DESIGN AND CONSTRUCTION OF A LEAK DETECTOR

CASE STUDY:

PIPELINE PRODUCT AND MARKETING COMPANY (PPMC), ILORIN

BY

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

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CERTIFICATION

This is to certify that this project was fully carried out by Olumoh Oladimeji, registration number 2001/12085EE of Department of Electrical and Computer Engineering, Federal University of Technology, Minna, under the supervision of Mr Salihu Bala.

04/12/07

Mr Salihu Bala. Date

(Project supervisor)

(Head of department) Date
Eng M. D Abdullahi

(External Examiner) Date

DEDICATION

This work is whole-heartedly dedicated to Almighty Allah, the most beneficent the most merciful who granted me the grace to come this far.

DECLARATION

I, Olumoh Oladimeji (2001/12085EE) hereby declare that this project presented for the award of degree (B.ENG) in the Department of Electrical/Computer Engineering, Federal University of Technology Minna, was fully carried out by me and has not been presented else where.

All information utilized and their sources have been duly acknowledged.

04/12/2007

Olumoh Oladimeji
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Date

ACKNOWLEDGEMENT

In the name of Allah, the most beneficient, the most merciful. It is with the deepest sense of gratitude to almighty Allah for giving me the strenght, courage , and wisdom that take me this far in my academic pursuit. Also , praise and glory to prophet Mohammed (SAW) for bringing light after the era of darkness , may Allah increase him in mercy and blessings (amen).

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ABSTRACT

This project is aimed at designing and construction of a leak detector using ultrasonic principle. The main objective of the project is to maintain the integrity of petroleum products pipeline, in order to ensure safe, efficient and effective transportation of gas and liquid petroleum product to its destination, by providing an affordable method of leak detection. Although the project also finds application in some other areas, but for the purpose of this research, its scope is limited to leak detection in petroleum products pipeline. To achieve the aforementioned aims and objective, the design uses an ultrasonic transducer, a gain amplifier, a tone decoder, a mixer and audio amplifier, a head phone and a 5-DOT LED driver circuit. The ultrasonic transducer is used to transform the ultrasound produced by the leak into electric signal, the gain amplifier amplifies this signal, the tone decoder is used to generate another high frequency signal which is mixed with the signal from the gain amplifier to give a signal with a low frequency considered audible to the human hearing. The audio amplifier further amplifies the mixed signal which drives the output devices (headphone and 5-DOT LED driver circuit) to give both audio and visual output respectively. At the end of this project, the leak detector was able to detect leak as intended, but its sensitivity still needs to be improved, to enable it detect minute fault effectively.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

For any system to work efficiently and effectively, the integrity of its operating parts need to be maintained, especially those that work on high pressure operating condition, such as: steam boilers in power generating station, heat exchanger, blast furnace, petroleum product pipelines, gas cylinder in refrigerator etc.

For the purpose of this project, however, integrity of petroleum product pipelines is of paramount interest, using pipelines and products marketing company, Ilorin Depot as a case study. Liquid or gas pipelines are flow lines operated at high pressure, used in transmitting natural gas and other liquids (petroleum products) to their destination. Most liquid petroleum products are highly inflammable, hence, it requires proper handling during transmission, to avoid any form of leak that might cause environmental pollution or even trigger fire out break, which might lead to loss of lives and properties [1].

Leak is a small hole or crack that lets liquid or gas flow in or out of something by accident [2]. However, leak detection continues to present a challenge, especially small leaks. Ecological and drinking water resources can be impacted by small hazardous liquid pipeline leaks that are not quickly detected. Among the possibilities for improving leak detection are monitoring systems that can detect small releases, sensors for small leak detection, technology for aerial surveillance for act borne chemicals, improvements in the cost and effectiveness of current leak detection systems and satellite imaging. New sensors, fibre optics, air borne leak detection, and remote leak sensing are all possibilities [1].

In this regard, several methods had been designed to facilitate leak detection in pipelines, in order to reduce the risk of environmental hazard caused by such leak. Such methods include acoustic emission inspection system, instrumented pig and ultrasonic methods [3]. The ultrasonic device seems less complicated, portable, less costly, and result oriented. Hence, emphasis will be laid on the design of this device to actualise our aims.

Ultrasonic leak detection equipment includes a portable handheld probe that is placed in contact with bare pipe surface at prescribed intervals. It consists of an input transducer, a gain amplifier, heterodyne receiver that produces the audible output (audio), and 5-dot LED driver circuit which gives the visual output.

1.2 CASE STUDY

Pipelines and products marketing Company, Ilorin Depot (PPMC).

1.2.1 AN OVERVIEW OF PPMC AND ITS OPERATION

The pipelines and products Marketing Company is essentially an engineering infrastructure Company designed to make available to Nigeria, domestic and commercial energy in the form of liquid petroleum fuels. It was formally called pipelines and product marketing section (PPMS), until 1988 when it was renamed petroleum product marketing company [PPMC].

It has many branches all over the country including the Ilorin depot, situated along Jebba road, okeose, Ilorin, Kwara state. It has the following system Data characteristics: pipeline segment (Ibadan-ilorin), Length (170) km, diameter (6") inch, linefill capacity (3,300)m^3, and flow rate (60)m^3/Hr [3].

The key elements of the business mission is to supply adequate stocks of petroleum products to the domestic markets, efficient transportation of crude oil to the refineries, efficient and effective evacuation of refined petroleum products from the refineries, competitive marketing of special products in the domestic and international markets, and safe operations at minimal costs [3].

However, to achieve the aforementioned aims, the integrity of the products pipelines system is a key element. Hence, the need to design proper techniques to efficiently transport these products to their destination, with the loss along the path reduced to the barest minimum, becomes very essential.

1.3 AIMS AND OBJECTIVES

- To design and construct a simple device that can detect leak in gas and liquid pipelines.
- To design and construct an ultrasonic sound detector with a visual indicator.
- To ensure safety of pipeline system operation at minimal cost.

1.4 MOTIVATION

The need to ensure safety of pipeline system operation at minimal cost and to reduce the threat to the ecosystem, as a result of leak of petroleum products along the pipelines conveying it, arose my interest to improve on the existing methods; to facilitate the leak detection.

1.5 METHODOLOGY

A stage by stage approach was used. Starting from the input transducer (ultrasonic transducer) that transforms the ultrasound to electrical signal, to the gain amplifier that amplified the electrical signal, a tone decoder that generates another high frequency signal was also introduced. A JFET (Mixer) was then introduced to beat the two signals together (heterodyning). An audio amplifier was finally used to amplify the mixed signal that drives the headphone and activate the 5 dot LED Driver circuit for both audio and visual output.

1.6 SCOPE

The scope of the work is limited to leak detection in petroleum products pipeline

1.7 OTHER APPLICATIONS OF ULTRASONICS

i. Ultrasonic Signalling: Because of their small wavelength, ultrasonic can propagate in the form of a beam. Hence, signalling and locating the presence of objects can be carried out with beams of ultrasonic. This application is employed in locating the depth of ocean.

ii. Ultrasonic flow detector: In metals especially, there may arise the presence of a foreign material or crack/crevice inside the body of metal which is mot visible in the naked eye. Ultrasonic can be used to detect their irregularities.

iii. Heating by ultrasonic: It was observed that when ultrasonic energy is concentrated in various materials, considerable amount of heat is produced. With the increase of frequency of ultrasonic waves, the heat generated increases in absorption.

iv. Biological effects: In medicine, the effect of high frequency of ultrasonic is employed to destroy harmful germs or bacteria.

v. Medical use: in Modern surgery, ultrasonic has a dominant role to play; ultrasonic has been used for the treatment of arthritis and other similar diseases. It is also used for measuring the rate of flow of blood, location of tumour and gallstone has also been done with ultrasonic [4].

CHAPTER TWO

LITERATURE REVIEW

2.1 THEORETICAL BACKGROUND

In general, the human ear is capable of receiving sound waves having the frequency lying between 15 and 1500c/s. Below and above this range, mechanical vibration fails to produce any sensation in the human ear. Though, there are no standard limits; the vibration lying above 15000C/S is known as ultrasonic. There are number of ways by which ultrasonic waves can be generated. The method to be employed depends on the power output necessary and the frequency range to be covered. Generators of mechanical type such as tuning forks or Galton's whistle can be used up to 10.000 C/S.

Other methods of ultrasonic generation include: piezoelectric method and magnetostriction method. Piezoelectric effect was first discovered by curie brothers in 1880 who found that certain crystal like quartz, fourmaline and rocheile salt will develop an electric charge when a mechanical pressure or tension is applied to the fade of the crystal. Their experiment showed that there is a relation between the mechanical pressure applied, and the nature of charge developed, and the sign of the charge changed, when the pressure was changed to tension [4].

However, not until recently was it discovered that most operating equipment and most leak problems produce a broad range of sound. The high frequency component (ultrasonic) of this sound is of extremely short wave length in nature; short wave length signal are fairly directional. Therefore, the isolation of these signals from the background noises and detect their exact location, forms the basis of its use for leak detection. Detecting and measuring ultrasonic waves are accomplished mainly through the use of a piezoelectric receiver or by optical means because ultrasonic waves can be rendered visible by diffraction of light. [5] There are several methods by which ultrasonic waves could be detected, these includes: Scoke method, Radio-meter method, Electrical detector, and Quartz Crystal receiver (piezoelectric).

Scoke method involves the techniques of introducing small particles in the field to photograph the waves with long-time of exposure and then measure the amplitude of the motion of the particles, which appear as streaks in the negative. In radiometer method, the ultrasonic waves are incident on a finite obstacles, such as a solid disc, they exert a pressure on the obstacle and tend to displace it. The electrical method was based on the discovery that when nickel wire is exposed to the ultrasonic beam, it suffers an oscillatory charge of temperature, and hence of resistance which is a representative of a fraction of the ultrasonic amplitude. The oscillation charge causes a change of current flow through the circuit which can be amplified and detected.

The Quartz crystal receiver method employs the principle of the fact that when ultrasonic waves are incident on a quartz or Rochelle salt crystal, alternating electromotive force of the same frequency as ultrasonic wave is generated. This voltage is very small in magnitude and a RF amplifier can be used to amplify it, which may be detected by a super heterodyne receiver. [4]

2.2 HISTORICAL BACKGROUND

Centuries ago, pipelines first carried water to villages and dwellings [1]. The history of oil and gas pipelines as they are used today began after what is considered the first commercial oil well was drilled in Pennsylvania in 1859. [1,2] The first cross

– country oil pipeline was laid in Pennsylvania in 1979, a 109- mi long 6 – in diameter line from Bradford to Allen town. In 1886, an 87-mi, 8-in diameter natural gas line for Kane, Pennsylvania, to Buffalo, New York, was built.

In the early 1900's, pipeline construction began to expand. In 1906, a 472-mi, 8-in pipeline form a new field in Indian Territory (Oklahoma) to Port Arthur, Texas, challenged the technology of time [1]. Early pipelines were built using threaded pipe that workers screwed together with large tongs. It wasn't until about 1920 that welding the separate lengths of pipe together became an accepted construction practise.

Liquid and gas pipelines have a very good record as far as leak is concerned. Yet, interest in further improving leak detection methods and equipment is high. Traditionally, pipelines were inspected visually by traversing the route on the ground or patrolling the pipeline route in light aircraft (Aerial inspection). The drawbacks in this method, is that it is inefficient, limited to visible leaks and largely based on trial and error.

Today's methods make it possible to detect very small leaks; the smaller the leak; the harder it is to find. The minimum size leak chat can be detected depends on number of factors: the type of fluid in the pipe, accuracy of the metering system and accuracy of the temperature and pressure transmitters, line size, wall thickness, length of line, steady-state or transient condition of the pipeline, analytic equipment and experience of the personnel involved. [1]

The design of a compute system has really helped in this regard, by designing computer models of the pipeline operation. The approach is simply by direct observation of pressure drop and volume loss with very good modelling. This method gives a range of short interval where this fault can be traced

Acoustic emission system is another development on leak detection techniques; it makes use of noise generated by gas or liquid from a leak in pressurized pipeline to detect and locate leaks [1, 2]. This system can provide continuous leak detection by permanently installing detectors and data transmission system. Acoustic emission is transmitted by the pipeline and is picked up by the sensors mounted at intervals on the signals to those typical of normal background noise. However, this method is largely dependent on the sensitivity of the sensor and the effectiveness of the transmission system. This method also gives the range of short interval where the leak can be traced.

Another developed technique is the instrument pigs [1]. In this method, a leak detecting pig can be moved to various positions in the pipeline by the fluid. When stopped at a test point, pressure is equalized in the test segment; that is leaking. An electronic system transmits data through the pipe wall and soil to the surface receives where it is analysed by micro-computer. This method requires the use of sophisticated equipment to realise its objectives.

Ultrasonic leak detection method: This includes the use of less sophisticated and portable handheld probe that is placed in contact with the bare pipe surface at prescribed interval. A leak pipe generates a sound wave of different spectral components, the highest of which are the ultrasonic, with frequency ranging from 20khz and above. The ultrasonic detector detects these high component frequencies, transform it to electric signal, and then so an audio output a through a super heterodyne receiver that displayed it on the screen of an oscilloscope. [1] This method is how ever limited to short length pipeline as compared to others that can be used to examine a long length pipelines, although, it gives a precise point of defect as against other methods. Therefore, this device can be used alongside with other ones to give a precise result.

CHAPTER THREE

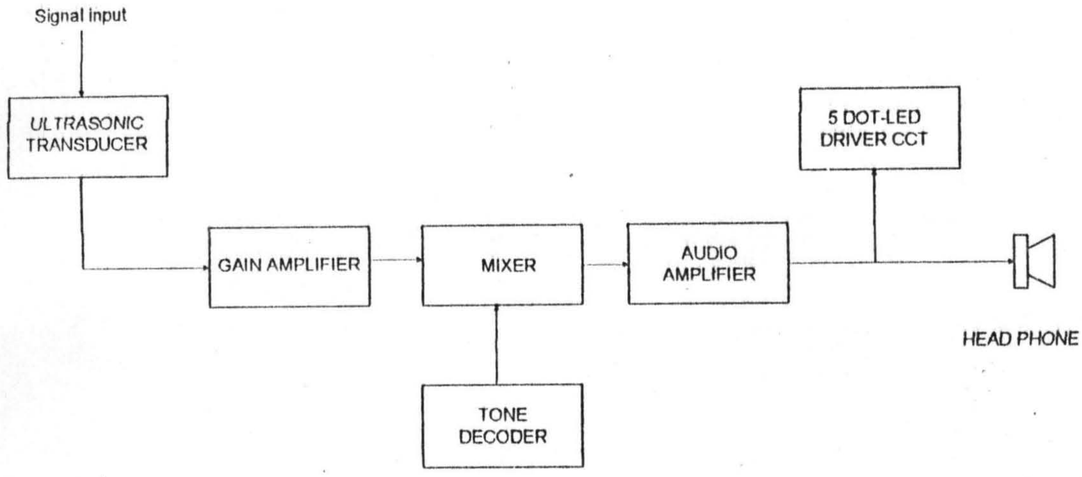
SYSTEM DESIGN AND ANALYSIS

3.1 INTRODUCTION

In the design of the ultrasonic detector, a stage-by-stage design approach was used. The design was broken into modules, with the subsequent modules dependent on the proceeding module. Starting from the input stage to the output stage, an input transducer was used to convert the ultrasound to an electrical signal, the signal is amplified using a gain amplifier, a tone decoder was used to generate another high frequency signal from the ultrasound, the two signals was then mixed, using heterodyne mixer. An audio amplifier was later introduced to amplify the mixed signal, phone and IC (AN6884) for both audio and visual output.

3.2 STAGES OF THE DESIGN

i. The input transducer (piezoelectric)
ii. The gain amplifying stage.
iii. The tone decoding stage
iv. The heterodyne mixer stage
v. Audio amplifying stage
vi. Output stage



Figs 3.0 BLOCK DIAGRAM OF ULTRASONIC SOUND DETECTOR

3.2.1 THE ULTRASONIC TRANSDUCER STAGE

The ultrasonic transducer is a device that transforms ultrasound at about 20 kHz to electrical signals. It consists of 2 piezoelectric crystals, e.g. quartz or Rochelle salt; when an ultrasound is incident on such material, an electric voltage is developed across the other two faces. Its ability to respond actively to frequency at 20 kHz and above makes it suitable for this application.

The circuit uses a piezo tweeter as an ultrasonic microphone.

ADVANTAGES OF PIEZO TWEEETER OVER OTHR SENSORS

i. Ultrasonic sensors are not affected by dust, dirt or high moisture environments.

ii. Resistant to external disturbances such as vibration, infrared radiation, ambient noise etc.

iii. Solid state units have virtually unlimited, maintenance free life span.

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OPERATING MANUAL

- Press the power button to turn the probe ON or OFF
- Press the power button ON, to put the probe in use
- The probe is traversed along the suspected leak pipeline, with the INPUT of the probe facing the bare pipe surface
- At least one of the five LEDs comes up, if there is leak
- Warning!
- Do not open the case when in use

The power button should be turned OFF when not in use

CONSIDERATION IN THE CHOICE OF APPROPRIATE TRANSDUCER

(i) Sensitivity: to enable detection of weak signals and provide sufficient output for the next stage

(ii) Frequency response of the transducer

(iii) Operating range: for good resolution and maintain chosen range requirement

(iv) Environment capability: the temperature range, corrosion resistance and size of the transducer is good

(v) Durability: since the transducer is environmental friendly.

3.2.2 THE GAIN AMPLIFIER

Amplifiers work by using a small input signal to control the release of energy from suitable source. [6]

The received signal from the transducer produces an electrical signal of low voltage magnitude. Hence there is need to introduce a gain amplifier to amplify the signal t a higher level.For the purpose of this design, two transistors was connected in cascade (cascade amplification), using the common emitter configuration. The output of the first stage feeds the second stage.

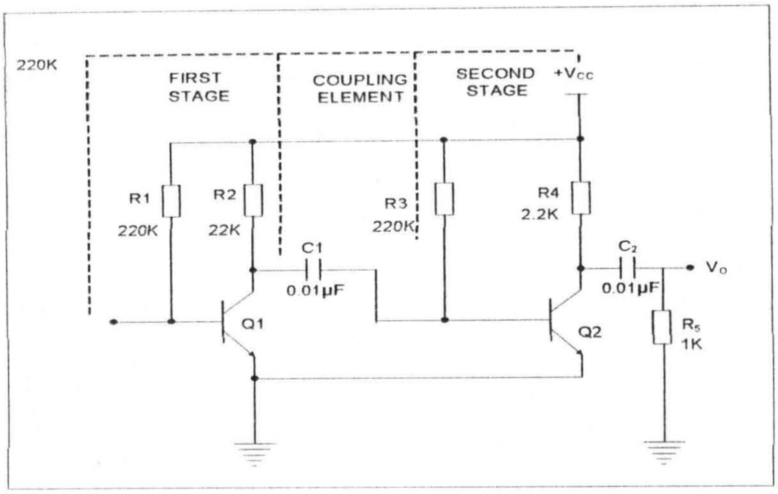


Fig3.1Gain amplifying circuit

CIRCUIT OPERATION

The brief circuit operation is as under:

i. The input signal is amplified by Q_1. it phase reversed (usual with CE configuration).

ii. The amplified output of Q_1 appears across R_2.

iii. The output of the first stage across R_2 is coupled to the input at R_3 by coupling capacitor C_1.

iv. The signal at the base of Q_2 appears across R_4 is coupled by C_2 to the next stage.

v. The output signal V_0 is the twice-amplified replica of the input signal. It is in phase with input voltage, because it has been reversed twice.

CONSIDERATION FOR THE CHOICE OF THE GAIN AMPLIFIER

i. It has a high current gain (β) (50-300).

ii. It has a moderately low input resistance.

iii. It has a very high overall voltage gain.

iv. It produces a very high power gain of the order 100,000 times.

v. Its output resistance is moderately high (50k or so) [7].

CALCULATION

If $\beta_1 = \beta_2 = 100$

Where R_1=220k

R_2=2.2K

R_3=220K

R_4=2.2K

$re_1 = re_2 = 25mV/I_{E2}$ ---------- (i)

Input resistance $ri = R_1 // \beta_1 . re_1$ ---------- (ii)

For finding re_1, we need $I_{E.1}$

$I_{E.1} \approx I_{c.1}$

$I_{c.1} = \beta . I_{B.1}$ ---------- (iii)

$I_{B.1} = V_{CC} / R_1$; V_{CC}=9V

$I_{B.1}$=9/220K=9/220000=$4.1*10^{-5}$A

I_{C1}=100*41=4100=4.1mA

$I_{E.1}$=4.1mA

$r_{e.1}$=25Mv/ I_E

$r_{e.1}$=25/4.1=6.09≈6.1Ω

$\beta_1 r_{e.1}=100*6.1=610\ \Omega$-- (from eqn iii)

$r_i = R_1 // \beta_1 . Re.1$-- (from eqn ii)

$r_i=220k//610=(220k*610)/(220k+610)=608.3\approx 608\Omega$

(ii) $A_{v1}=r_{o.1}/ r_{e.1}$

$r_{o.1}= R_2//r_{i.2}$

$r_{i.2}=R_3// \beta_2 r_{e.2}$: $R_4=2.2K$

$r_{o.1}= (2200*610)/ (2200+610) =477.5\approx 478\Omega$

$r_{e.1}=6.1\Omega$

$A_{V.1}= r_{o.1}/ r_{e.1}=478/6.1=78.29\approx 78.3\Omega$

(iii) $A_{v2}= r_{o.2}/r_{e.2}$

$r_{o.2}= R_4//R_5$

$r_{o.2}=2.2//1.0$

$r_{o.2}= (2.2*1)/ (2.2+1) =0.6875K\approx 0.69K$

$r_{e.2}=25mV/ I_{E\cdot 2}=25/4.1=113.3$

(iv) $A_V= A_{V.1}*) A_{v2}=78.3*113.3=8871.4\approx 8871$

(v) $G_v=20\log_{10} A_V$ dB

$=20 \log_{10} 8871\approx 78.9$ dB

NOTE:

$r_{i.1}$:-the input impedance of the first stage

$r_{o.1}$:-the output impedance of the second stage

$r_{i.2}$:-the input impedance of the second stage

$r_{o.2}$:-the output impedance of the second stage

$r_{e.1}$:-the junction resistance of Q_1

$r_{e.2}$:-the junction resistance of Q_2

$I_{E.1}$:-the emitter current of the first stage

$I_{E.2}$:-the emitter current of the second stage

A_{v1} :-the amplification of stage 1

A_{v2} :-the amplification of stage 2

A_v :-the over all amplification

3.2.3 THE TONE DECODING STAGE

The tone decoder is an AF/RF amplifier. It essentially used here to generate another sound wave of very high frequency from the ultrasound LM567 (IC) is used for this purpose.

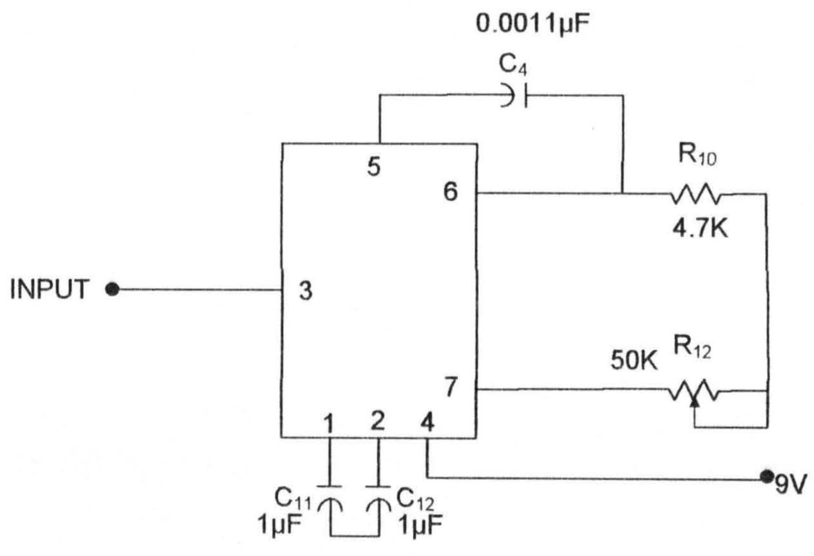


Fig 3.2 CONNECTION OF THE TONE DECODER

The frequency of the output signal from decoder;

$F_O=1/(1.1*C_4*(R_{10}+R_{12}))$

$=1/(1.1*0.0011*10^{-6}*(4.7+50)*10^3)$

$=15555HZ\approx15.5KHZ$

3.2.4 HETERODYNE MIXER STAGE

Heterodyne is the beating together of signal of different frequency to achieve another desired signal of different frequency. The difference in frequency obtained is term the intermediate frequency [4]. Heterodyne is desired in this design, in order to bring the externally high frequency of the ultrasonic to a range considered audible to human.

A JFET was used in design of this circuit, with the gate serving as input for the two signals, connected in the common drain mode. It does the heterodyne by finding the difference between the two signals, one from the gain amplifier and the other from the local oscillator (tone decoder).

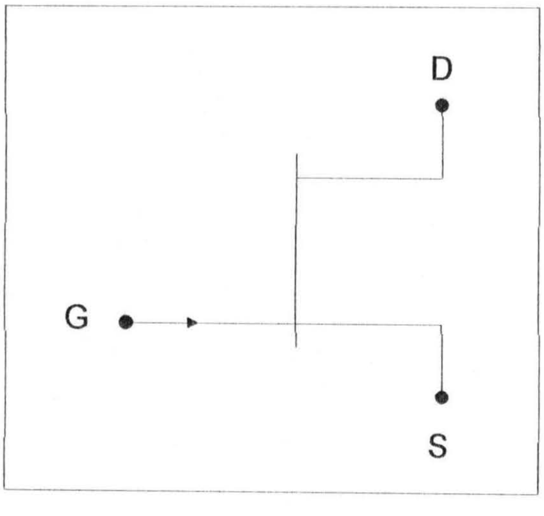


Fig 3.3 Circuit symbol of FET

The advantage of this is that the IF amplifier cascade which has a fixed input frequency regardless of that of the received signal can be designed more easily for improved selectivity. The JFET has the following notations:

Source : - the terminal through which the majority of the carriers enter.

Drain : - the terminal through which majority carriers leave the bar.

Gate : -These are two internally-connected heavily-doped impurity regions which form two P-N junctions.

THEORY OF OPERATION

(i) Gates are always reversed-biased. Hence, gate current I_G is practically Zero.

(ii) The source terminal was connected to the end of the drain supply which provides the necessary charged carriers. The source terminal"s" was connected to the negative end of the drain voltage supply (for obtaining electrons).

(iii) For the configuration used (common drain), the load resistance was connected in series with the source terminal. The input signal was applied to the gate and the output taken from the source.

(iv) The frequency of the output signal is the difference between the frequencies of the two input signals F_A- F_0 [7]

F_A = Frequency of the amplified signal =20 kHz

F_0 = Frequency of the local oscillation signal =15.5 KHz

F = Frequency of the mixer output signal

$F = (20-15.5)\ KHz = 4.5\ KHz$

NOTE:

F_A is not a single frequency, but signal with a wide range of frequency component. The 20 KHz chosen was just within the range.

ADVANTAGES OF JFET

i. High input impedance
ii. Small size
iii. Ruggedness
iv. High frequency response
v. Low noise
vi. Durable
vii. High immunity to radiation

OTHER APPLICATIONS OF JFET

i. For mixer operation of FM and TV receivers.
ii. Large-scale integration and computer memories because of its very small size.
iii. It could be also used as an amplifier.

3.2.5 AUDIO AMPLIFYING STAGE

The function of the audio amplifier in this project is to amplify the level of the voltage from its low magnitude to a higher level that can effectively drive the headphone. However, it is necessary to match the amplifiers output impedance and the impedance of the headphone.

In the design of circuit, the audio amplifier used is an operational amplifier (LM386) IC. Fig below shows the pin connection of the operational amplifier. The output is a high level signal compared to its input.

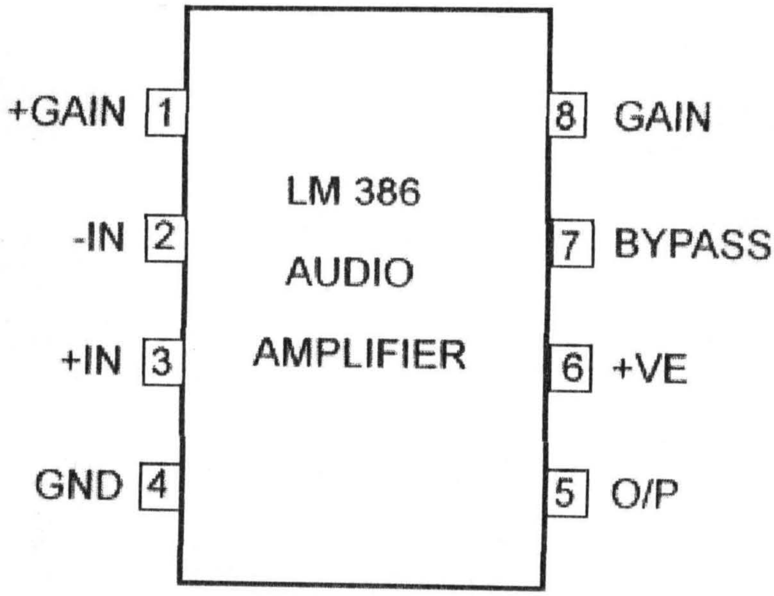


Fig 3.4 Pin out Connection of (LM386) IC

The parameters of the audio power amplify are:

- Input resistance 50Ω

- Operating supply voltage 9v
- Voltage gain 26db
- Input bias current 250nA
- Input voltage ±0.4
- Output power 0.73W

The gain is internally set to 20 to keep the external count low. The inputs are ground referenced while the output is automatically biased to one of the supply voltage.

3.2.6 AUDIO OUTPUT STAGE

For this purpose, a headphone was used; these will enable the uses of the leak detector to appreciate the presence of leak along the test specimen. It does this by giving an appreciable loudness that is friendly to human earrings, through the conversion of the electrical signal earlier generated in the circuit, to a sound wave audible to human.

CONSIDERATION IN SELECTION OF THE HEADPHONE

i. It was ensured that the headphone had no box resonance hence produce less noise.

ii. Acoustic advantage over speakers of not existing room resonance, thus giving the listener a more accurate sense of acoustics.

iii. Its portability and privacy

iv. Its sensitivity.

TECHNICAL SPECIFICATION OF THE HEADPHONE

Sensitivity	111db @ 1 KHz, 1V
Input Capability	70mW
Nominal Impedance	32Ω
Frequency Response	20- 20,000Hz

3.2.7 VISUAL OUTPUT STAGE

This is a stage that incorporates a visual alerting device which enhances detection of leak, incase of a noisy environment. The visual indicator is actualised through the use of (AN6884) IC with Few light emitting diodes connected across its output pins. The supply to the output pins increases as the signal strength increases, hence, when the probe is moved near the leak site, the level indicator increases gradually, until the maximum is reached when the five LED come up. The AN6884 is a monolithic integrated circuit driving 5-LED and is capable of logarithmic (db) bar graph display for input signal. Incorporating high gain rectification amplifier and able to apply A.C (UV meter, etc) / DC (signal meter, etc) widely. Fig 3.5 below shows the IC (AN6884) and its connection. [8]

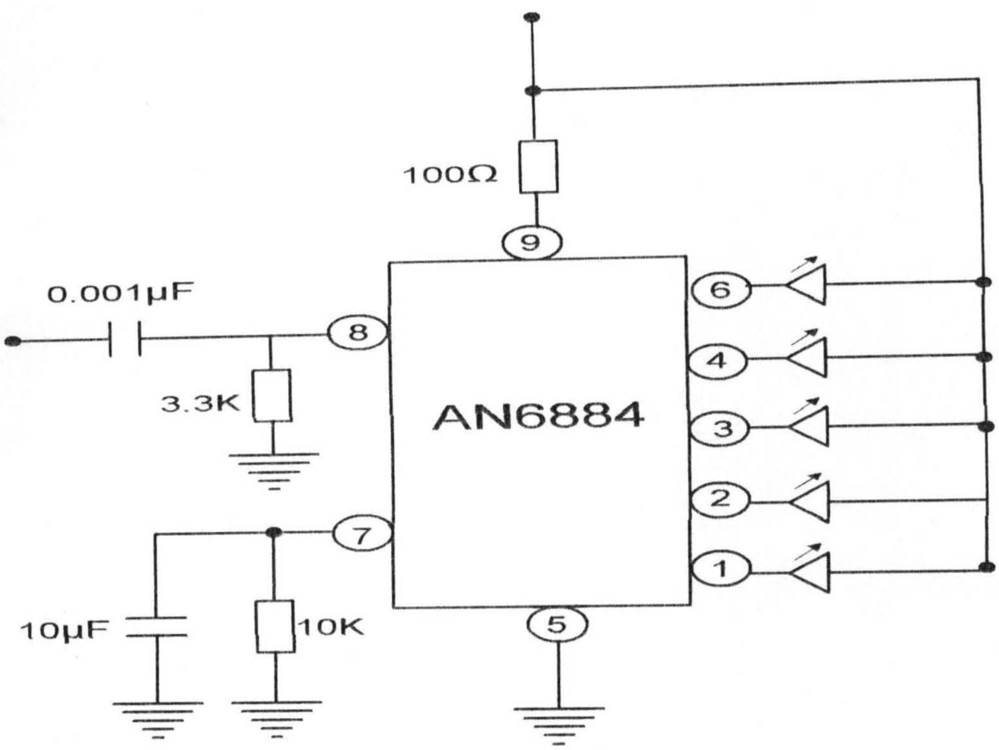


Fig 3.5 Pin out and construction of (AN6884)

Pin number	Pin name
1	LED1 output
2	LED2 output
3	LED3 output
4	LED4 output
5	GND
6	LED5 output
7	Amp output
8	Amp input
9	V_{cc}

Table 3.0 AN6884 Pin-out

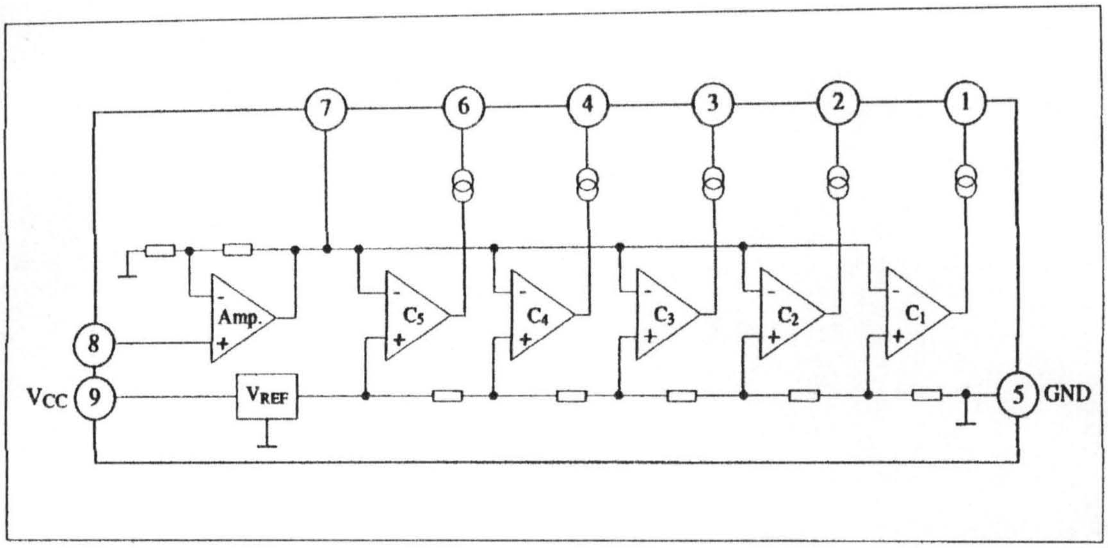


Fig 3.51 Block diagram

Features:

- Wide range of operating voltage
- Vcc (opt)=3.5V-16V
- Constant current output: I_{LED}=15mA
- Built-in-high gain amp: G_V=26dB typ
- Low noise when LED on
- 5-dot LED bar logarithmic response -10,-5,0,3,6 dB
- Fewer external components

3.3 POWER SUPPLY UNIT

The circuit is powered by a 9v dc battery. The dc battery is preferable to ac source, as it makes the device versatile and thus can be used in areas where there is no power supply.

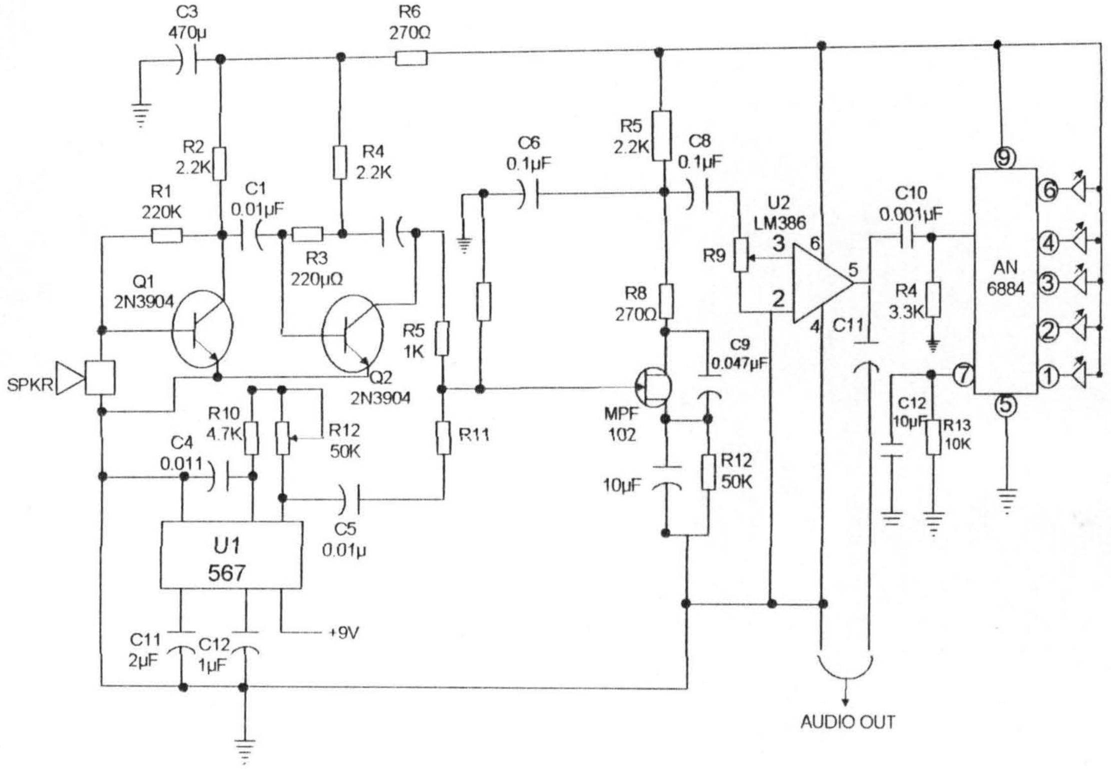


Fig 3.6 Ultrasonic sound receiver

CHAPTER FOUR

TEST, RESULT AND DISCUSSION OF RESULT

4.1 TESTS AND RESULTS

After coupling, the various components of the device (leak detector), the device was put to test in the following ways:

(i) By using a gas cylinder: here, a gas cylinder serves as the leak source, gas was released from the gas cylinder to the probe (leak detector), a cracking sound was heard from the headphone while the five leads of the 5 dot LED driver circuit (signal indicator) fully lights up. However, as the probe was moved further away from the source, the signal level drops, while the sound from the head phone also get faint.

(ii) By using an ultrasonic generator circuit: another test conducted was on ultra sound generator circuit. A similar result was observed as the regulator of the signal output from the ultra sound generator circuit enabled me to ascertain a remarkable difference between the signal strength and output of the leak detector. As the strength of the ultrasound is varied, the output of the detector varies directly with it.

(iii) Pressurised ball: the last test was conducted using an air filled ball. The air in the ball was released with the aid of a valve to the probe; a faint rushing sound was heard on the headphone. The signal level indicator also responded to it, although, the highest level was not attained on the level indicator. Also, it was observed that as the volume of air in the ball reduces, the signal level on the indicator also reduces.

4.2 DISCUSSION OF RESULT

The expected result from the device (leak detector) is to give an audible and visual output in the presence of leak in the test specimen. The cracking sound heard when put to test using a gas cylinder as the leak source, inferred the presence of leak. Although the sound was not as audible as expected. This short-coming may be as a result of low response of some of the circuit components to the signal, such as: the capacitor and the mixer. However, the signal level indicator (5 DOT LED DRIVER circuit) make-up for this short-coming, as it fully light up to indicates the presence of the leak.

As stated earlier, similar result was observed with the use of ultrasonic generator circuit. The variance in the audibility of the sound on he headphone and the intensity of the signal on the signal level indicator as the ultrasound was varied, indicates that the strength of leak determines the output of the leak detector. The stronger the strength of the leak, the more audible the sound on the headphone, and the stronger the intensity of the signal on the level indicator.

The faint-rushing sound observed when pressurised ball was used was also a positive result. The faint-rushing sound however was because the strength of the signal input (leak) was low, which could not readily drive the headphone. However the signal level indicator was actively functional. This is because it has a very high logarithmic response of -10, -5, 0, 3, 6db corresponding to L6, L4, L3, L2, L1 of the output pins of the s DOT LED Driver Circuit.

4.3 RELEVANCE OF RESULT OBTAINED TO THE CASE-STUDY.

The result obtained when the device was put to test as described above, suggested that the device could be employed by the pipeline product marketing company (PPMC) to maintain the integrity of its pipeline through effective leak detection techniques, to ensure safety and minimize losses along the pipeline.

4.4 TROUBLE SHOOTING

In case any problem emerges, and the device start malfunctioning, the fault could be traced as follows;

-i- Signal is fed into the device

-ii- The input to the gain amplifier is traced using a multimeter;with first terminal of the meter at input end of the amplifier and other terminal at output end of the amplifier.

-iii- The output of the gain amplifier is also measured to confirm its functionality using a multimeter.

-iv- The frequency output of the tone decoder is also measured using multimeter.

-v- The output frequency of the mixer is also measured, to see if the signal is properly mixed.

-vi- Finally, the audio amplifier output should be traced to verify the presence of signal using multimeter

-vii- With this, any faulty stage could be easily identified, isolated and then corrected.

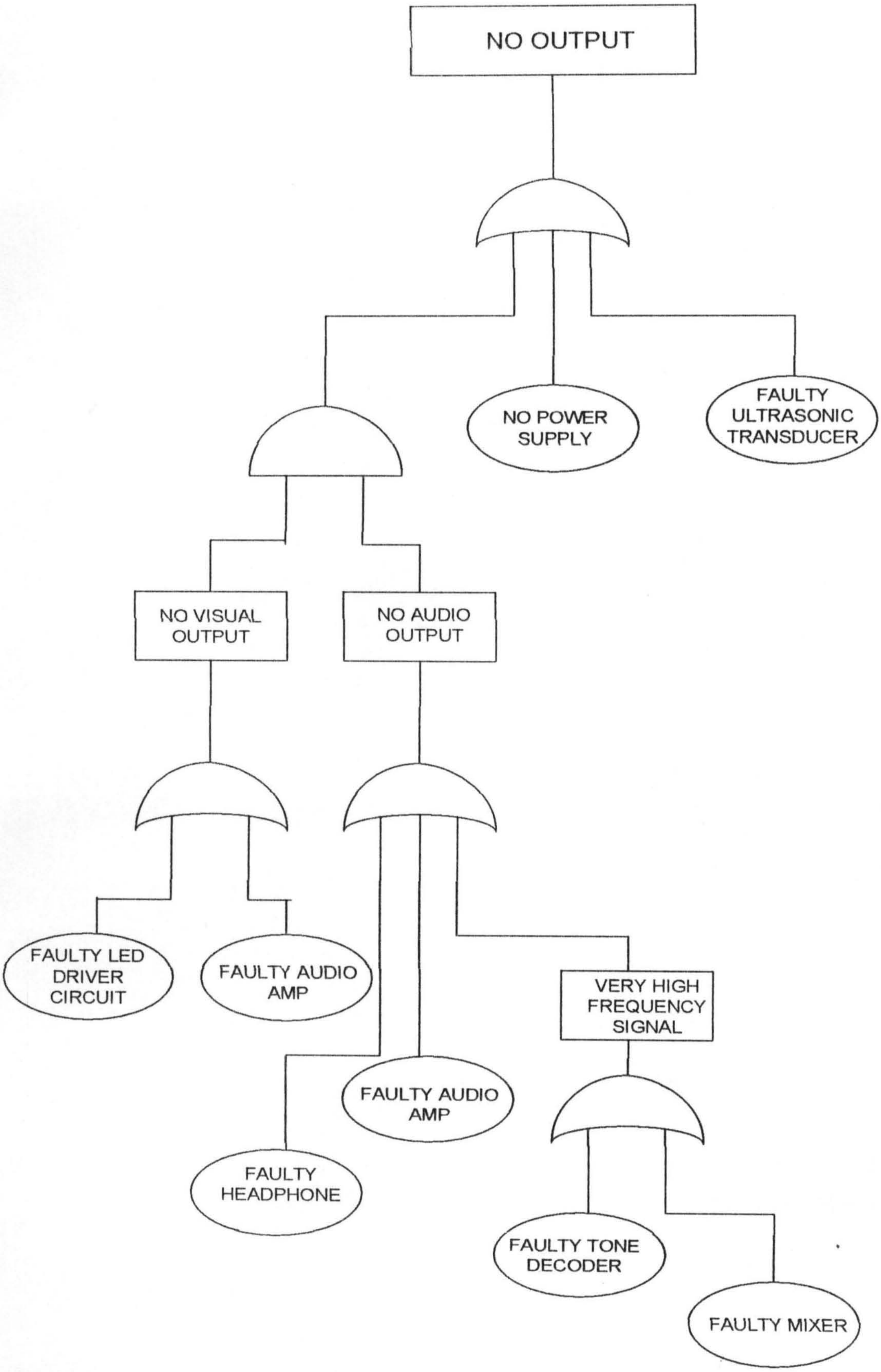
4.4.1 FAULT TREE ANALYSIS OF THE LEAK DETECTOR (FTA).

- FTA is a top-down approach used to identify all possible causes of a particular failure mode of a system
- It starts with an undesirable event called TOP EVENT and then determining all the way it can happen. [9]

4.4.2 DEFINITION OF THE TOP EVENT

The event to be analyzed (TOP EVENT) is the incidence of failure output.

4.4.3 CONSTRUCTION OF THE FAULT TREE


NO OUTPUT
NO POWER SUPPLY
FAULTY ULTRASONIC TRANSDUCER
NO VISUAL OUTPUT
NO AUDIO OUTPUT
FAULTY LED DRIVER CIRCUIT
FAULTY AUDIO AMP
VERY HIGH FREQUENCY SIGNAL
FAULTY AUDIO AMP
FAULTY HEADPHONE
FAULTY TONE DECODER
FAULTY MIXER

4.4.4 ANALYSIS OT THE FAULT TREE

- Top event: No output
- There will be no output if there is no power supply t the circuit or the ultrasonic transducer is faulty or no visual and audio output.
- There will be no visual output if the LED driver circuit is faulty or faulty audio amplifier.
- There will be no audio output if the headphone is faulty or there is very high frequency signal input to the audio amplifier.
- There will be a very high frequency signal if the tone decoder is faulty or the mixer is faulty.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATON

5.1 CONCLUSION

The aim and objectives of this research has been actualized; the leak detector has been successfully designed and constructed, with the intended result obtained. Therefore, the device could be used to detect leaks along pipeline and other similar system.

5.2 PROBLEM ENCOUNTERED

In the cause of this project several problems were encountered; among which are:

(i) The availability of the ultrasonic transducer: the ultrasonic transducer was a bit difficult to get.

(ii) One of the capacitors used was giving a poor response to the signal, hence the output was affected. Detection of this fault required troubleshooting which was time consuming.

(iii) To obtain the audio output was a bit problematic due to the interference from the ambient signal. This was tackled by using a RC filter to remove out of bound signal

(iv) Problem of power failure from the power holdings company of Nigeria delayed the efficiency of my work during construction

5.3 AREA OF POSSIBLE IMPROVEMENT

-i- A sensitive meter could be configured with the visual output section to enable a more visual observation.

-ii- The sensitivity of the device could be improved so that minute faults could be easily detected.

5.4 RECOMMENDATION

- Software could be designed to interface the pipeline network with computer so that fault would be detected as it occurred. This will make the ultrasonic equipment more meaningful.
- Human factor inform of vandalisation of pipelines should be checked, to increase the lifespan of pipelines.
- Preventive and predictive maintenance should be encouraged to avoid the incidence of fault.

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