DESIGN AND IMPLEMENTATION OF A DIGITAL VOLUME UNIT METER AS AN EQUALISER AND A HEALTH DEVICE

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SUBMITTED TO THE

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DEDICATION

I dedicate this report to God, the Almighty; the all-knowing, the all sufficient, the giver of wisdom, knowledge and understanding.

DECLARATION OF ORIGINALITY

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CERTIFICATION

I, ABIOYE Tomiwa Ayokunnumi, of the department of electrical and electronics engineering, Federal University Oye-Ekiti, Ekiti State, Nigeria with the matriculation number EEE/13/1087 hereby certify that I designed a digital VU meter to be implemented as a sound level indicator and as an health device.

ABSTRACT

People engaged in noise prone occupations are often exposed to damaging levels of sound which over time often results in hearing losses unknown to the victims. While workplace ethics requires the use of protective devices when exposed to high level of noise; for environments lacking suitable audio levels monitoring and alert systems, workers are sometimes left to decide on the perceived unsafe levels based on their personal level of discomfort which is not only relatively inaccurate but also increases the risk of hearing losses over time as the risk of sound to hearing not only depends on loudness but also duration. This project work thus focuses on the design and development of a suitable device which not only serves as a VU meter which over the years has found diverse usage in recording and broadcasting studios as a veritable tool for sound quality control but also a safe sound level monitoring system with integrated alert features suitable for use in factories, shop floors, work stations and other noise prone environments.

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CHAPTER ONE

1.0 INTRODUCTION

Sound is a form of energy having the ability to propagate in air and water. It is produced when substances vibrate in any of the aforementioned medium. In humans, sound is essentially one of the most favored medium of communication, as it forms the basis for music and speech and it is produced by vibration of the human vocal cords. The human ear has the capability to hear sounds in the range of 20Hz to 20 kHz. Sounds with lower or higher frequency cannot be heard by the human ear though some animals such as bats, elephants and dogs have a keener sense of hearing.

The need to accurately measure the measure sound waves and its accompanying characteristics cannot be over emphasized especially in recording and broadcast studios. An overview of the sound signal level not only helps to avoid over-loading but also to control distortion and noise so as to have a good production mix. The measurement of the signal level is often done by either a Volume unit (VU) meter or a Peak Program Meter (PPM). The VU meter and the PPM both perform the same function though in relatively different manners. A VU meter displays the average volume level of an audio signal whereas the peak program meter basically displays the peak volume of the audio signal.

The VU meter is basically a device displaying a representation of the signal level in an audio equipment. It was standardized in 1942 to be used with telephone and radio broadcast equipment to measure the strength of audio signals. This is done by employing special ballistics that average out complex waveform to produce a level variation similar to that heard by the human ear. For complex waveforms such as speech, a VU meter reads between the average and peak values of the sound wave.

1.1 STATEMENT OF THE PROBLEM

To operate a sound recording and reproduction system and to determine the safe and unsafe levels of sounds for humans, there exist the need to accurately determine the audio signal levels and also to avoid overloading, noise and distortion in signal transmission, hence the need for a VU meter.

1.2 MOTIVATION TOWARDS PROJECT

I did my SIWES training at a TV/Radio station, and at a point was posted to the radio recording, mixing and audio monitoring studio. This made me realize the importance of a volume unit meter or otherwise called an equalizer. I got interested in the functions of this device (that is normally attached to a recording device) and started a mini-research at the instruction of my boss who made us do a mini-defense of research topics every Monday morning. So, when I was required to pick a project topic, it occurred to me that FUOYE would most likely establish a radio station soon and hence, the importance of an equalizer.

Therefore, I decided to design a digital VU meter which would metamorphose into a mini-equalizer when the need arises and also to be used otherwise to determine safe and unsafe levels of sounds.

1.3 SIGNIFICANCE OF PROJECT

In the event that the university establishes a campus radio station, the VU meter would be extremely helpful in the setting up of the recording room, equalizers, mixing consoles, tape machines and compressors to measure the power levels of audio signals. Other significances includes:

1. Measuring the audio levels in a recording studio
2. Determining the sound intensity in communications system

3. Measuring the sound level in an environment or area
4. Determining the safe and unsafe levels of sound in a working environment.

1.4 AIMS AND OBJECTIVES

This work is aimed at designing and constructing a functional volume unit meter for measuring audio signal levels.

The objectives of the research are to;

1. To design a device capable of measuring audio levels.
2. To incorporate a health-related feature that indicates when sound is safe and when it is unsafe for human hearing.
3. To evaluate the performance of the designed VU meter.

1.5 CONTRIBUTION TO KNOWLEDGE

This project work thus present in method and functionality, a volume unit (VU) meter. The implementation and dual-functionality of the device as a health meter and a sound level indicator adds to previous knowledge and designs.

CHAPTER TWO

2.0 LITERATURE REVIEW

The measurement of sound is a relatively new science as sound was thought to be transient and that any attempt to capture it would be a rather fruitless exercise. Until the 17th century, natural philosophers were of the firm believe that it was absolutely illogical to quantify sound or even make plausible theories about its measurement.

The great philosopher Aristotle from his work in theater designs held the belief that high pitches must travel faster than lower pitches. Though there existed in his time the experimental prowess to test his hypothesis, it was not until about 2000 years later were such experiments performed due to the fear of being mocked and even ostracized.

The word acoustic a term which is now well used to describe the study and application of sound was actually a French word used by Francis Bacon (1561-1626) in 1605 in his book titled "Advancement of learning". In the year 1863, an anonymous author in Philosophical Transactions of the Royal Society wrote "Hearing may be divided into direct, refracted and reflexed, which are yet nameless unless we call them acousticks, diacousticks and catacousticks". These words came to being because it was trendy for philosophers and scientists in the 19th century to give names to the experiments and concepts they were performing.

The late 17th century however, gave rise birth to the development of calculus; a new branch of mathematics which birthed formulas for concepts such as displacement of strings, superposition and propagation, plates and shells, density and elasticity. Despite the aforementioned breakthrough and the resulting huge and powerful machines for processing and analyzing experimental results, not a single defining statement as to concept of sound was released by the science community.

The fact that sound traveled more slower than light is not a new one, as even far back as prehistoric time, lightning flashes were observed to be followed by thunder a pointer of the aforesaid fact. The earliest actual measurements of sound were made by Pierre Gassendi (1592-1655) and Matin Mersenne (1588-1648). Matin Mersenne in his experiment used a pendulum to measure the time between the flash of an exploding gunpowder and the arrival of the sound. Gassendi in his experiment however used a mechanical timepiece, and it was his discovery that all pitches travel at the same speed, having observed the high pitched crack of a musket and the boom of a cannon to arrive at the same time.

In 1687 in his famous book "Principia Mathematica", Isaac Newton employed the concept of calculus to create a purely mathematical analysis to predict the speed of sound. An experiment conducted by his friends; John Flamsteed and Edmond Halley (discoverer of the Halley Comet), at the Greenwich Observatory produced a rather surprising result. They found Newton's prediction to be 20% slow when they observed through a telescope, a cannon fired at 4.8km away.

Several attempts at obtaining a different result by replication failed as they could not get their measurement to agree with theory. Unable to account for their measurements, they had to abandon their work, while Newton went ahead to published his theorized speed of sound.

In the year 1738, "the Academy of Sciences" located in Paris conducted series of experiments and presented to the public a value of the speed of sound which differs only about 0.5% from the generally accepted value today.

The earliest attempt toward analyzing the frequency of sound was carried out by Galilei Galileo, who drew a knife edge across the serrated edge of a coin. Haven observed the tone produced, he was of the opinion that sound was a sequence of pulses in air and that sliding the knife more quickly produced higher tone or a faster sequence of pulses.

The British Scientist Robert Hooke in his diary in 1705, described a sound producing machine which he demonstrated before the Royal Society some years later. The aforesaid machine consisted of a toothed wooden wheel rotated against a reed or card to produce music-like sound for a regular set of teeth or speech like sound for irregular set of teeth. Despite this great invention, Hooke's work wasn't published or used for the next 150 years.

Furthermore, a French scientist Felix Savart in 1834, performed an experiment to determine the frequency of sound wave in a method similar to what is known in modern engineering as "heterodyne analysis". In his experiment, Savart connected a mechanical tachometer to the axis of a toothed wheel. He calibrated a rotational scale with the toothed will and demonstrated that specific tones were associated with specific frequencies. He thus was able to determine the frequency of a tone heard in air by using his ear to match it with the toothed wheel and reading the frequency off the tachometer.

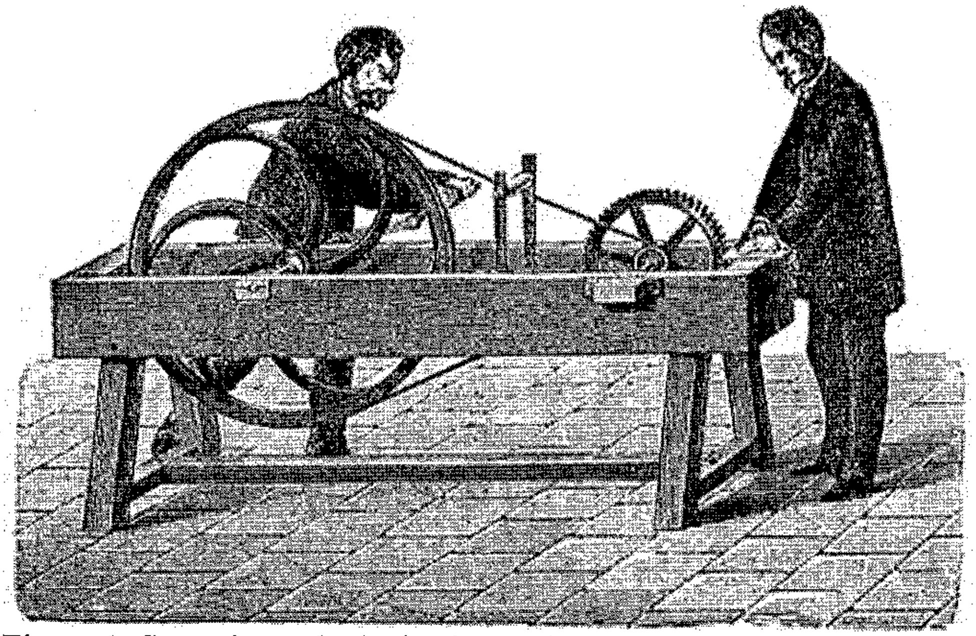


Figure 1, Savart's toothed wheel experiment

The year 1711 brought about an invention which greatly changed the science of the measurement of sound waves with the invention of tuning fork. This presented a frequency standard. The end of the 29th century Karl Rudolp built an ultra – accurate tuning force to drive escarpment, a concept that would be incorporated into wristwatches a century later.

The attempt towards understanding the concept of sound waves continued to yield positive fruits as in the 18th century, Thomas Young coated a glass cylinder with lamp-black, pushed a pin through a flexible diaphragm and by shouting into the diaphragm was able to see the sound waves scratched into the lamp-black. The Frenchman Edouard-Leon Scott de Martinville elaborated on his idea by used the ears of decapitated dogs as receiving horns to concentrate the sound waves. Across the small end of the ear he put a feather, who's sharpened tip 'wrote' sound waves in the lamp-black on a cylinder. He demonstrated this invention called the

Phonoautograh. Later versions looked stunningly like Edison's phonograph of 20 years. Although of course it could not play back.

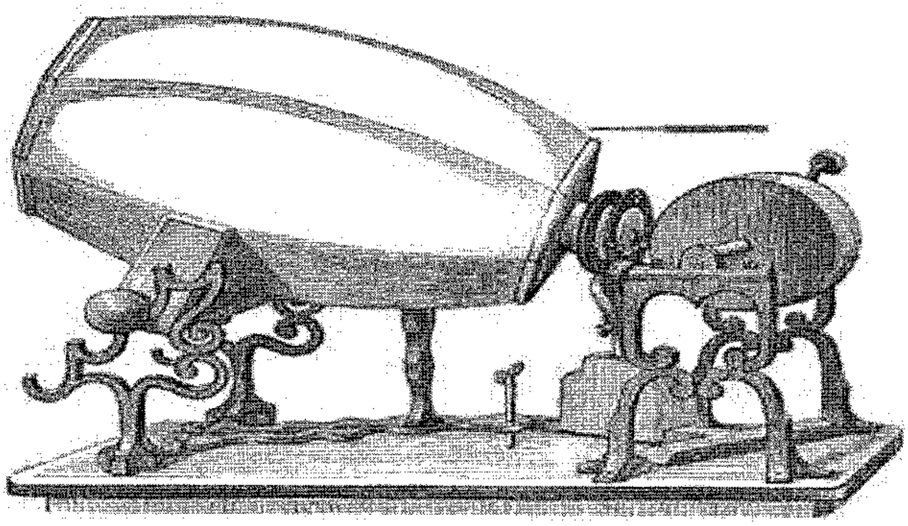


Figure 2, The Eduard Leon Scott's experiment

Over the next couple of years, pressed by the need to accurately compare newly mass produced tuning fork against standard ones in factory conditions, the French scientist Lissajous developed an optical method of measuring the sound emanated by objects. Lissajours turned two forks at right angles to each other, so one vibrated horizontally and the other vertically. Lissajous would shine a spot of light unto a tine of one fork and reflect it onto the tine of the other fork. He then observes the looping pattern through a lens system

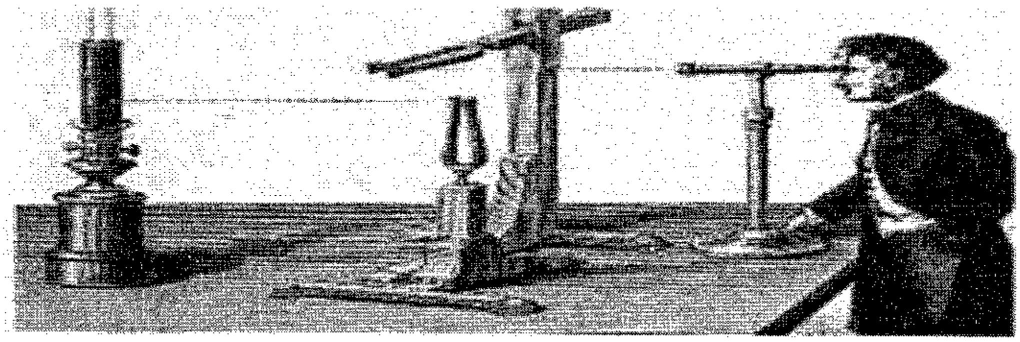


Figure 2, The Lissajous's experiment

He further improved on his design by projecting the formed pattern onto a screen. The pattern formed shows the relative frequency, amplitude and phase of the sound wave. A further improvement by Hermann Helmholtz made it possible to compare the frequency with sounds captured from and the design was referred to as a timebase.

The measurement of the amplitude of sound waves was not possible until the 18th century when Lord Rayleigh put a small reflective disk in a glass tube so it could pivot along a diameter. One end of the tube was open but had a tissue across it so random drafts could not discombobulate the apparatus.

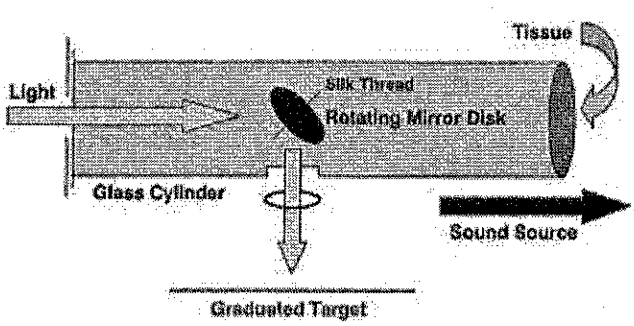


Figure 3, The Lord Rayleigh apparatus

The disk would rotate proportionally to the particle velocity of sound waves in the glass tube. This approach presented a form of volume velocity measurement and by shining a beam of light unto the disk and reflecting it back onto a graduated target, he could measure its rotation and thus the amplitude of the sound wave.

Over the next decade with the improvement in science and technology which brought about the invention of the Fleming's device and the vacuum tube; a non-mechanical approach was adopted towards the measurement of sound waves. The discovery by Palo Alto de Forest of a three audio amplifier capable of increasing audio- frequency signals by over a 100% greatly improved the relative ease with which audio signals could be measured.

In the year 1913, Edwin Howard Armstrong further demonstrated that the amplifying power of Palo's device could be further increased when part of its output was fed to the input. Despite facing a lot of legal and patency issues, Palo's design which had be earlier on sold to AT& T telecommunications was vastly applied to audio devices by AT&T such that in the year 1915, they were able to broadcast from a radio transmitter in Arlington, Virginia using 500 audions.

The first Sound-Level meter was developed by AT & T in 1917 but like so many other designs which came after it, the device was relatively of great physical size and until the early 1920s a great deal of acoustic measurement was done outdoor to erroneous reading from reflections in measurement environment. In the mid-1920s Bell Laboratories attempted to solve the aforementioned problem by using well damped measurement chambers.

Over the years, with advancement in science and technology, a variety of Vu meters has been patented and produced and they include designs whose signal display ranges from LEDs, 7-segments displays, LCD to Graphical LCD and computer monitors and smart phones.

Richard C Heyser, architect of time-delay spectrometry and founder of the modern school of mathematically based audio measurements offered wisdom on this subject "Any audio system can be completely measured by impulse response, steady state frequency response or selected variations.

CHAPTER THREE

DESIGN METHODOLOGY

3.0 DESIGN METHODOLOGY

Analog audio signal levels are often expressed in decibels compared to one reference level and often displayed in a non-linear decibel scale. The device is designed to not only function as a VU meter but also to act as an audio health protection device. This is achieved via the integration of an LCD screen which displays the average sound intensity and also the safety status of the current sound volume.

The following factors amongst others were considered in the design of the device

1. Ease of operation: the device should be easy to operate require little or no technical know how
2. The device was also designed to be relatively maintenance free requiring only an occasional change of battery
3. The device was also constructed using local materials

3.1 DESIGN PRINCIPLES

The device consists of two major parts; the VU (volume unit) and the audio health monitoring unit. It consist of the following essential components.

1. LM3915 volume unit chip
2. Liquid crystal display LCD
3. The PIC16f887 microcontroller
4. The Electret microphone
5. Light emitting diodes LEDs

3.1.1 The LM3915 VU IC

The LM3915 is a monolithic integrated circuit that senses analog voltage levels and drives ten LEDs, LCDs or vacuum fluorescent displays, providing a logarithmic 3 dB/step analog display. One pin changes the display from a bar graph to a moving dot display. LED current drive is regulated and programmable, eliminating the need for current limiting resistors. The whole display system can operate from a single supply as low as 3V or as high as 25V. The IC contains an adjustable voltage reference and an accurate ten-step voltage divider. The high impedance input buffer accepts signals down to ground and up to within 1.5V of the positive supply. Further, it needs no protection against inputs of ±35V. The input buffer drives 10 individual comparator referenced to the precision divider. Accuracy is typically better than 1 db. The LM3915's 3 dB/step display is suited for signals with wide dynamic range, such as audio level, power, light intensity or vibration. Audio applications include average or peak level indicators, power meters and RF signal strength meters. Replacing conventional meters with an LED bar graph results in a faster responding, more rugged display with high visibility that retains the ease of interpretation of an analog display.

The LM3915 is extremely easy to apply. A 1.2V full scale meter requires only one resistor in addition to the ten LEDs. One more resistor programs the full scale anywhere from 1.2V to 12V independent of supply voltage. LED brightness is easily controlled with a single pot. The LM3915 is very versatile. The outputs can drive LCDs, vacuum fluorescents and incandescent bulbs as well as LEDs of any color. Multiple devices can be cascaded for a dot or bar mode display with a range of 60 or 90 dB. LM3915s can also be cascaded with LM3914s for a linear/log display or with LM3916s for an extended-range VU meter.

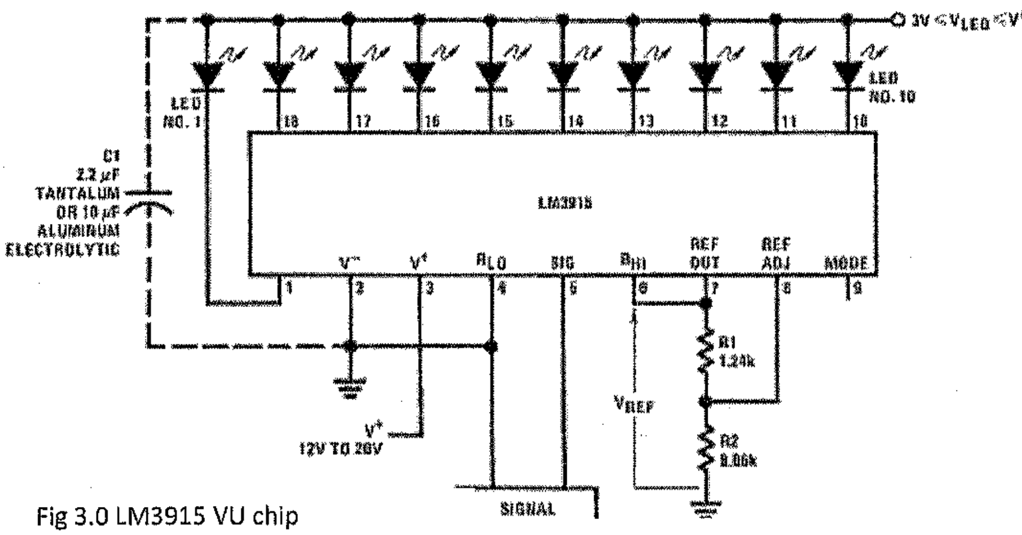


Fig 3.0 LM3915 VU chip

The electrical characteristics are as given below

LM3915 Pin Description

Pins 1, 10 to 18: Each of these pins is connected to the cathode of the output LED. The anode of the output LEDs are connected to the 3V to 20V supply.

Pin 2: This pin is the negative analog voltage supply and is usually connected to ground.

Pin 3: This pin is the positive voltage supply and usually the supply voltage is at min 3 V to max 20V

Pin 4: This pin is usually grounded

Pin 5: This pin is the signal input pin and the audio signal input is given to this pin.

Pin 6 and Pin 7 are shorted together. The current through pin 7 decides the current drawn by each LED.4e

Pin 8: It is the pin used for adjusting the reference voltage. There is a resistance of 1.2kohms between pin 7 and pin 8 such that a voltage of 1.25V is between the pins.

A potential divider is connected to the resistor which is used to adjust the reference voltage.

Pin 9: This is the mode select pin and is used to select either the dot mode or the bar mode. For the bar mode, the pin is connected directly to pin 3, i.e. to the positive voltage supply. For dot mode, the pin is left open, without any connection.

3.1.2 OPERATION OF THE LM3915

LM3915 basically receives analog voltage as input in the range between 0 to 1.5V and this is given to the buffer amplifier which drives a series of 10 comparators. There is a reference voltage source which can be programmed. This reference voltage is given to each comparator using a 1:10 Potential divider arrangement. Each comparator compares the input voltage with a reference voltage and accordingly drives the corresponding LED connected to it.

It can operate in dot mode or bar mode. In bar mode, the LEDs are driven in continuous mode, i.e. the glowing of LEDs appears as if in continuous form. In dot mode, a single LED glows at a time.

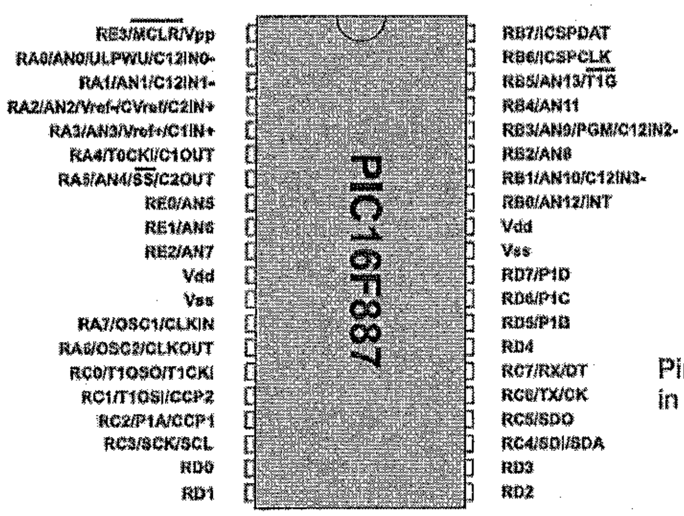
Using a LM3914 / 15 IC U2 – Dot/Bar Display Driver along with signal amplifier IC LM324 IC U1 to 4 a nice dancing light as per audio signals are feasible. High power lamps can also be used by adding opto-coupler in series with the LEDs and the diac of the opto driving the triac for 230 volt lamps. The entire display system can operate from a single supply as low as 3V or as high as 25V. Numerous mechanisms could be cascaded for a dot mode display or bar mode display with an extent of 60dB or 90 dB. LM3915 can also be cascaded with LM3914 for a linear/log display or with LM3916s for an extended-range VU meter.

The LM3915 displays are used in audio applications, power meter and RF signal strength meters. And these displays are suited for signals with wide dynamic range, for example audio level, power and etc.

3.1.3 THE PIC 16F887 MICROCONTROLLER

The PIC16F887 is a 40-pin (for PDIP package) and 8-bit CMOS PIC Microcontroller that comes with Nano Watt technology. Economical price and user-friendly architecture make this device easy to use and easy to configure. It is available in three packages known as PDIP, QFN, and TQFP. The first one comes with a 40-pin layout design while remaining two contains 44 pins on each layout. This PIC version, like other models in the PIC community, contains everything that is required to make an embedded system and drive automation. The PIC16F887 incorporates 256 bytes of EEPROM data memory, 368 bytes of RAM, and program memory of 8K.

Apart from self-programming capability, it also contains 2 Comparators, 10-bit Analog-to-Digital (A/D) converter with 14 channels, and capture, compare and PWM functions.



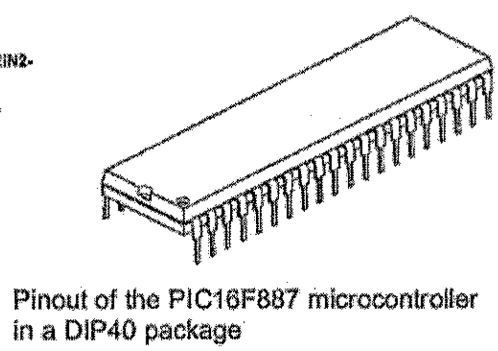


Fig 3.2 Pic16f887 Microcontroller

The asynchronous serial port is added on the chip that can be configured both ways i.e. the 2-wire Inter-Integrated Circuit (I^2C^{TM}) Bus or 3-wire Serial Peripheral Interface (SPI^{TM})

The Enhanced Universal Asynchronous Receiver Transmitter (EUSART) feature makes this chip compatible with the .devices where serial communication is an integral part of the project.

The functions that make this device unique in terms of ease of use include

1. Power-Saving Sleep mode
2. Industrial and Extended Temperature range
3. Wide operating voltage range (2.0V-5.5V)
4. SR Latch mode
5. Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
6. Power-on Reset (POR)
7. Ultra-Low-Power Wake-up (ULPWU)
8. Multiplexed Master Clear with pull-up/input pin
9. Individually programmable weak pull-ups
10. Brown-out Reset (BOR) with software control option
11. Enhanced low-current Watchdog Timer (WDT)

3.1.4 THE LIQUID CRYSTAL DISPLAY (LCD)

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced Cathode ray tube (CRT)

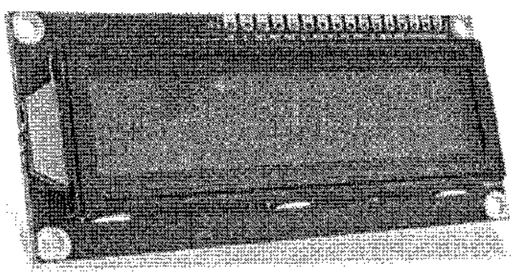


Fig 3.3 LCD screen

displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.

3.1.5 THE ELECTRET MIC

An electret microphone is a type of electrostatic capacitor-based microphone, which eliminates the need for a polarizing power supply by using a permanently charged material.

An electret is a stable dielectric material with a permanently embedded static electric dipole moment (which, due to the high resistance and chemical stability of the material, will not decay for hundreds of years). The name comes from electrostatic and magnet; drawing analogy to the formation of a magnet by alignment of magnetic domains in a piece of iron. Electrets are commonly made by first melting a suitable dielectric material such as a plastic or wax that contains polar molecules, and then allowing it to re-solidify in a powerful electrostatic field. The polar molecules of the dielectric align themselves to the direction of the electrostatic field, producing a permanent electrostatic "bias". Modern electret microphones use PTFE plastic, either in film or solute form, to form the electret.

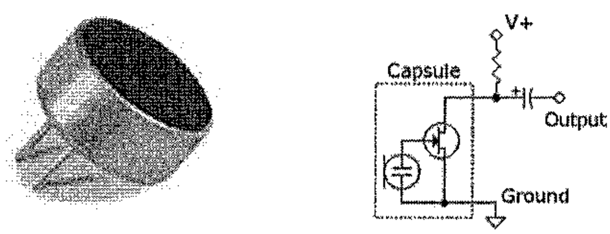


Fig 3.4 Electret Microphone

3.2 DEVICE AS AN AUDIO HEALTH MONITORING DEVICE

The risk of sound to hearing depends on 2 major factor; how loud the sound is and the length of exposure as illustrated in the chart below.

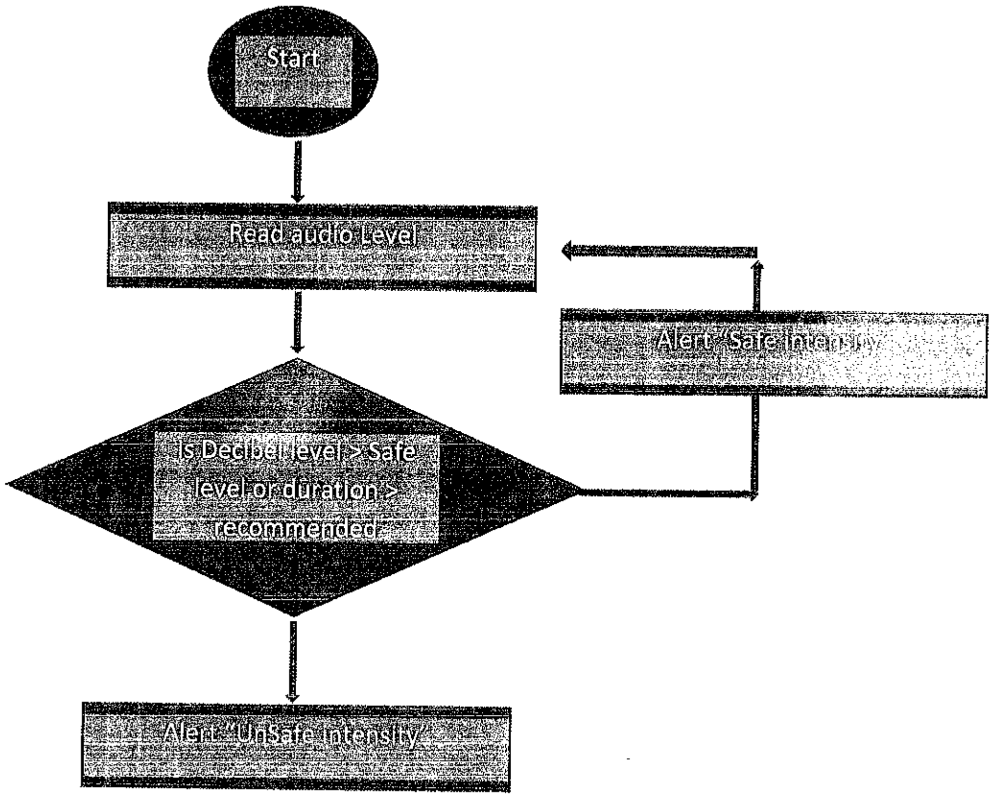
Noise Level (dB)	Maximum Exposure Time per 24 Hours
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7.5 minutes
106	3.7 minutes

109	112 seconds
112	56 seconds
115	28 seconds
118	14 seconds
121	7 seconds
124	3 seconds
127	1 second
130–140	less than 1 second
140	**NO EXPOSURE**

Table 1 Noise level in db and Max exposure time

However, since different people's ears differ in their degree of vulnerability to noise, noise exposure levels that are well tolerated by some people may cause harm in others. Thus if after being exposed to a certain level of noise , a rushing, roaring, or ringing sensation is felt or ordinary sounds seem muffled or quieter than normal, then it is safe to assume that that level of noise is damaging and hearing protection is needed in that situation in the future. It is also advised to rest your ears (which mean no noise above 70 dB) for at least 24 hours.

The human ears are not able to tolerate or adapt to noise levels, thus if a certain noise level does not seem to bother an individual as much as it did before, it is not because the ears have toughened up to it; rather, often due to the fact that the individual has lost some of his hearing.



3.3 CONSTRUCTION OVERVIEW

The device is housed in a thermoset plastic casing. The case is cut to dimension using a suitable hacksaw. The edges are further cleaned out by filing off the sharp edges using a hand file.

The component pieces are properly aligned and glued using an epoxy glue. The components are then carefully soldered to the PCB according to the prepared circuit.

3.4 VU METER CIRCUIT OVERVIEW

The circuit basically comprises of the following components:

1. LM3915
2. The PIC16f887 Microcontroller

3. The LCD Screen
4. Voltage regulator
5. Light Emitting Diodes LED
6. The Electret Mic
7. Resistors and capacitor

The input signal from the microphone is fed to the signal pin (5) of the LM3915 IC U2 via the resistor capacitor amplification arrangement. The LM3915 being a dedicated Vu IC chip converts the input signal to corresponding decibel levels which is displayed via the LED 1-10.

The amplified input signal is also fed into an RA0 (pin 2) an ADC pin of the pic16f887 microcontroller which is programmed to compare the peak signal against a determined threshold and generate the corresponding visual alert on LCD.

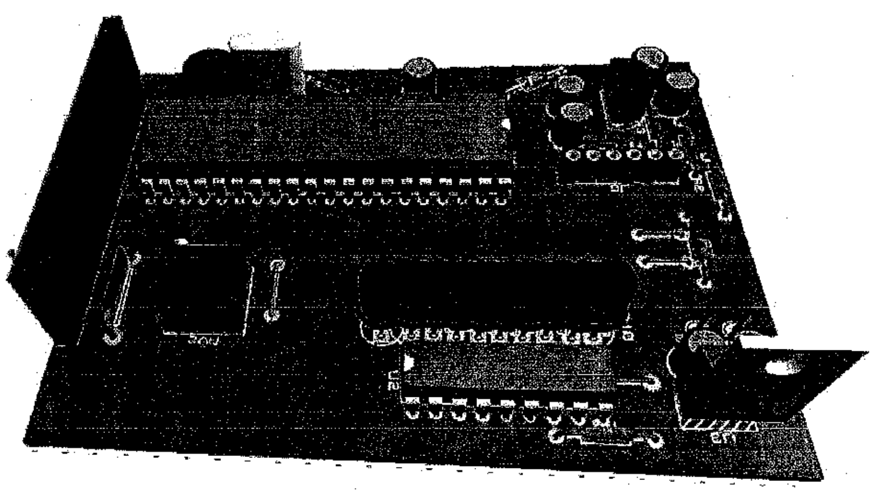


Fig 3.6 PCB

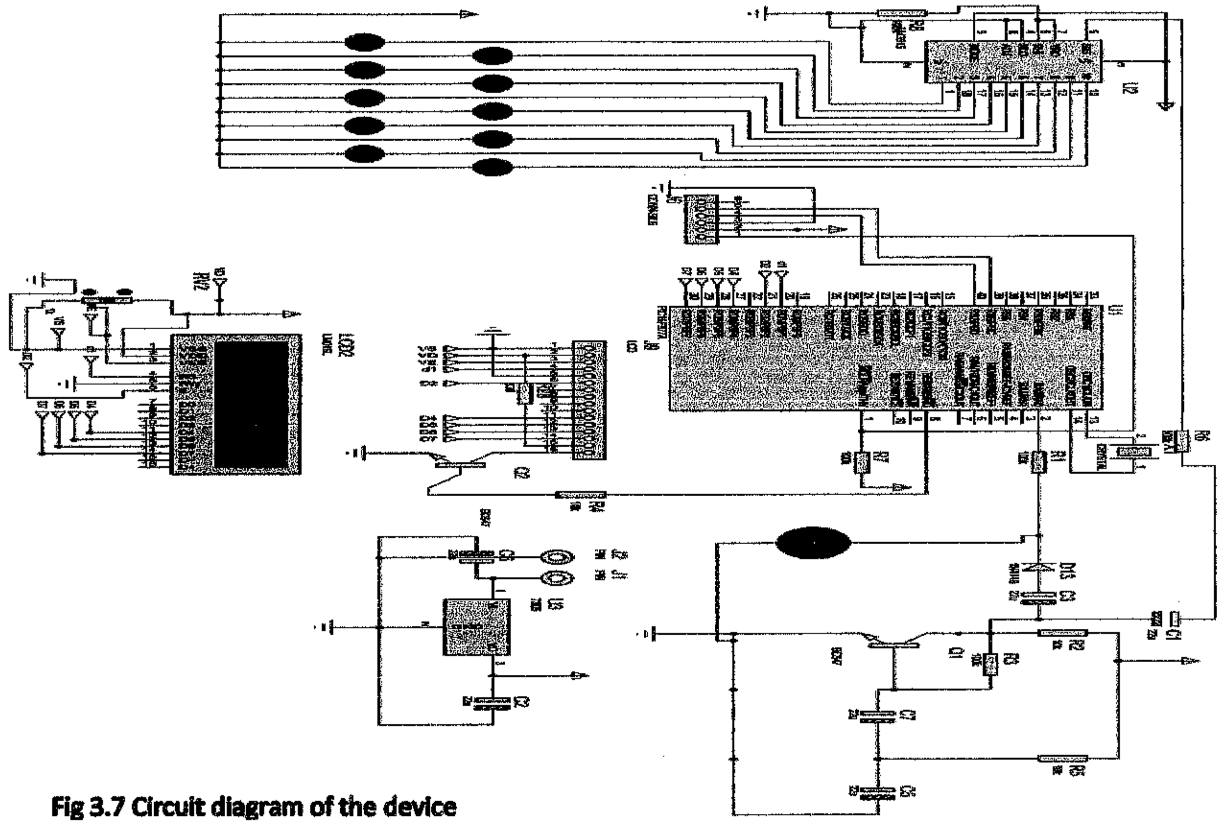


Fig 3.7 Circuit diagram of the device

3.5 MODE OF OPERATION

When switched on, the ambient sound intensity is picked up by the microphone located at the top face of the device. The amplified input signal from the microphone is then passed to both the LM3915 IC and the PIC16f887 microcontroller.

The LED which are arranged in linear form glows according to the sound intensity. The device is also designed to function as an audio health device by monitoring and warning the user when the ambient sound level is within or above the safe decibel range. However, since the maximum range of the device is within 30 decibels, the device is scaled to display the "Unsafe Sound Intensity" alert at around 30 decibels.

3.6 CIRCUIT DESIGN AND PROGRAMMING IDE

The schematic circuit and PCB designs were made with the Proteus Electronics design suite and the programming of the pic16f887 microcontroller unit was carried out with the microcontroller version of C programming language "Mikro C" using the professional version of mikro C IDE from Microchip Company.

CHAPTER FOUR

RESULT AND DISCUSSIONS

4.0 PERFORMANCE EVALUATION

The objective of this work is to produce a device which not only acts as a suitable sound volume unit indicator but also capable of monitoring the intensity of sound and duration of exposure to determine if it's within the safe or unsafe level.

The constructed device was thus tested and performance evaluation carried out by measuring the following parameters

1. Response and ability to detect and indicate sound volume via the arranged LEDs in linear form
2. Ability to sample sound level and duration of exposure and give the necessary sound level alert status

Performance as a Sound Volume Unit Meter

The device was switched on and exposed to sound emanating from different sources. The device was observed to respond efficiently to varying sound level as indicated on the LEDs.

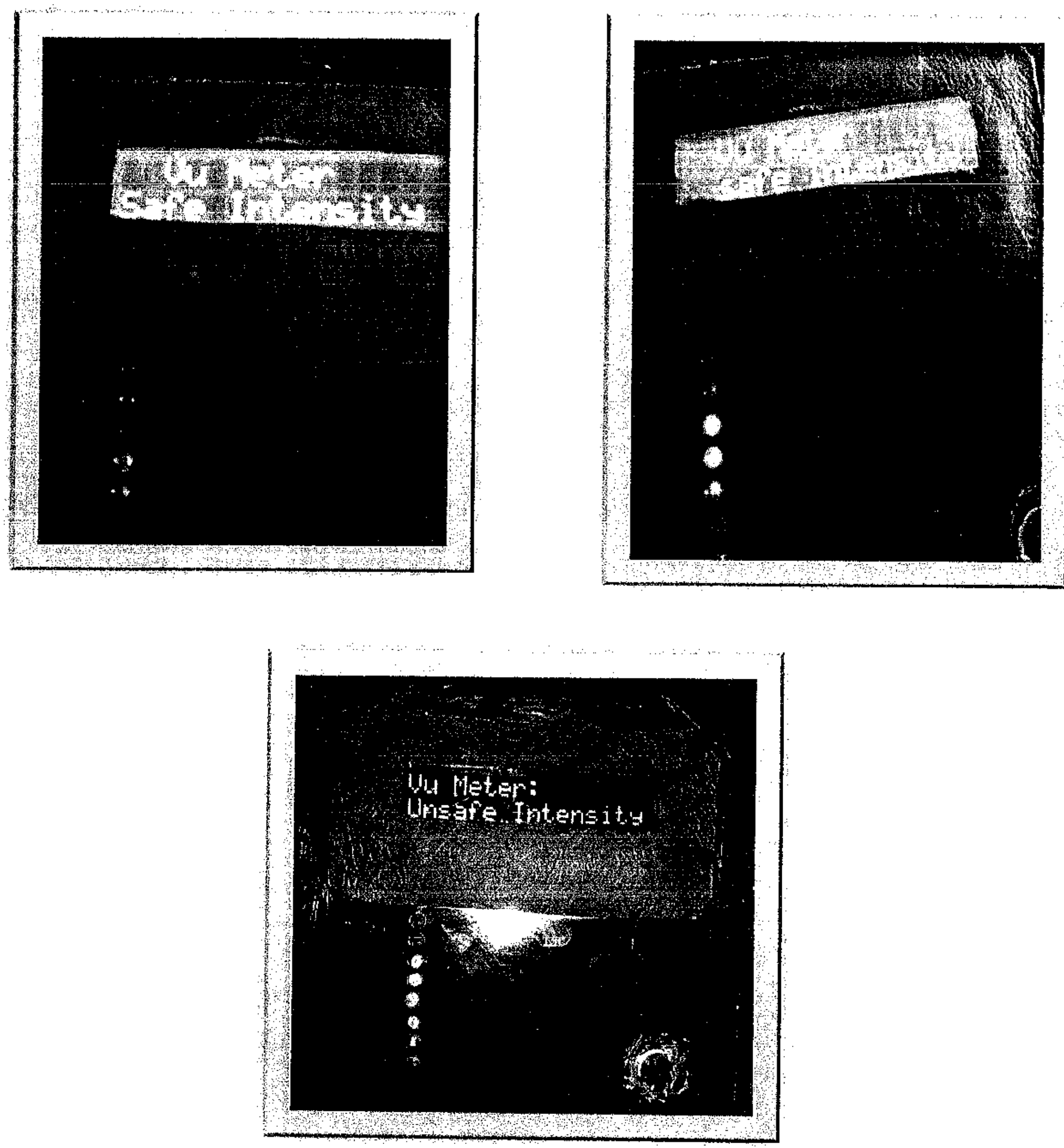


Fig 4.0 VU meter response to different levels of audio signals

Performance evaluation of audio health monitoring

To test the performance of the device, the device was switched on and exposed to just normal conversation (around 6 dB) for a period of time. Throughout the duration of the test conversational audio level, a safe intensity alert was displayed on the LCD screen

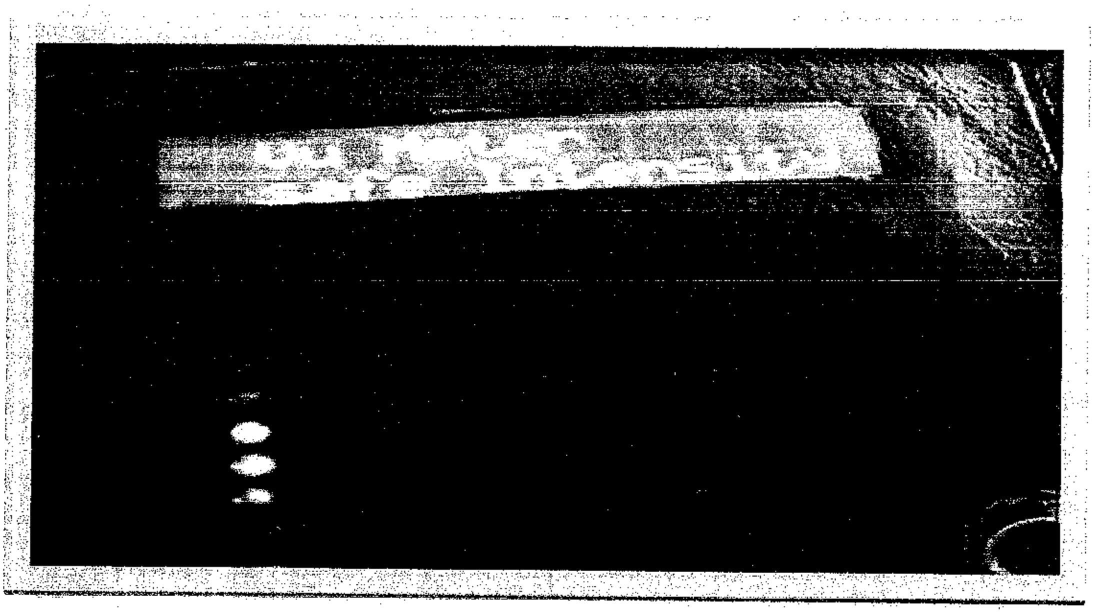


Fig 4.0 VU meter response to different levels of audio signals (Normal signal level)

However as the sound levels gradually begin to rise above 30 dB as obtainable in heated conversations and moderately lound music and audio sources, the alert was observed to fluctuate intermittently between a "Safe intensity and unsafe intensity".

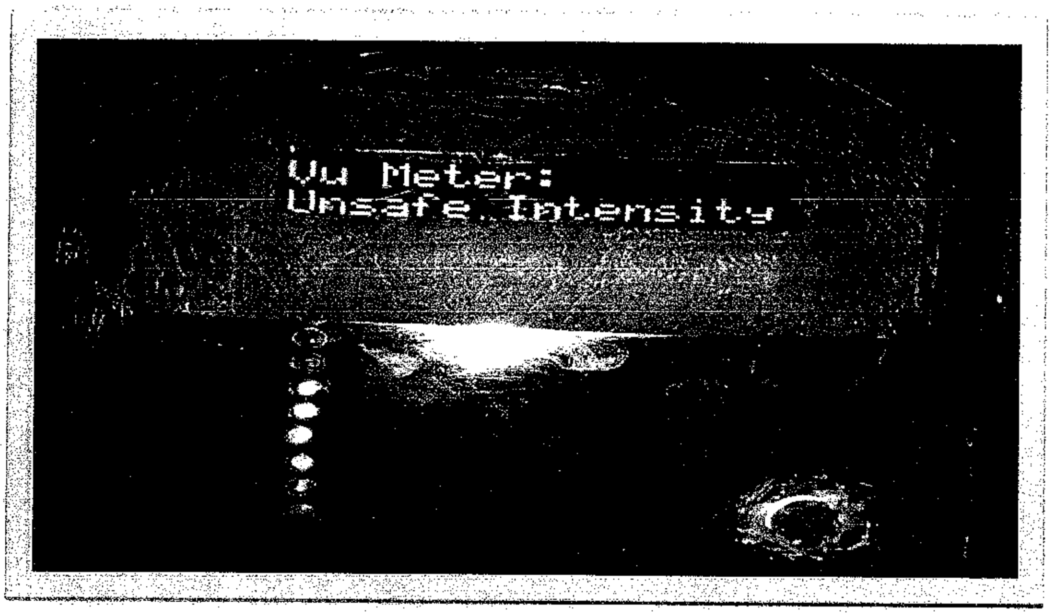


Fig 4.0 Unsafe level Alert for sound levels greater than 30dB

A further increase in the sound level for even a short duration of time as obtainable in very loud music was observed to produce an unsafe intensity alert on the LCD screen indicating the need to move away from the sound source, eliminate or reduce the sound level where applicable or use hearing protection devices or sound mufflers.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

VU meters are important devices used for representation of the signal level in audio equipment and are applicable in sound editing studio, recording houses and broadcasting studio. The device thus constructed features the adaptation of a vu meter to not only display signal levels via the attached light emitting diodes (LED) but also monitor the amount and duration of exposure to the measured sound level. This level which is then compared with a preprogrammed level and duration reference is then used to generate a suitable visual "SAFE LEVEL" or "UNSAFE LEVEL" alert on the liquid crystal Display (LCD) screen.

The device which basically contains the LM3915 volume unit chip, the pic16f887 microcontroller, LEDs and LCD, was tested and its performance as a vu meter and as an ambient sound level monitoring device was tested and found to confirm to design objectives.

Aside being a functional tool for recording houses and broadcast studios, the device is thus applicable for factory floors, machine shops and other relatively noise prone environment to alert the workers in real time of the current sound levels so as to ensure that necessary actions are taken to prevent exposure to dangerous sound levels and prevent hearing loss.

5.1 RECOMMENDATION

In order to ensure a more efficient device and avoid the need to scale down to the audio ranges of the vu chip (30db), multiple LM3915 can be cascaded to accommodate any desired audio signal level or ranges. Also, a rechargeable battery unit could also be integrated into the system to facilitate low usage cost

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APPENDIX 1

VU METER CODE:

```
sbit LCD_RS at RD1_bit;

sbit LCD_EN at RD2_bit;

sbit LCD_D4 at RD4_bit;

sbit LCD_D5 at RD5_bit;

sbit LCD_D6 at RD6_bit;

sbit LCD_D7 at RD7_bit;


sbit LCD_RS_Direction at TRISD1_bit;

sbit LCD_EN_Direction at TRISD2_bit;

sbit LCD_D4_Direction at TRISD4_bit;

sbit LCD_D5_Direction at TRISD5_bit;

sbit LCD_D6_Direction at TRISD6_bit;

sbit LCD_D7_Direction at TRISD7_bit;

//-----------------------------------------

//-----------------------------------------

 char *msg1 ="FUOYE 2018";

 char *msg2 ="Vu Meter";
```

```
int zeroValue=0;


  int sensorPin = 2;      //pin number to use the ADC

   int sensorValue = 0;   //initialization of sensor variable, equivalent to EMA
Y

   float EMA_a = 0.9;      //initialization of EMA alpha

   int EMA_S = 0;

    int vv;

 char *sf="Safe Intensity  " ;

 char *unsf="Unsafe Intensity"  ;

//--------------------------------------

 int threshold=50;

//--------------------------------------

void intro(){

    Lcd_Init();              // Initialize LCD

    Lcd_Cmd(_LCD_CLEAR);      // Clear LCD

    Lcd_Cmd(_LCD_CURSOR_OFF); // Turn cursor off

    Lcd_out(1,4,msg1);

    lcd_Out(2,2,msg2);
```

```
    delay_ms(1000);

    Lcd_Cmd(_LCD_CLEAR);

    lcd_Out(1,3,msg2);

}

//---------------------------------------------

 void InitADC(void)

 {

        // Initalise Ports FOR ADC //

        PORTA = 0x00;

        TRISA = 0xFF; //Port A is all inputs.

        // Set Up ADC Parameters //

        ANSEL = 0b00001111; //All AN0-AN8 are analogue is now analog input

        ANSELH = 0x00; //Set


        // the analog high bits to 0

        //ADCON1 = 0x80; // Sets ADRESL to contain the first 7 bits of
conversion, ADRESH will have the final 3 bits.


}   // void InitADC(void)
```

```
//***********************************************************************
************

void main()
{
   TRISA.F2=1;
   ANSELH=0;
   C1ON_bit = 0;                      // Disable comparators
   C2ON_bit =0;
//================================
   intro();
   InitADC();
    for (vv=0; vv<10; vv++)
   {
   ZeroValue  +=   ADC_Read(2);


   }
  zeroValue /=    vv;
  delay_ms(50);
```

```
// inttostr(zeroValue,zero);
// lcd_Out(1,3,zero);
while(1)
{

  sensorValue =   ADC_Read(2);
  EMA_S = (EMA_a*sensorValue) + ((1-EMA_a)*EMA_S);
  delay_ms(10);

   EMA_S= EMA_S- zeroValue ;

  if ( EMA_S <threshold)
  {
   delay_ms(50);
    if(   EMA_S <threshold)
        {
```

```
 Lcd_out(2,1,sf);
// Lcd_out(1,9,adcval);


}
}
else if ( EMA_S >threshold)
 {
  delay_ms(50);
   if(  EMA_S >threshold)
        {
 Lcd_out(2,1,unsf);
 // Lcd_out(1,9,adcval);
}
}
```