans and leaves residue (for dry chemical base fire extinguisher) while water base fire extinguishing techniques freezes in cold climates and conduct electricity. Using sound wave with certain frequency as a fire extinguisher will have significant advantages such as leaving no residues and non-toxic.

- How to extinguish fire using sound waves?
- What is the range of frequency which can extinguish the fire?
- Which method is used for firefighting?
- What is the distance between the prototype and the flame?

Fig. 2.3: Photographic view of residue released during use chemical foam for fire extinguisher

2.5 Proposed Solution

The existing system can extinguish only alcohol fueled fires. Our proposed solution aims to extinguish different types of fires such as solid, liquid, gas. Our proposed system has a advantage over the existing system in aspects such as size, cost, electricity, wide scope to advancement because we are making use of sound waves instead of water and chemical foam. The step towards sound waves is the wide scope as it provides safety to humans. It is

a portable device and conducts no electricity as well as it saves water and leaves no residue and non-toxic. It helps make our work simple and also we can attach to it other peripherals as per our wish to modify like we are providing facility of attach it to a drone and extinguish the fire in that area where human can't reach.

2.6 Scope of Study

- Acoustic simulation will be performed prior to experiment to study the acoustic pressure and acoustic velocity profile in the collimator.
- The suitable sound wave frequency between 0 Hz to 200 Hz put out the flames is determined.
- The experiment is conducted with three different sources of flames: wooden fire (solid), gasoline (liquid) and butane gas (gas).
- The permissible distance between the collimator and flame to cause fire extinction is also investigated.

2.7 Objectives

- To identify the frequency range that will be able to suppress an open flame.
- To analyze the physics of sound-flame interactions.
- Our objective is to develop an environmentally friendly and safe method to extinguish fire using acoustics set up.

Chapter 3

Methodology

3.1 Research Methodology

The experiment will be carried out in two stages, the first one is the results confirmation on the previous experiment done by previous researchers. It was stated that the optimum sound frequency for fire extinction is 60 Hz. This experiment will be focusing on the observation in the frequency range of 35–200 Hz (human hearing frequency) in order to confirm the results from previous research.

The types of flames that is going to be tested are Solid combustibles including wd, paper, cloth, plastic, metals, or electrical equipment's in order to determine if it is needed to change the frequency to extinguish the flame. A collimator will be used to modify the intensity and direction of the sound wave in the experiments. Collimator will increase the intensity of the sound wave to a single point which will provide better results in suppressing the flame. An acoustic simulation will be executed prior to experimental setup to study the propagation of sound wave (acoustic wave), specifically to study the acoustic pressure and acoustic velocity profiles in the collimator.

3.2 Design Layout

The development of a portable re extinguisher is initiated with the basic design approach as shown in fig 3.2. The key components includes a Tone generator, power amplifier, sub woofer, power supply, and vortex tube.

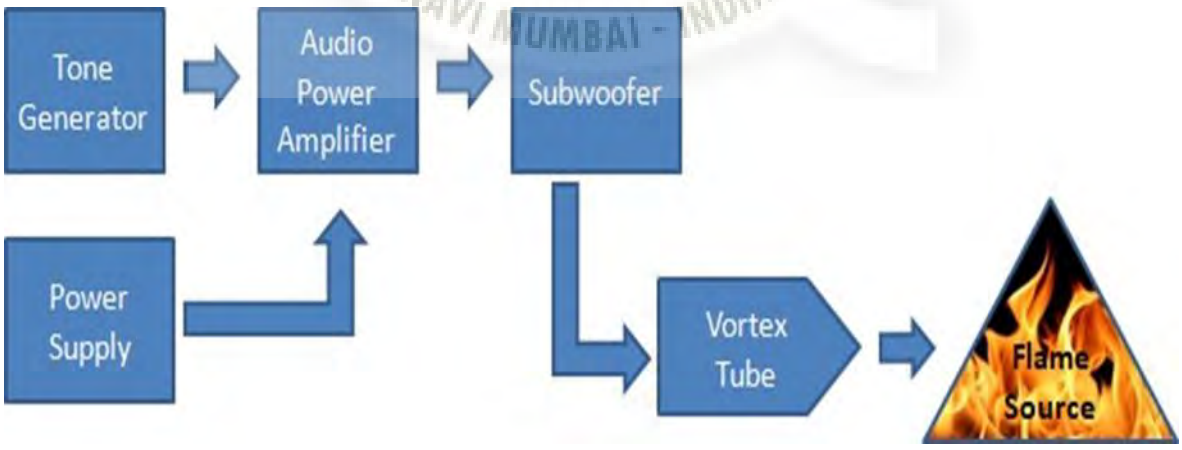


Fig. 3.1: Block Diagram

Tone generator generates the frequency waves between 30 to 90Hz. The Tone generator is interfaced with the subwoofer. These sound waves are amplified using power amplifier. The generated sound waves are made to travel to the vortex tube. Sub woofer along with the vortex tube is designed to focus the sound waves in single direction and to produce extremely low frequencies used to extinguish the fire.

By hitting fire with low frequency sound waves, The oscillation creates a space that separates air molecules from the source of the flame. The pressure wave is going back and forth, creating specific space between the oxidizing agent and fuel (wood paper etc). It keeps the fire from reigniting. The pressure at the flame source decreases, thus the temperature at the source of the flame decreases as well suppressing the fire.

3.3 Circuit Diagram of CD4440 Amplifier

Fig 3.2 CD4440 Amplifier

3.4 Circuit Diagram of IC8038 Tone Generator

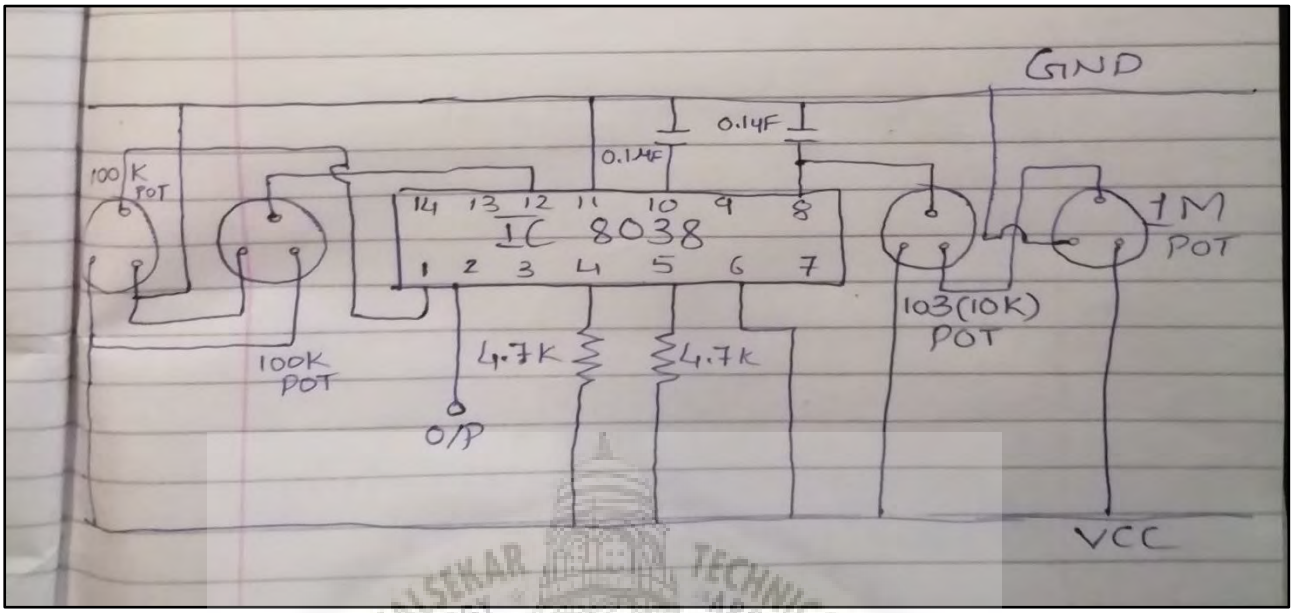


Fig 3.3 Tone Generator

3.5 Circuit Diagram of Power Supply

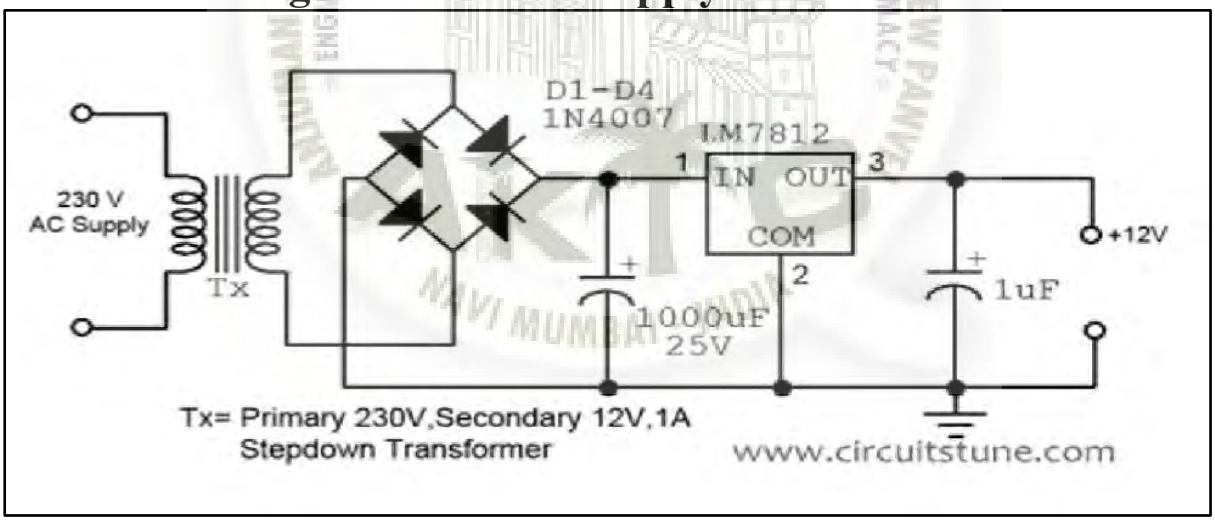


Fig 3.4 Power supply

Chapter 4

System Requirements And Specifications

4.1 Tone Generator IC 8038

The IC 8038 is a function generator chip, capable of generating triangular, square , sine, pulse and saw tooth wave forms.

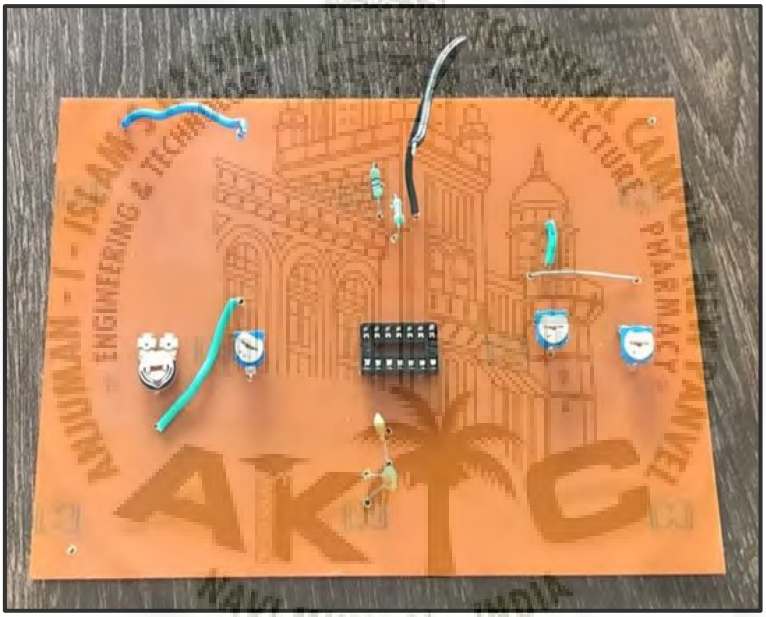


Fig. 4.1: Tone generator

From these sine, square triangular wave forms can be made simultaneously. There is an option to control the parameters like frequency, duty cycle and distortion of these functions. The circuit here is designed to produce waveforms from 20Hz to 20kHz.The IC 8038 has to be operated from a dual power supply.

4.1.1 IC 8038 Pin Conguration

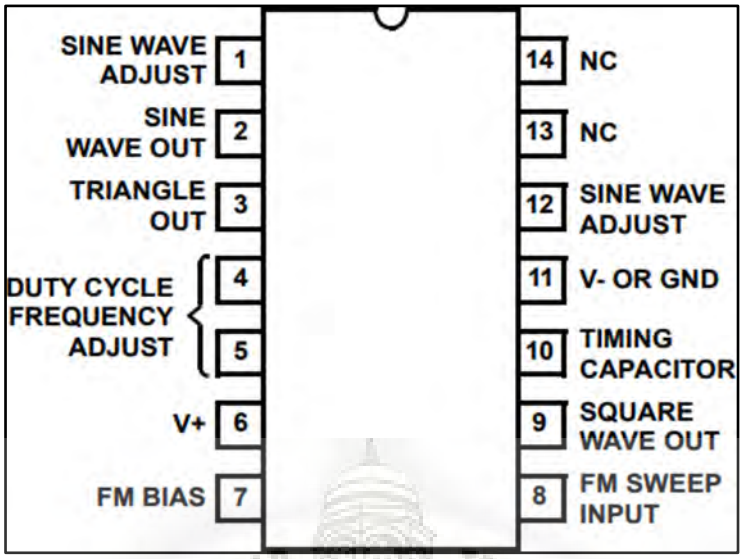


Fig. 4.2: IC 8038 Pins

4.1.2 Features Of IC 8038

- Wide Frequency Range - 0.001Hz to 300kHz
- High Level Outputs TTL to 28V
- Simultaneous Sine, Square, and Triangle Wave Outputs

4.2 CD4440 Amplifier

CD4440 is a two channel audio power amplifier IC with inbuilt in dual channels enables it for stereo and bridge amplifier applications. In dual mode it gives 80W per channel.

It has good ripple rejection of 46dB, small residual noise, built in over voltage and surge voltage protection etc. ideal feature of the IC is its pin-to-pin protection. t requires minimum number of external parts, it has small pop noise at the time of power supply ON/OFF.

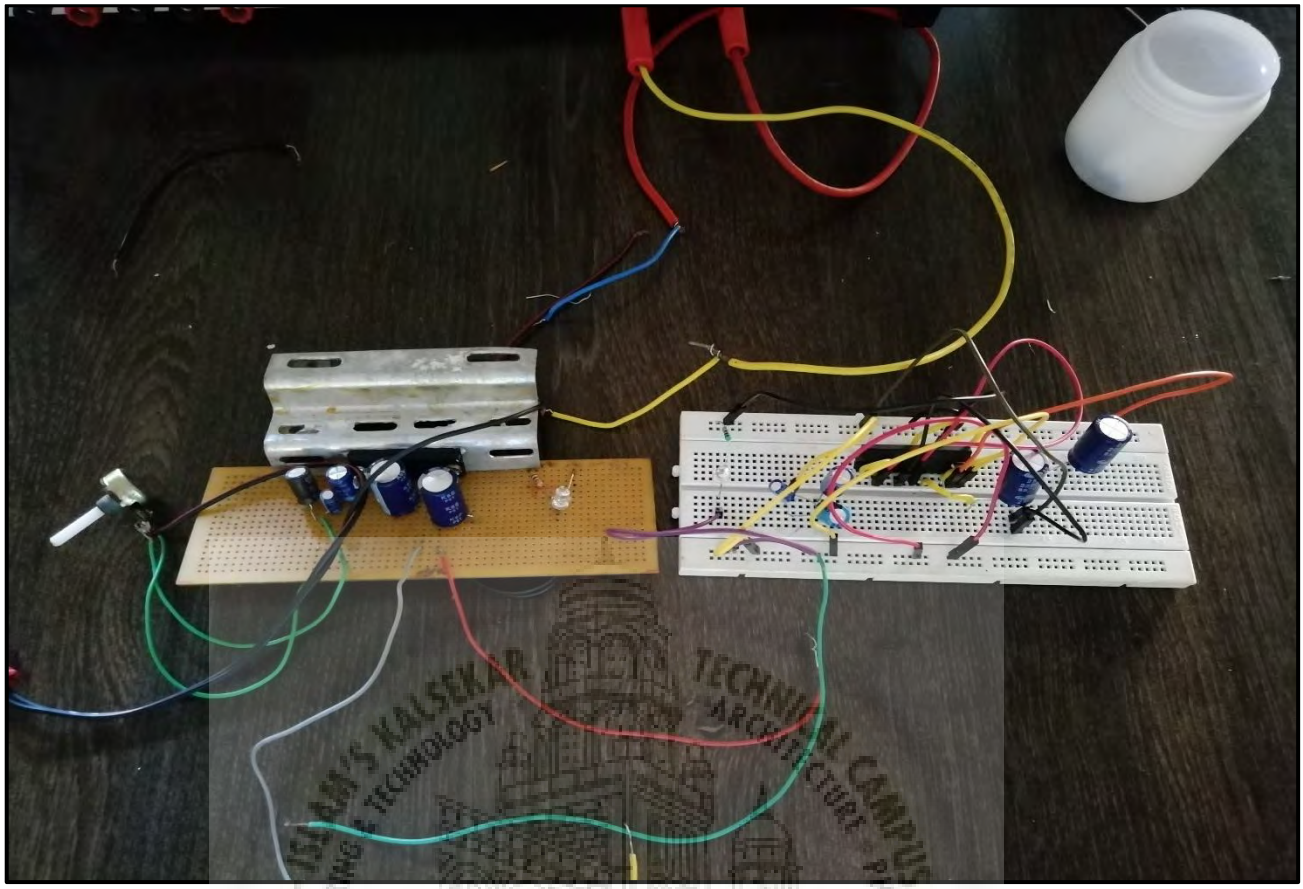


Fig. 4.3 80watt CD4440 Amplifier

4.2.1 Features Of IC CD4440

- Built in two channels to use as Mono and Stereo
- 46 dB Ripple rejection
- 18V Max. Power handling and 12V typical
- Good channel separation and low distortion
- Built in Audio Muting function and Pin-to-Pin protection
- Surge protection circuitry
- 80watts power output

4.3 SUBWOOFER

A Subwoofer, or a complete loudspeaker, which is dedicated to the reproduction of pitched audio frequencies known as bass. The typical frequency range for a Subwoofer is about 20–60 Hz for consumer products below 100 Hz for professional live sound, and below 80 Hz in THX-approved systems. In this project we use a 4ohm 300watts subwoofer. Subwoofer are made up of one or more woofers mounted in a loudspeaker enclosure often

Fig. 4.4 4ohm 300watt Subwoofer

made of wood capable of withstanding air pressure while resisting deformation. Subwoofer enclosures come in a variety of designs, including bass reflex, infinite baffle, horn-loaded, and band pass designs, representing unique trade-offs with respect to efficiency, bandwidth, size and cost.

4.4 Vortex Tube

An air vortex cannon works primarily by applying force quickly and efficiently to air molecules contained in a semi-enclosed space. When the stretchy balloon surface at the back of the cannon snaps forward, it collides directly with air molecules, accelerating them towards the opening of the cannon and setting off a chain reaction of high-speed collisions with other air molecules and the sides of the cannon's barrel. The only way for all of these colliding high-speed air molecules to escape is out through the opening at the end of the barrel. The rapid escape of the air molecules forms a stream, or jet, of air that flows straight out of the cannon.

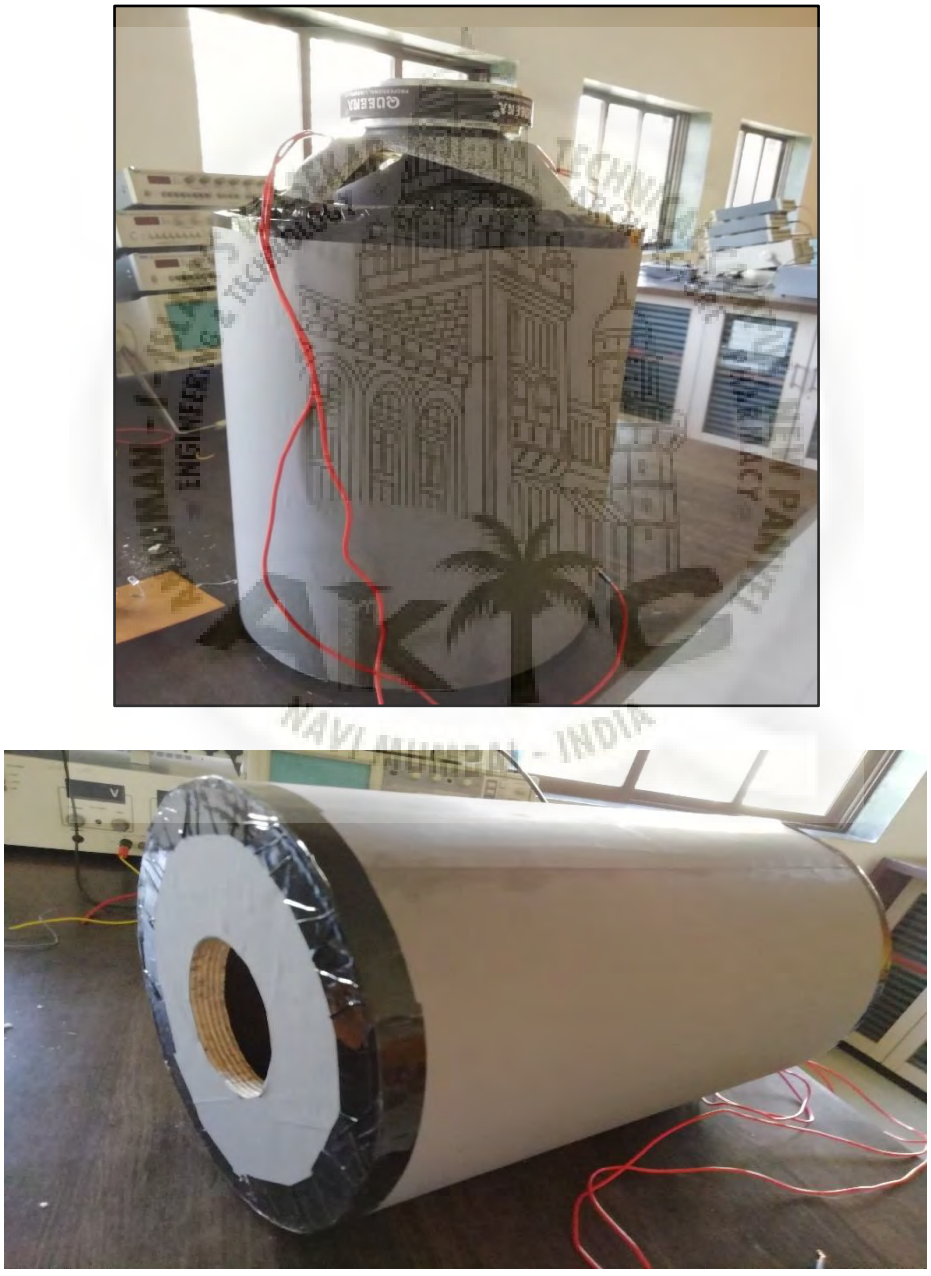


Fig. 4.5: Vortex tube

When a jet of air escapes the opening of air vortex cannon into the still air outside, it forms a stable donut-shaped gaseous projectile. This flying gas donut is called a toroidal vortex or vortex ring, hence the name air vortex cannon.

4.5 Potentiometer

Low-power potentiometers, both linear and rotary, are used to control audio equipment, chang- ing loudness, frequency attenuation, and other characteristics of audio signals. The 'log pot' is used as the volume control in audio power amplifiers, where it is also called an "audio taper pot", because the amplitude response of the human ear is approximately logarithmic.

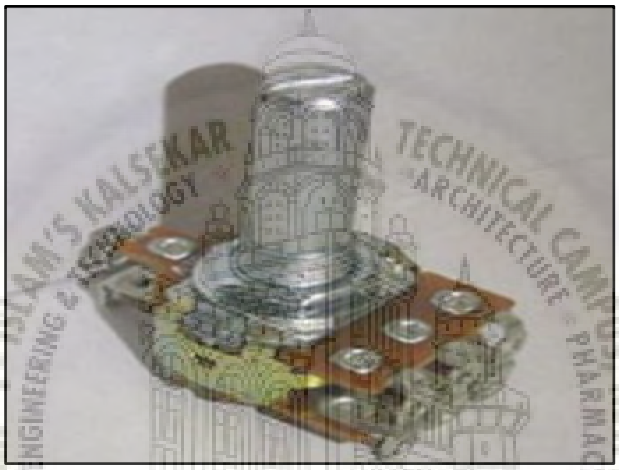


Fig. 4.6: Pot

It ensures that on a volume control marked 0 to 10, for example, a setting of 5 sounds subjectively half as loud as a setting of 10. There is also an anti-log pot or reverse audio taper which is simply the reverse of a logarithmic potentiometer. It is almost always used in a ganged configuration with a logarithmic potentiometer, for instance, in an audio balance control. Potentiometers used in combination with filter networks act as tone controls or equalizers.

4.6 Power Supply

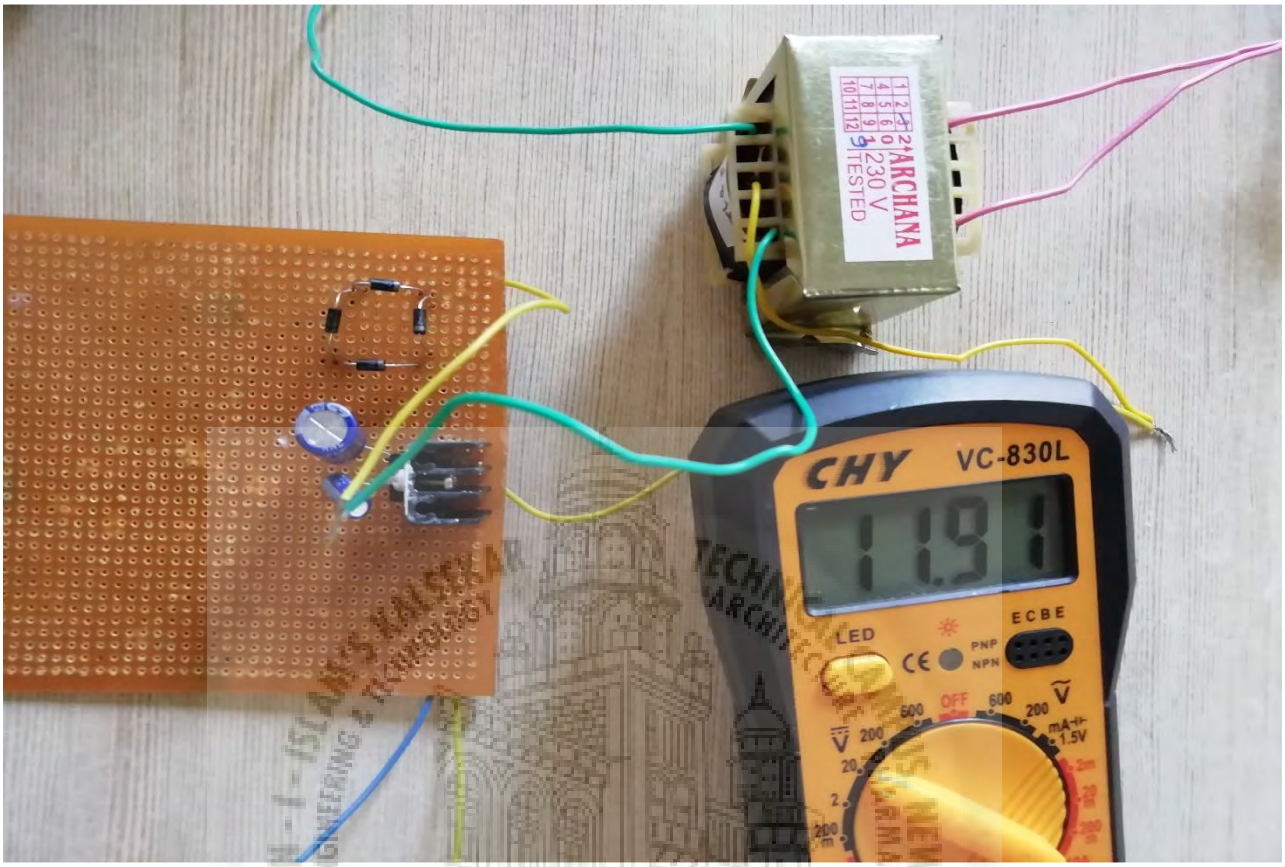


Fig. 4.7 Power supply

4.7 Hardware Requirements

- IC 8038
- IC CD4440 Amplifier 80watts
- Subwoofer 4ohms 300watt
- Potentiometer - 10k 1M 100k
- Audio jack 3.5mm
- Diode IN4007
- Breadboard
- PCB
- Resistor - 100k 10ohm 4.7k 1ohm
- Capacitor - 220uF 0.1uF 100uF 2200uF 470uf 1uf 1000uf
- Step down Transformer 12-0-12 1amp
- Flexible ply

4.8 Software Requirements

- Simple Tone generator (Android app)

Chapter 5

System Design And Testing

5.1 Testing And Observations on Breadboard

Tone Generator IC 8038

Tone Generator circuit using IC 8038 is implemented on breadboard and Output is observed on DSO (Digital Storage Oscilloscope).

Fig. 5.1: Tone Generator IC 8038

Pure Sine Wave

As IC8038 is a variable oscillator, at the output from pin no.2 We get a pure sinewave at 90hz as shown in below fig.

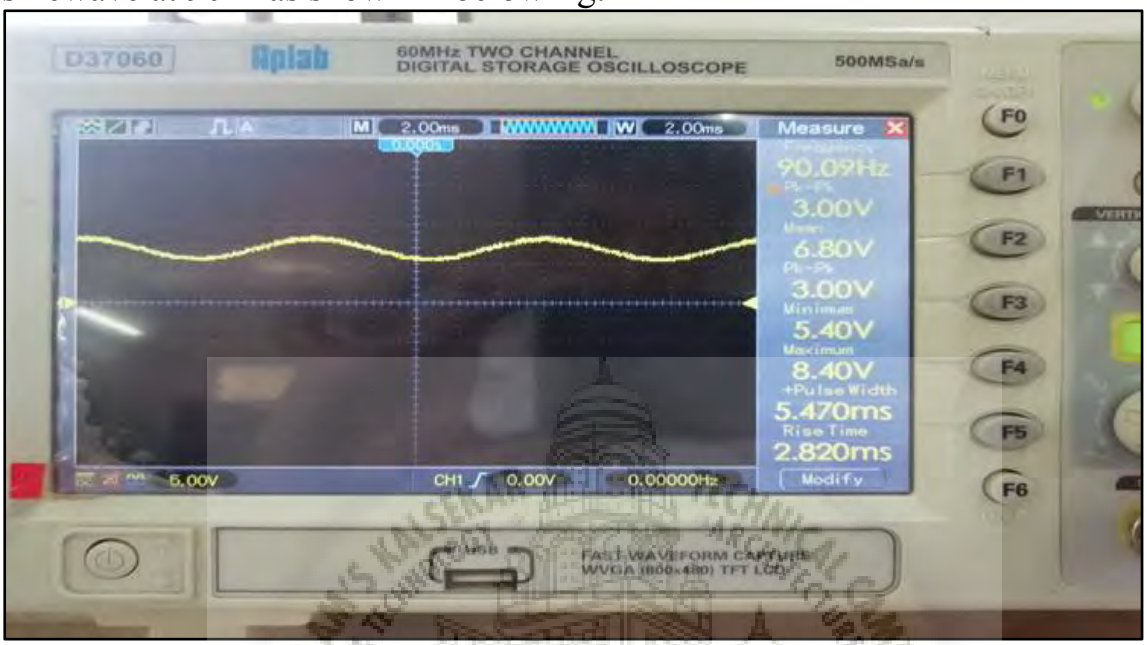


Fig. 5.2: Pure sinewave

Variation in Frequency

As IC8038 is a variable oscillator which gives a variable frequency between 20hz to 20khz. After testing on breadboard we get variation in frequency in the range between 20hz to 20khz.

Fig. 5.3: Variation in Frequency

IC CD4440 Amplifier

IC CD4440 circuit is mounted on breadboard and at the load subwoofer of 4ohm is connected. Input to amplifier is given from Android app and Output is taken from the subwoofer, at the output we get pure sound signal.

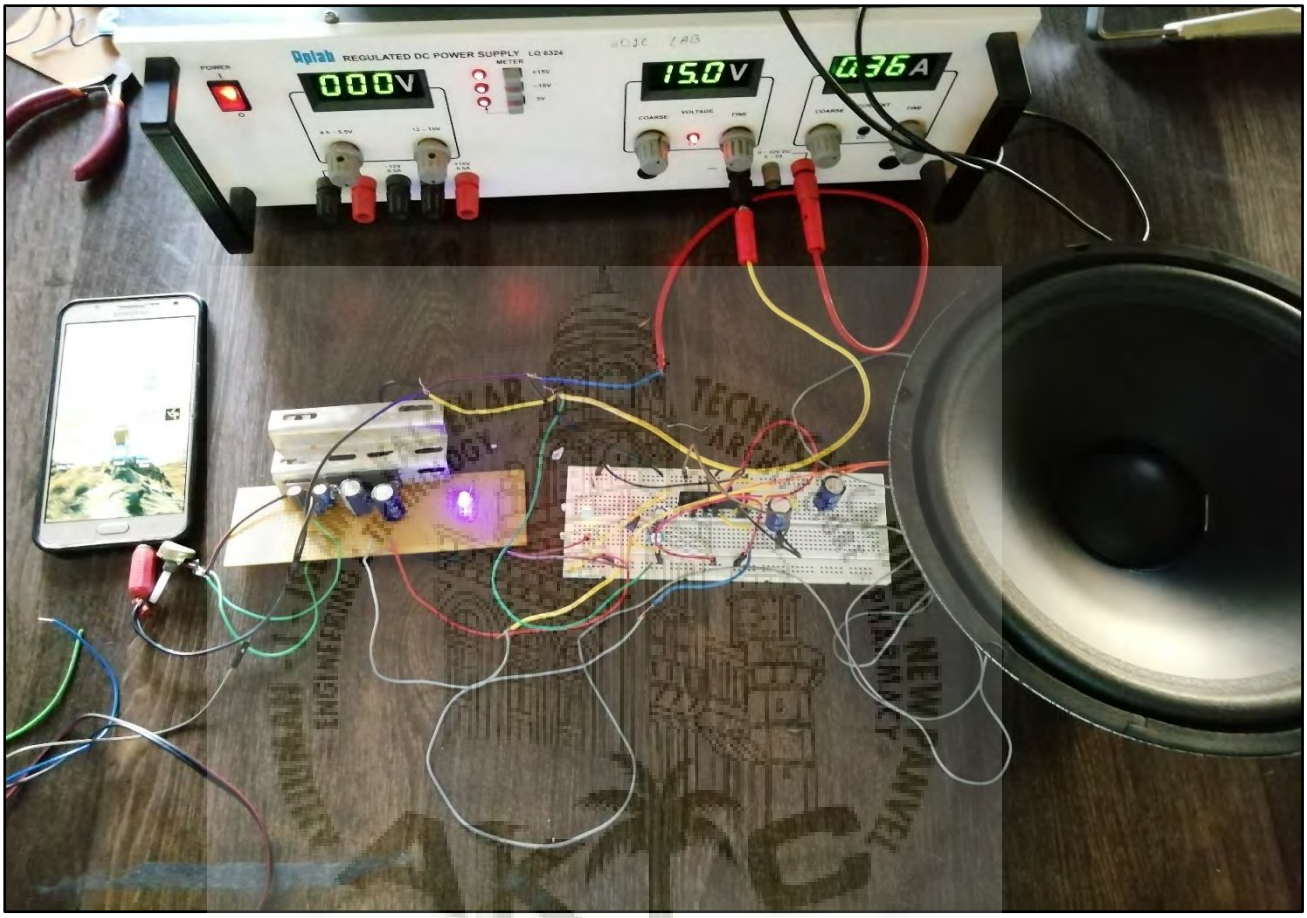


Fig. 5.4: IC CD4440 Subwoofer Amplifier

IC CD4440 Circuit

40 watt amplifier Circuit mounted on Breadboard.
4ohm 300watts subwoofer is connected at the load. After observing We get large amount of vibration at 50hz.

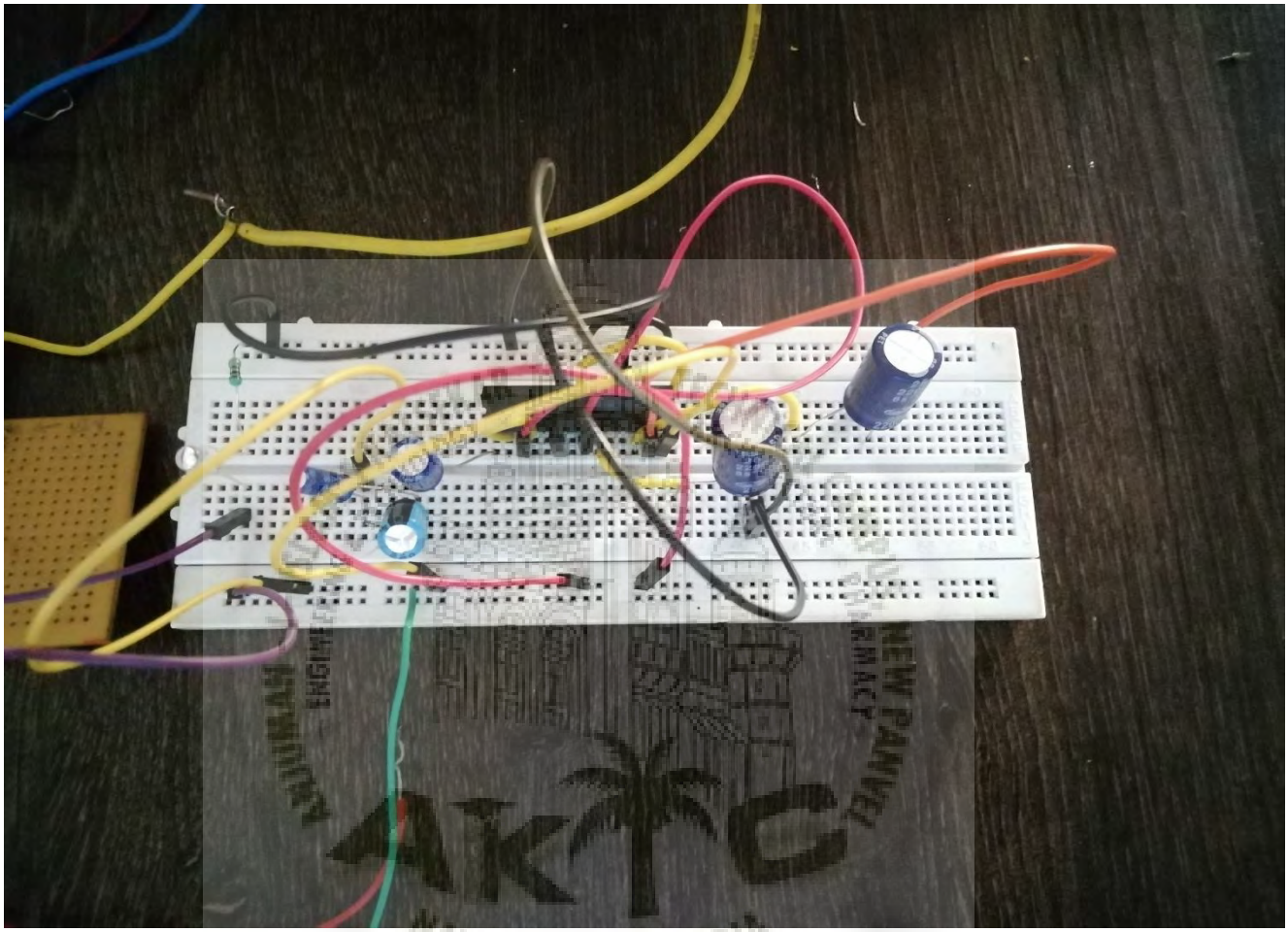


Fig. 5.5 Breadboard Circuit of CD4440 Amplifier

Power Supply 12V 1Amp

Step down transformer 12-0-12 1Amp is used for making 12v power supply. Output is measured on multimeter. We get 11.95v after observing supply on multimeter.

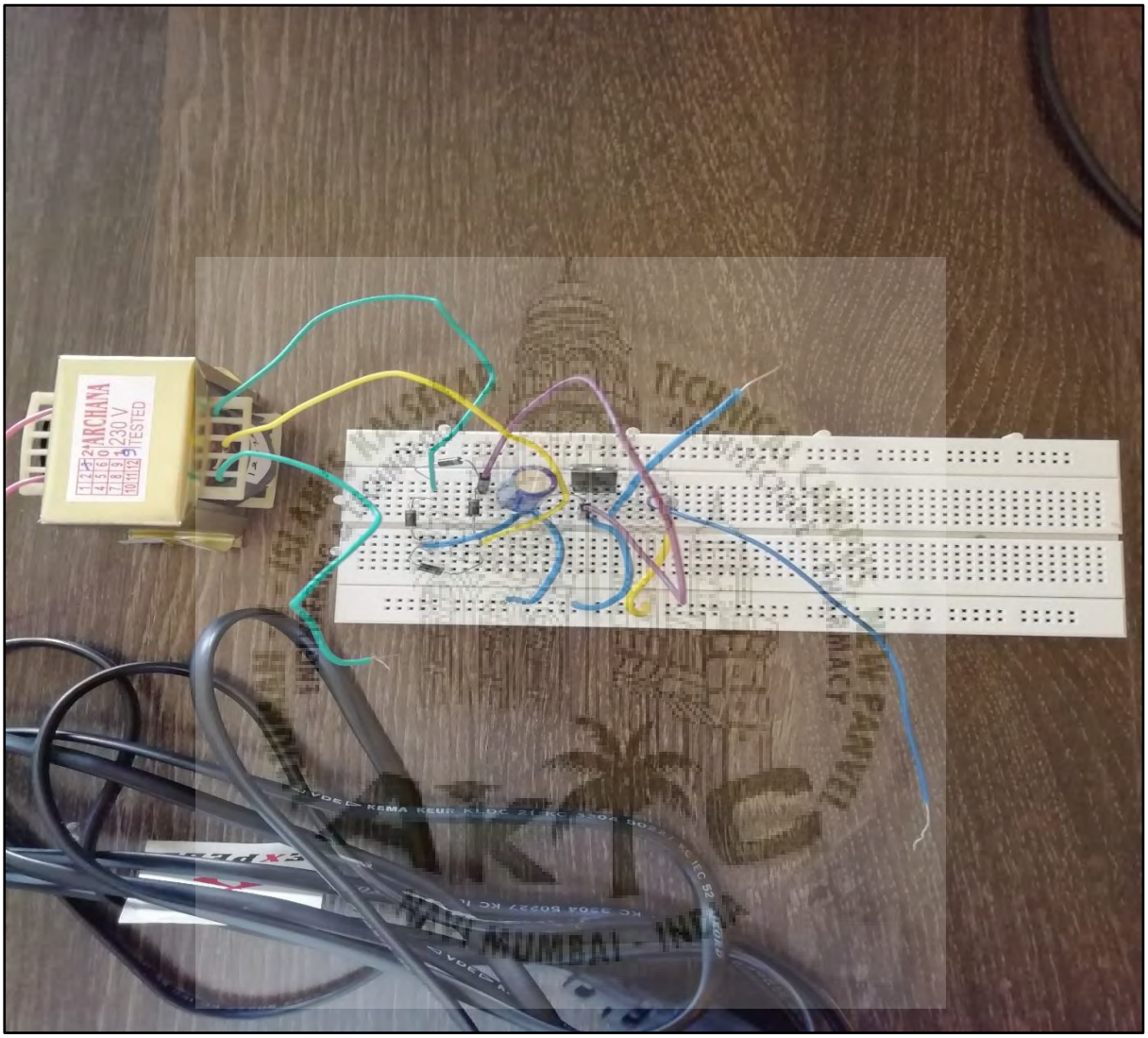


Fig.5.6 Breadboard Circuit of 12v 1amp power supply

Chapter 6

Implementation

6.1 PCB Layout

Fig. 6.1: PCB laser Marking of IC 8038 Tone generator

- **WHAT IS PCB?**

PCB means printed circuit board. It is designed by certain fabrication process. A con- ductive coating material is given on an insulating base material. This is also called a copper clad. Then by using art work the circuit can be drawn to mount the desired components as per circuit. PCB is also called as Printed Wired Board (PWB).

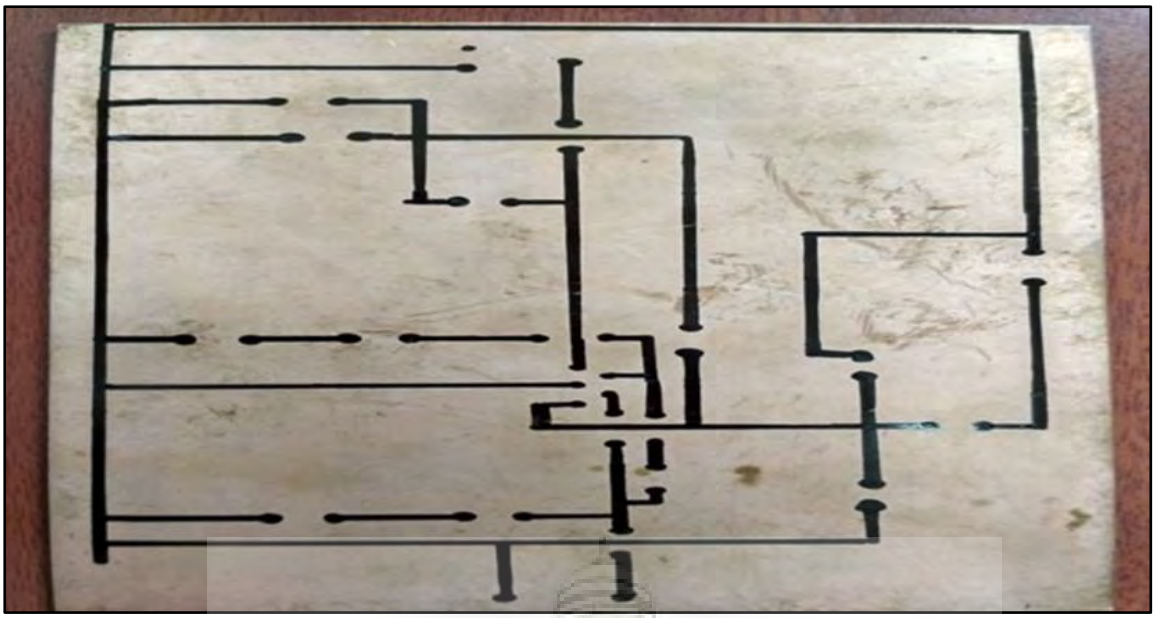


Fig. 6.2: PCB laser Marking of IC CD4440 Amplifier

• Need of PCB

Using PCB we can reduce the size of apparatus to be designed. A PCB is necessary because it holds every component firmly in its place and thus increases circuit reliability. Soldering becomes easy because of PCB.

• STEPS INVOLVED IN FABRICATION OF PCB ART WORK PREPARATION

The purpose of art work is to develop a layout for the final circuit board. It is the first and most important step as the mounting of various components and conductor thickness is decided in this step. Art work is always prepared from the component side of PCB, with the help of circuit diameter.

• PRINTING

This involves transferring of the art work into the copper clad. There are three methods of printing such as:

1. Direct Resist Method

2. Photo Resist Method

3. Screen Printing

4. In this project we used screen printing method. In this method the resist ink applied through a stencil or mask to the surface of the blank circuit board. The stencil is produced and attached to a fine mesh, metal, nylon, polyester or silk screen. The resist ink is force through the opening in the stencil onto the

surface of the blank board. This process produced a positive plate of the copper foil. When dry, the board is ready for etching.

6.2 Etching Process

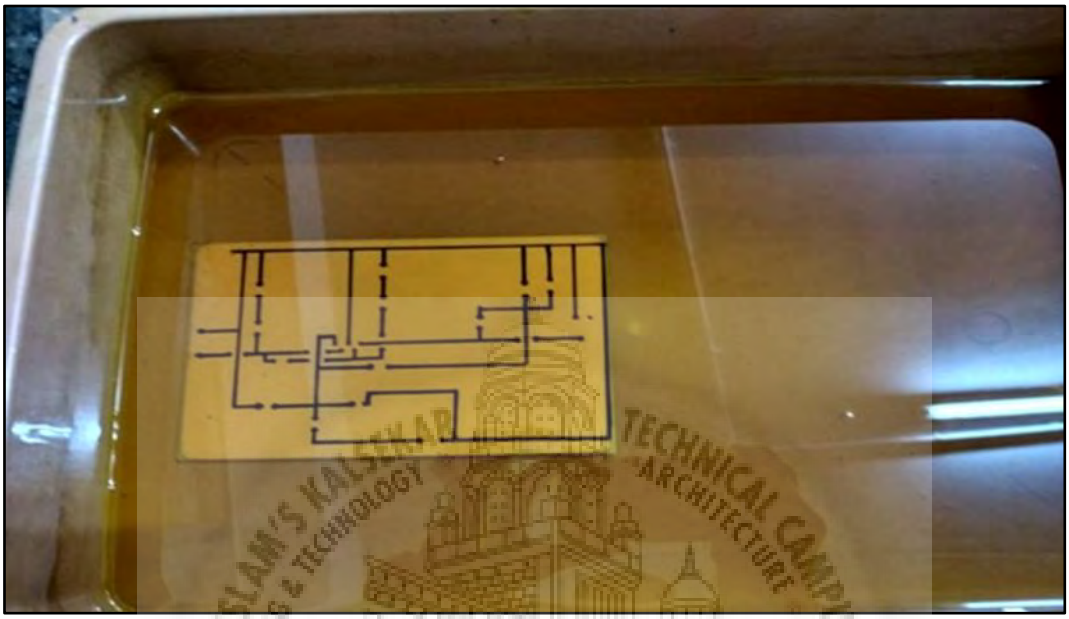


Fig. 6.3: Etching Process of IC CD4440 Amplifier

This step involves removal of unwanted copper from copper clad. The most common etchant used is ferric chloride. The copper clad is dropped in solution. After an hour, the PCB is taken out and washed in clean water. The chemical used for etching is Ferric Chloride (Fe2Cl3).

Fig. 6.4: Etching Process of IC 8038 Tone Generator

6.3 DRILLING

Fig. 6.5 Drilling

In this step drilling of PCB is done after removing of etch resist tape and pads. The holes are drilled according to the diameter of respective component lead. A whole stack of board can be drilled using various jigs and brushes. The speed of drilling is an important consideration with maintaining the size and location of hole with requires tolerance and maintaining deformity at their edges. When holes are drilled in PCB, the laminate is uncovered in PTH. To provide a conducting layer within the hole, electrode-less copper plating is used. The plate is coated with palladium and immersed electrolytic containing copper ions.

6.4 Soldering

Soldering is a method of joining two parts or more than two parts of metal. Fusible alloy metal alloys are used for this purpose. Prior to soldering metal portion are to be joined and the solder must be heat. Since, the solder has a much lower melting point than the metal to be joined. It melts, while the metals remain hard. At the place where the molten solder comes in contact with hard metal, complex physiochemical process takes place.

Fig. 6.6 Soldering of Tone Generator PCB

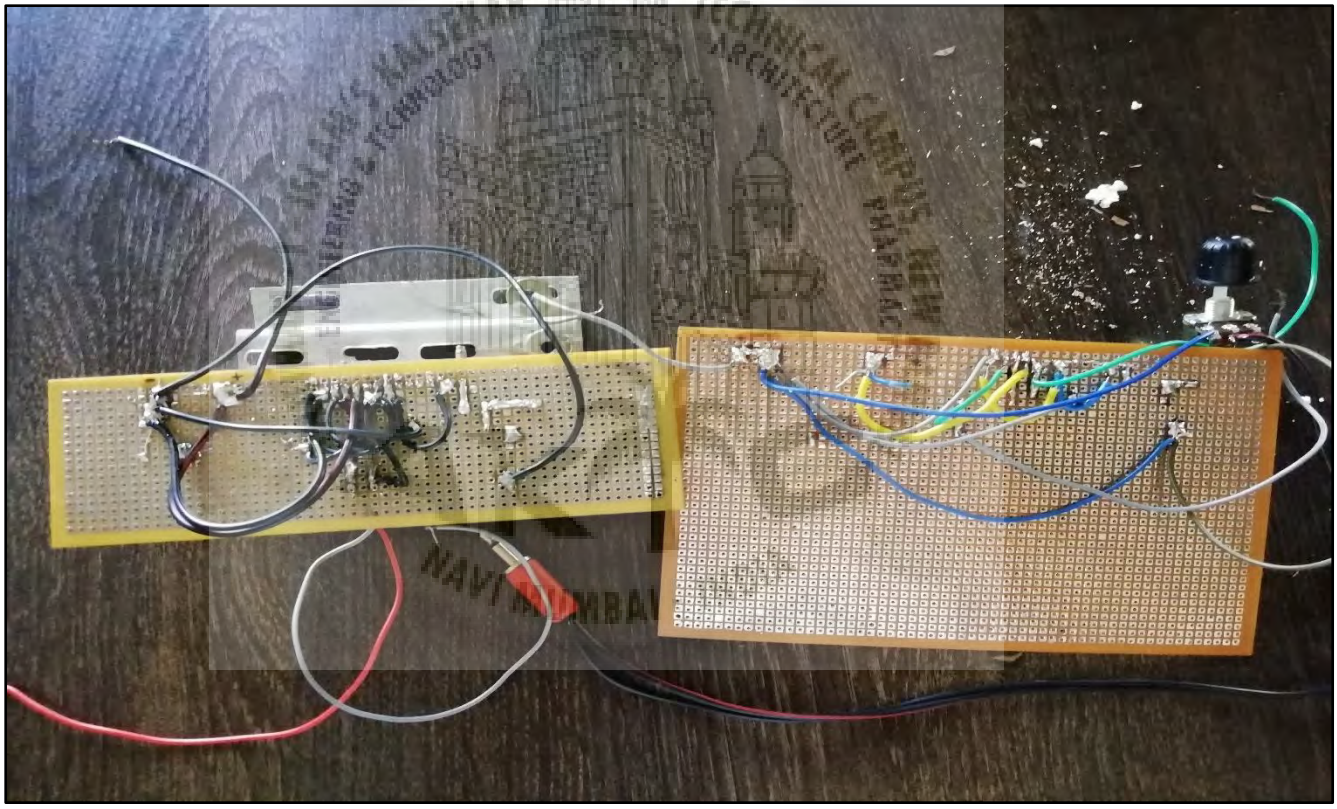


Fig. 6.7 Soldering of 80watts Amplifier PCB

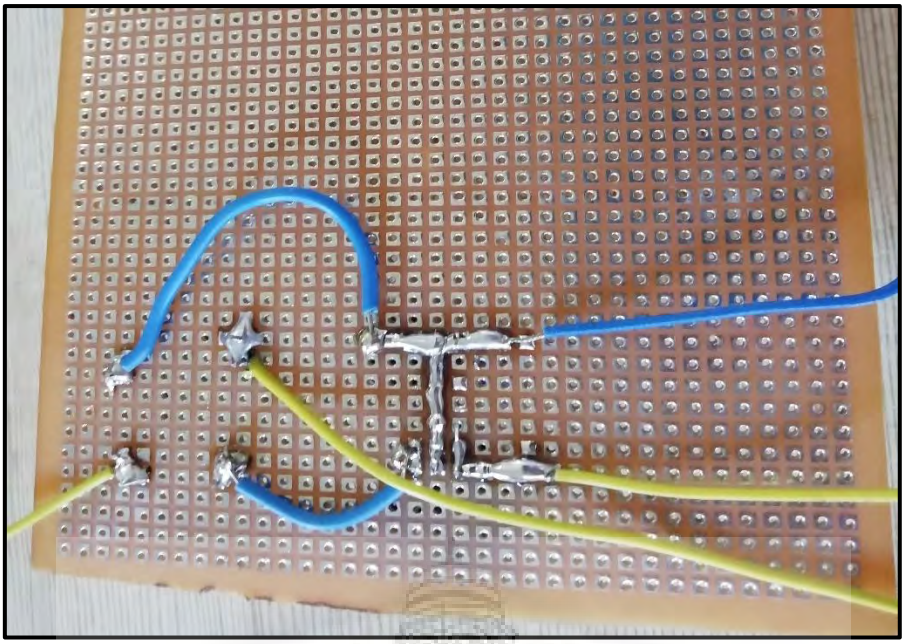
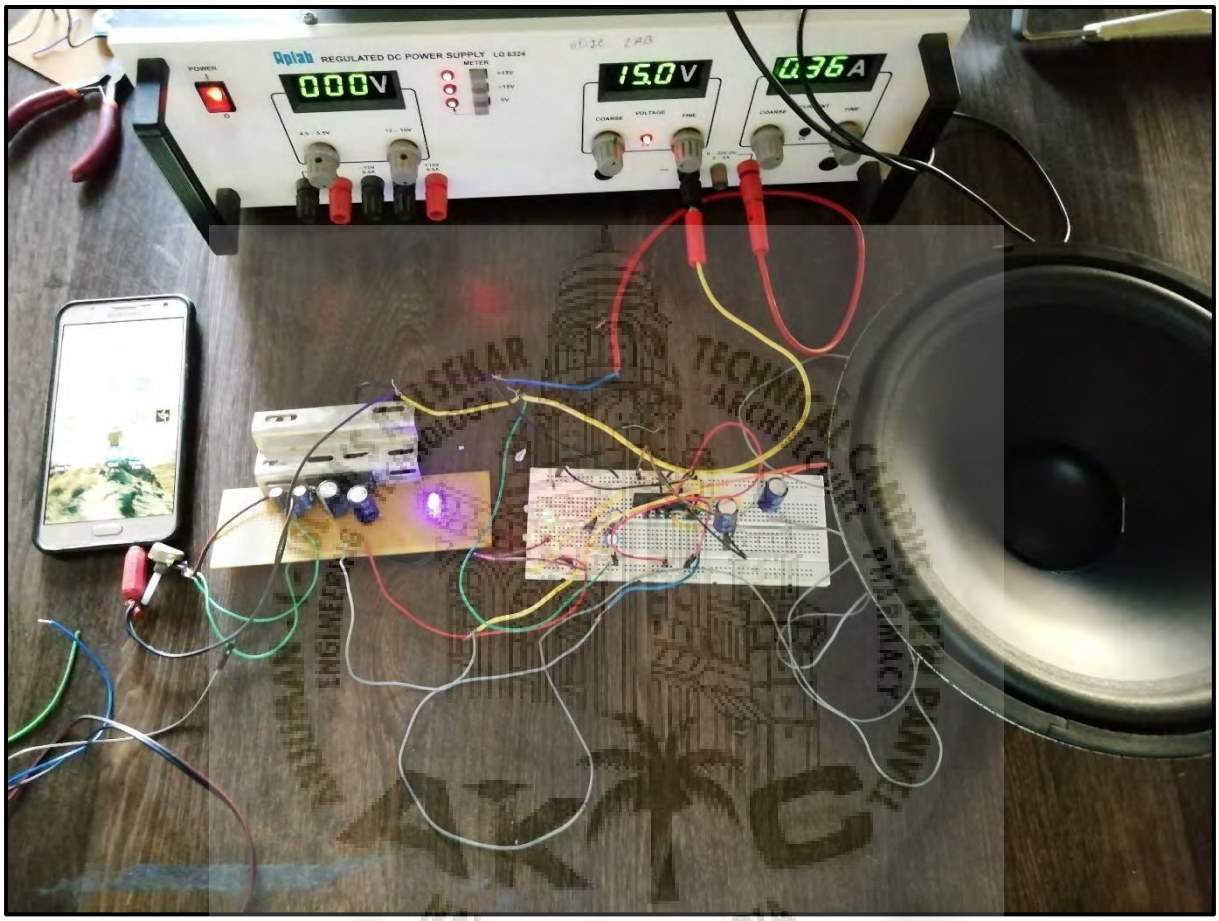


Fig. 6.8 Power supply PCB

Chapter 7

Result and Circuit Demonstration



Frequency in Hz	Amplifier Output power in watts	Flame extinction in seconds
45 Hz	80watts	20sec
50 Hz	80watts	24sec

Chapter 8

Applications & Advantages

8.1 Applications

The major applications of wave extinguisher are:

1. The wave extinguisher was initially developed as a tool to put out small indoor fires, for example, flames in the kitchen or server rooms packed with computers. The device though has much wider application and can be adapted for consumer or professional use.

2. Generally when fire is caused in an electrical panel circuit, using water is not possible as water conducts electricity, thus using sound waves to extinguish fire is one of its main application.

3. It can be used in place of chemical fire extinguishers and water as sound wave fire extin- guisher leaves no residue and it is nontoxic.

4. Fire is an important issue in space. Acoustic suppression of the flames can be beneficial in confined areas in space, where the sound waves can be easily directed without spreading all over in the non-gravity environment.

5. Energy working environment requiring permanent operations attention like At power plant control rooms, At flight control centres.

8.2 Advantages

- No residue compared to chemical fire extinguisher.
- Light weight.
- Compact size
- Less damage to surroundings.
- No refilling date.
- Can be used in confined places.
- Low cost

Chapter 9

Conclusion

The device made should must be installed in successive corners of the space station and must generate a sonic boom of sound at particular period of time without intervention of human.

The idea of Sound Fire Extinguisher can be a innovative one, however, it is efficient and effective, and can be used in today's world. For instance, installed in every electrical control panel, designed to turn on whenever fire is detected. It can be programmed to alternate the frequency based on the width of the flame. The effectiveness of a certain frequency needs to be in proportion with the width of the flame. With many possible applications, fighting fire with sound is a promising venue, and it can be possibly used for a larger area in which sound pressure waves can be used to save an important control center, or an astronauts life or can be used to extinguish the fire in that area where human can't reach without risking human life.

Chapter 10

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