DESIGN AND CONSTRUCTION

OF A

TELEPHONE CONVERSATION

RECORDER

BY

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A thesis submitted to the department of Electrical and computer Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna, in partial fulfillment of the requirements for the award of bachelor of Engineering Degree (B.Eng) in Electrical and Computer Engineering.

November 2004

CERTIFICATION

This is to certify that this project, "DESIGN AND CONSTRUCTION OF TELEPHONE CONVERSATION RECORDER" has been presented by ADESANYA TAIWO,A and prepared in accordance with the specification governing the presentation of B.ENG. Degree in the Department of Electrical and Computer Engineering, School of Engineering and Engineering Technology, Federal University of Technology Minna.

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EXTERNAL SUPERVISOR DATE

DECLARATION

I, ADESANYA TAIWO. A hereby declares that this project work is wholly presented by me, under the close supervision of Engr. M.D. Abdullahi and to the best of my knowledge it has neve: been presented elsewhere.

.... 8/12/04.

SIGNATURE OF STUDENT DATE

DEDICATION

To my source of inspiration, my reason and meaning of life, my ever-flowing fountain of wisdom, the immortal, invisible, the only wise God for giving me the grace to complete my programme.

To my parents, Otunba & Deaconess Adesanya who have been there for me all through, whose dedication, forthrightness and conscientiousness have been my search light.They have been so wonderful and a blessing to my life.

ACKNOWLEDGEMENT

I love to acknowledge those who have contributed towards making this project a success and making my stay in F.U.T Minna a fulfilled one.

My sincere gratitude goes to my supervisor, Engr. M.D. Abdullahi, his constructive criticism, and advice contributed immensely to the success of this project.

To my parents Otunba & Deaconess Adesanya, who through their prayer and financial commitment have placed in my hands and etched on my heart what will always keep me above. To my brothers and sisters, I say thanks for your love and support.

I am highly greatful to my Guardian, Engr. And Mrs Oyedotun and family, who through their prayers and support have bequeathed a resounding legacy on me. To Prof. F.O. Akinbode, the Dean of Engineering department, I say thanks for his fatherly love and advice.

To all members of NFCS especially the final year brethren, you have become a part of me, you are my fulfillment, I love you all.

Now I will have tough time doing the rest of the acknowledgement. I owe this to too many people. I will mention but a few – To my very special friends Ogunsowo T.A, Asaju M.A, Barnines I.E, Folarin J.O, Malachi G, Ndako Y, Arinze N, Mogbo O, Foluke, Nta A, Odini O MaryAnn S Anokwu C, Makun J, Momoh A, Agboola L, Kamikun, Shola. To all the G.O.C, to my friends in Air force Base Maikunkele, Lukmon, Agbegunde and Mr. Somorekun, and too many others, I love you all – see you at the top. The future is bright.

My heartfelt appreciation goes to all staff of PPC and CSL. I love you all. To my cousins, Wale A, the Ashirus, the Ajibolas, thanks for your love and care.

Lastly and most important, I give the greatest and uncontested bow to the lifter of my head and my future, my inheritance and my sure reward – The Almighty God.

ABSTRACT

This report presents the design and construction of a telephone conversation recorder-that is an electronic circuit which records conversation between the two ends. The aim is to record conversation made and afford to listen to the recorded message afterwards. The circuit enables automatic switching On and Off the tape recorder when the handset is lifted or on hand-free. The tape recorder gets switched off when the handset is replaced.

The signals are suitably attenuated to a level at which they can be recorded using the "MIC- IN " socket of the tape recorder.

The tape recorder was kept loaded with a cassette and the record buttons remain pressed down to enable it record the conversation as soon as the handset is lifted or hands -free.

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CHAPTER ONE

1.0 INTRODUCTION

Communication is the transfer of information between two or more points. In electrical engineering terms, communication refers to the sending, processing and reception of information using electrical means. The information or message to be sent, processed, and received may take different forms. It may be voice, picture, written message, electrical signal e.t.c. And the means of this communication can be in the form of a radio link, optical fiber, microwave, twisted cable, satellite and telephone network.

In this modern technology, equipments such as cassette player recorder, the compact disk, the answering machine and voice mail facility form the sources of home entertainment and home information management. They are all examples of audio storage and retrieval systems in one form or the other.

Sometimes it is useful to record telephone conversations. A telephone conversation recorder is basically an electronic device that enables or allows conversation to be recorded between two ends i.e the caller and the receiver. The circuit enables automatic switching on and off the tape recorder when the handset is lifted.

The tape recorder gets switched off when the handset is replaced. The message can then be retrieved by playing back the recorded message. The signals are suitably attenuated to a level at which they can be recorded using the'MIC- IN' socket of the tape recorder.

1.01 SET-UP AND RELEASE OF A CALL

Each telephone has a switch that indicates on- or off-hook conditions. When the hook is raised, the switch is closed and an approximately 50mA current flows. This is detected by a relay giving information to the control unit in the exchange. The control unit is an efficient and reliable computer in the telephone exchange. It activates signalling circuits that then receive the dialed digits from the A-subscriber (let the subscriber who initiates a call be A-subscriber and a subscriber who receives a call be B-subscriber).

When a call is coming to the B-subscriber, the telephone exchange supplies a ringing voltage to the subscriber loop and the bell of the telephone starts ringing. The ringing voltage is often about 70V AC with a 25Hz frequency, which is high enough to activate the bell on any telephone.

The ringing voltage is switched off immediately when the off-hook condition is detected on the loop of the subscriber B, and then an end-to-end speech circuit is connected and the conversation may start and be recoded by the tape recorder.

Fig 1.1 shows the signalling phases on a subscriber's loop. When the exchange detects the off-hook condition of a subscriber loop, it brings out a dial tone when the hook i.e the handset is raised and that it is ready to receive digits.

After dialling, it determines whether the circuit establishment is successful by sending out a ringing note when the telephone at the other end rings. When the subscriber B answers, the exchange switches off both the ringing signal and the ringing tone and connects the circuit through. At the end of the conversation, an on-hook condition is detected by the exchange and the speech circuit is released.

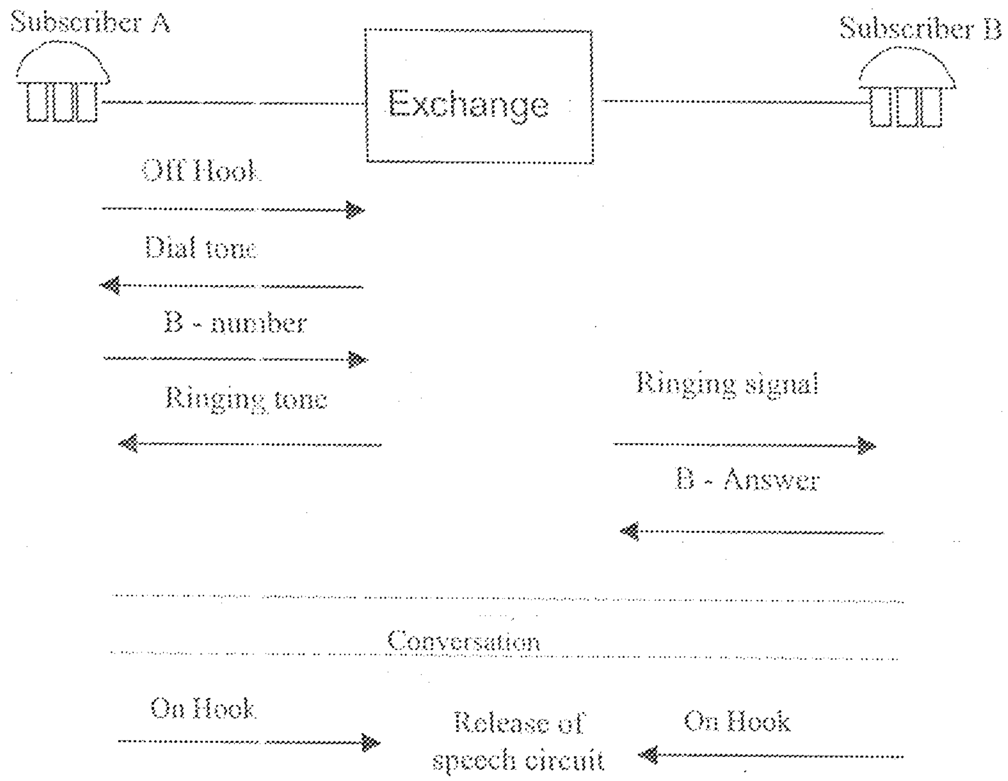

Fig. 1.1 Subscriber signaling phase loop

The main function of the telephone conversation recorder includes on/off hook detection, ability to listen to the conversations made at any point in time by playing back the tape. It may also be function as a security device when the circuit is kept hidden away from the telephone box.

In the tone mode, the telephone operates not in pulse but in frequencies known as the Dual Tone Multi frequency mode such that each number is a combination of two frequencies; high and low frequencies.

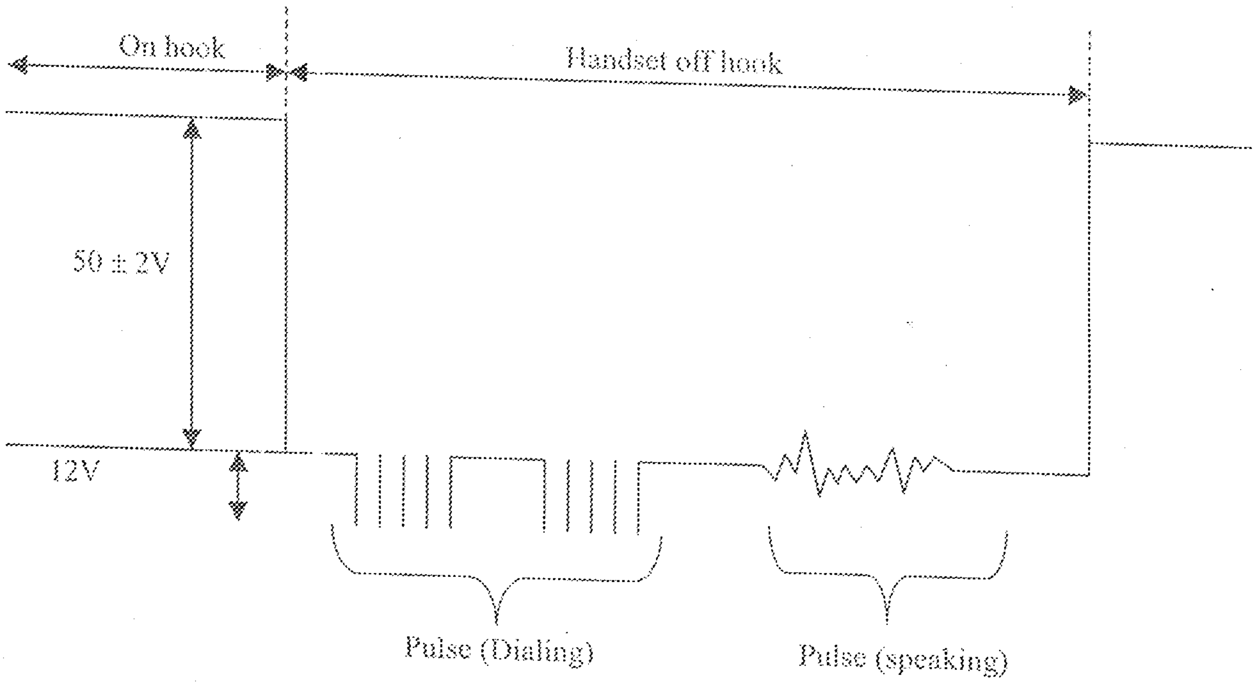

Fig1.2: Voltage Variation in an off-hook/on- hook mode

The voltage across the telephone is 50±2V. When the handset is off-hook (lifted or hands free) the voltage drops to 12V. When a caller speaks an alternating voltage is superimposed onto direct voltage.

The voice output (receiving) and the voice input (transmitting) are both recorded through the MIC-IN socket. When the handset is replaced, conversation is terminated and the voltage again rises to 50±2V.

The generalized block diagram is shown below:

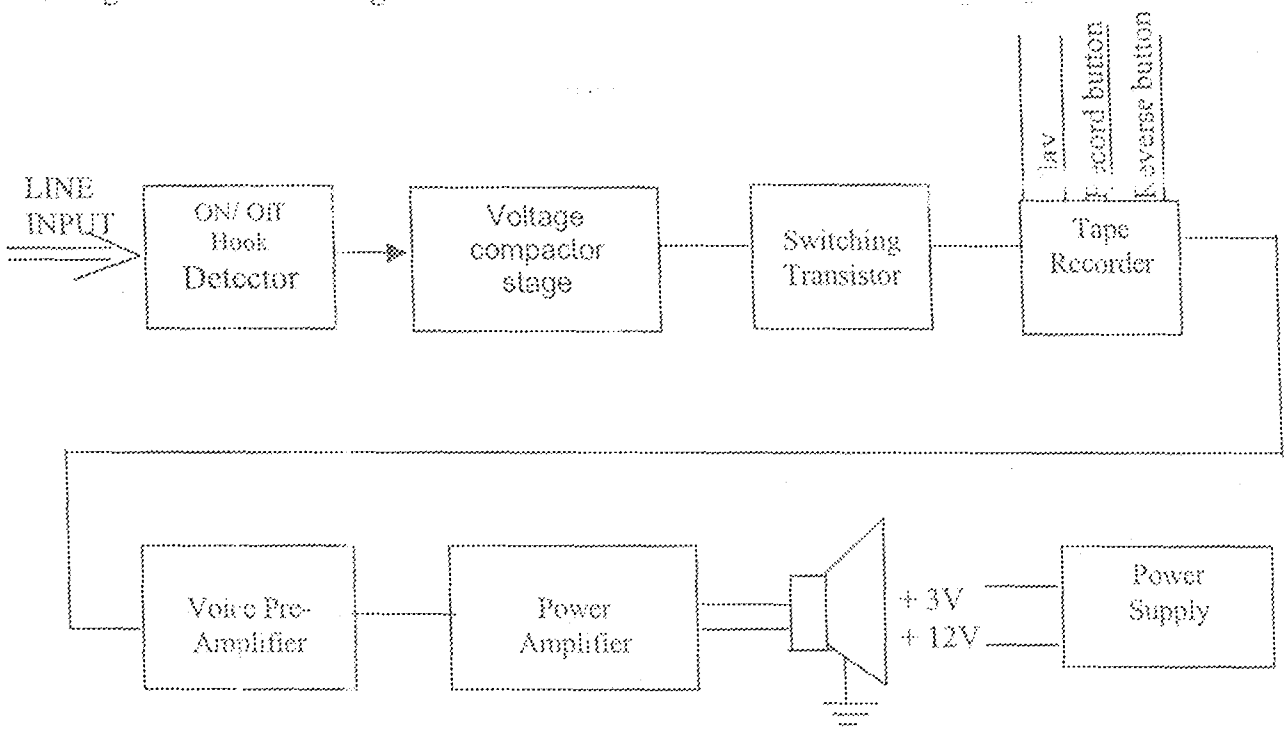

Fig.1.3 Block diagram of a telephone conversation recorder.

1.02 ON-HOOK/ OFF-HOOK DETECTION

This circuit is responsible for indicating when the handset is on-hook or off-hook, i.e. when the voltage drops from 50±2V to 12V and vice versa. During the on-hook condition it does not take any current from line and there is full 48V present between the line wires. When telephone is off-hook, it takes its operating current from the line and the voltage drops to about 12V.

1.03 VOLTAGE COMPARATOR STAGE.

This compares the two voltage levels in the circuit and output high or low depending on the difference between the voltage inputs.

1.04 THE SWITCHING CIRCUIT

This is mainly made up of a relay, which is used to switch on/off the tape recorder. The tape recorder gets switched on when a voltage of 12V is being sensed by the relay in the off-hook condition and gets switched off when the voltage is 48V in the on-hook condition.

1.05 THE VOICE AMPLIFIER UNIT

The voice amplifier unit converts the voice signal from the line to an audible form as desired by the user. The signals are suitably attenuated to a level at which they can be recorded using the MIC-IN socket of the tape recorder.

1.06 THE RECORDING UNIT

This consists of a cassette player recorder loaded with a cassette with the record button remains pressed to enable it record the conversation as soon as the handset is picked and stops recording when the handset is replaced.

1.1 AIMS AND OBJECTIVES

The telephone conversation recorder is aimed at recording conversation being between two ends (the caller and the receiver) and accessibility to playback the recorded message after the conversations have been terminated.

In this modern technology, it is sometimes useful to record telephone conversation because it serves as storage system. The message can be retrieved or listen to at any point in time.

Moreover, it can also be used as a security device when kept in a hidden place far away from the telephone box to ascertain the number of calls coming in or going out and the conversation made.

1.1.0 ACCURACY AND PRECISION

The digital devices used almost throughout the circuit are of high accuracy and kept precision device components.

1.1.1 ECONOMY AND SIMPLICITY

With a portable cassette player recorder used to record the conversation made and reduction in the number of components makes the work simple and economically reasonable.

1.1.2 DURABILITY

To prevent over voltages either from ringing voltage of the telephone which causes up to 120V and other external factors which might cause components failure or breakdown, the circuit was constructed to this effect to checkmate it.

1.1.3 EFFICIENT POWER CONSUMPTION

The reduction in the number of components should achieve a proportional decrease in the amount of power consumed. This makes the telephone conversation recorder a power efficient device.

CHAPTER TWO

2.0 LITERATURE REVIEW

The concept of communication between people came to existence by a careful study of sound by Graham Bell in 1876. He developed a telephone using the same instrument as transmitter (the speaking part of telephone) and a receiver (the listening part). The experiment worked well for him as a receiver but less successful as a transmitter.

However, improved transmitter, which exploited the properties of carbon transmitter was used {Thomas Alva Edison 1877}. He discovered that when the contact area between the carbon granules is increased, there was a drop in the resistance of the circuit thereby leading to a momentary increase in current, which follows the intricate changes in air pressure so that original sound can be effectively reproduced at the distant end.

Generally, a telephone is an electrical device, which conveys sound over a distance. It is designed for voice communication. Its bandpass signal is 300HZ-3400HZ and signal-to-noise ratio of about 30dB. The telephone transmitted actual sound and made telecommunication in mediate. improve switching technology (used to transfer calls from one local network to another) meant individual telephones could be connected for personal conversations.

The telephone system can be categorized by the nature of transmission used (Ferral .G. Strembler, 1952) namely:

1. SIMPLEX SYSTEM: This system allows transmission in one direction as shown in figure 2.1

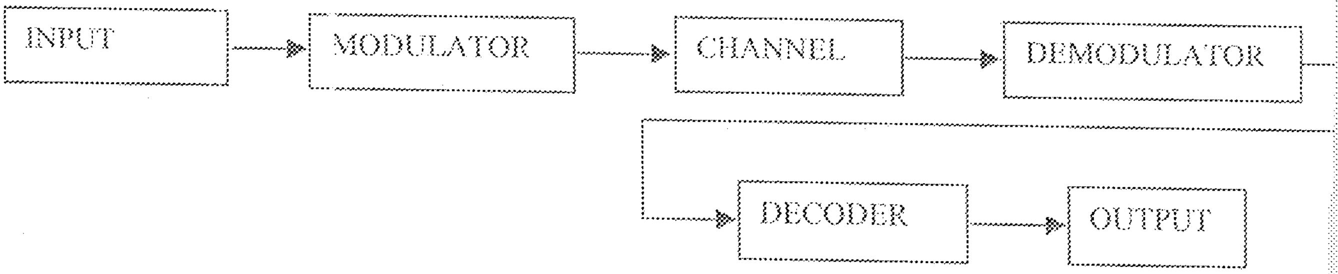

Figure 2.1: Simplex transmission systems.

2. DUPLEX SYSTEM: This maybe half duplex system or full duplex system.

Half duplex system: This is used when it is require to maintain two way communication by sending the message back to its original source either for verification of the message, comparison or control. The flow of information is one way as shown in figure 2.2

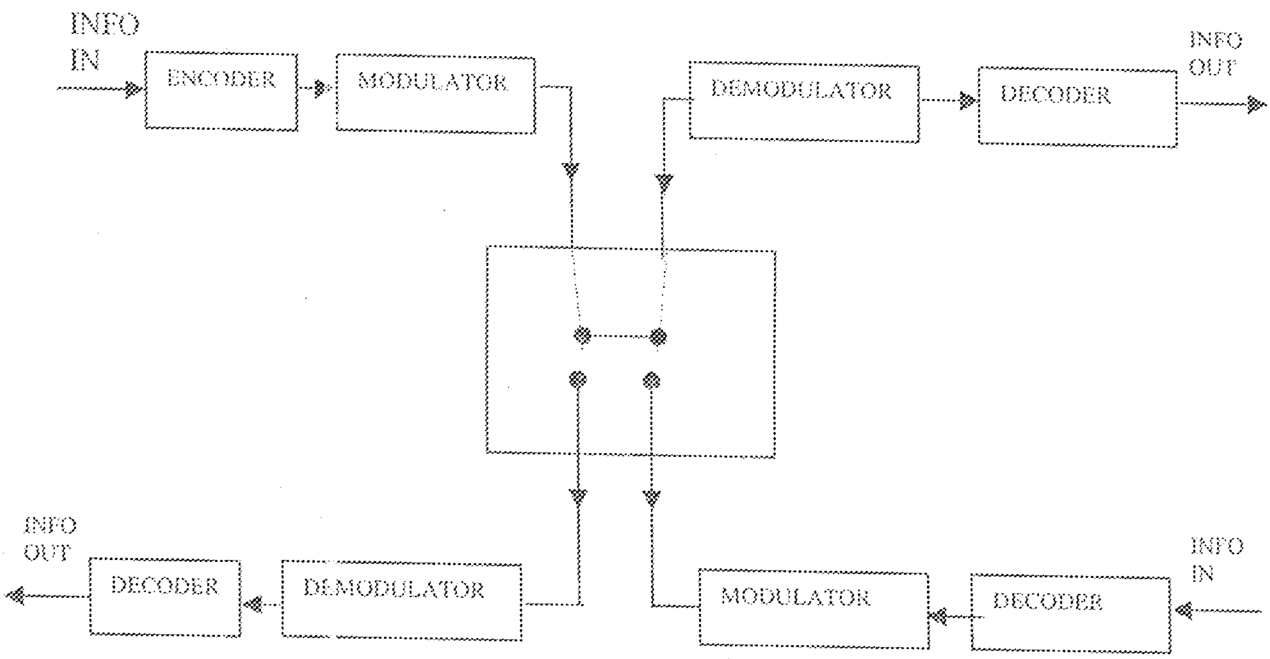

Figure 2.2: Half duplex transmission system

Full duplex system: This is when the transmission of signals is simultaneous in both directions as shown in figure 2.3

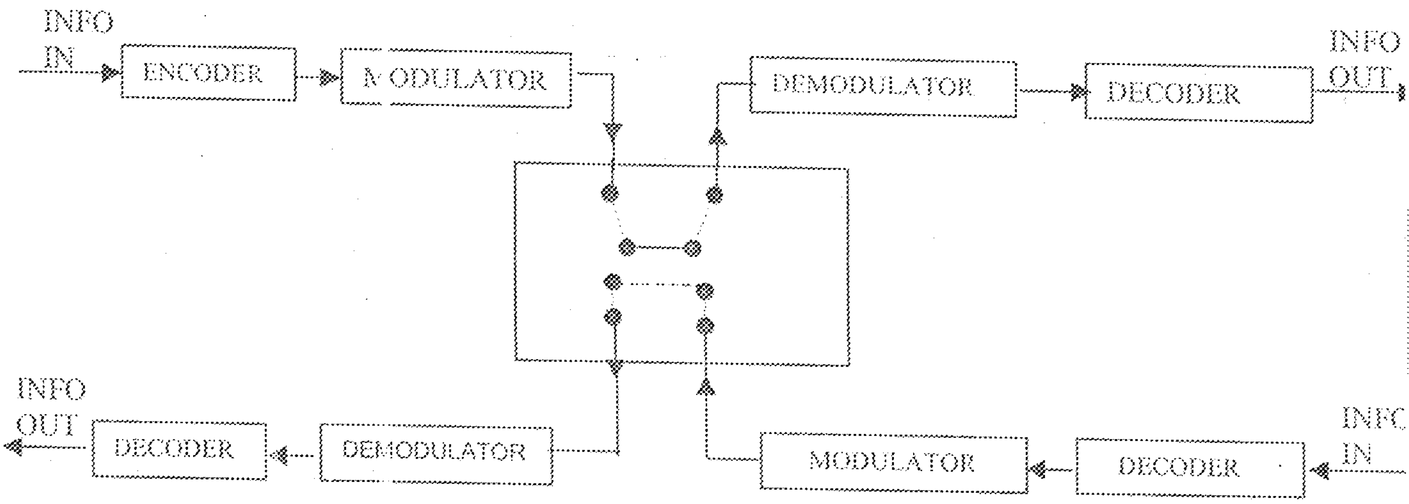

Figure 2.3: Full duplex transmission systems

The three technologies needed for communication through a network are:

(a) Transmission

(b) Switching

(c) Signaling

Each of these technologies requires specialist for engineering operation and maintenance.

2.01 TRANSMISSION

Transmission is the process of transporting information between end points of a system or a network. Transmission system use three basic media for transfer of information from one point to another.

1. Copper cables such as LANs and telephone subscriber lines.

II. Optical fibre cables such as high data rate transmission in a telecommunication network.

III. Radio waves such as cellular phones and satellite transmission.

It is noted in transmission that the number of speech channels (which is one measure of transmission capacity) needed between exchanges is much smaller than the number of subscriber since only a small fraction of them has a call connected at the same time.

2.02 SWITCHING

In principle, all telephones could still be connected by cables as they were in the very beginning of the history of telephony. However, when the number of telephones grew, it was soon noticed that it was necessary to switch signals from one wire to another. Then only a few cable connections were needed between exchanges because the number of ongoing calls was much smaller than the number of telephones.

The first switches were not automatic and switching was done manually on switchboards. Automatic switches known as exchange were developed in 1887 by Strowger. Then the switching had to be controlled with the help of pulses generated by a dial. For many decades, exchanges were complex, series of electromechanical selectors but during the last twenty years, they have developed into software controlled digital exchanges that can provide additional services. Modern exchanges usually have a quite large capacity, tens of thousands subscribers and thousands of them have an ongoing call at the same time.

2.03 SIGNALLING

Signalling is the mechanism that allows network entities (customer or network switches) to establish, maintain and terminate sessions in a network. Signalling is carried out with the help of specific signals or messages that indicate to the other end what is requested of it by this connection. Some examples about signalling on subscriber lines are:

I. ***Off-hook condition***: This exchange notices that the subscriber has raised the telephone hook (DC loop is broken) and gives a dial tone to the subscribers.

II. ***Dial:*** The subscriber dials digits and are received by the exchange.

III. ***On-hook condition***: The exchange notices that the subscriber has finished the call (subscriber loop is connected) clears the connection and stops billing.

Signalling is naturally needed between exchanges as well, because most calls have to be connected via more than one exchange. Many different signalling systems are in use for the interconnection of different exchanges. Signalling is an extremely complex matter in a telecommunication network.

2.04 OPERATION OF A CONVENTIONAL TELEPHONE

An ordinary home telephone receives the electrical power that needs for operation from the local exchange via two copper wires. These two wires that carry a speech signal are called a " pain" or a "local loop". This principle of power supply makes basic telephone services independent from an electric power network. Local exchange have large capacity battery that keeps the exchange and subscriber sets operational for a few hours if the supply of the electricity is cut off.

This is essential because the operation of the telephone network is especially important in emergency situation when the electric power supply may be down.

2.05 RELAYS AND ELECTROMECHANICAL DEVICES

Relays and electromechanical devices operate on the principle of electromagnetism. They are used where a small current in one circuit is needed to control another circuit containing a device such as lamp or electric motor that require a large current, or control several different switches simultaneously.

The diagram below shows the schematic diagram of a relay. The current needed to operate a relay is called the pull-in current and the drop-out current, which is the current in the coil when the relay just stops working.

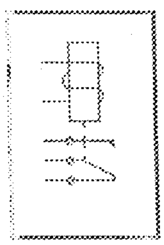

Fig. 2.4: Schematic diagram of a relay.

If the coil resistance of the relay is R and its operating voltage is V, then, the pull-in current

$$I = V / R$$

2.06 MICROPHONE

The microphone converts acoustic or mechanical energy into electrical energy. When the hook of a telephone is raised, the on/off hook switch is closed and current start flowing on the subscriber loop through the microphone that is connected to the subscriber loop.

A good microphone should responds more or less equally to all sounds in the audio frequency range, i.e. from 20HZ to about 20KHZ. Otherwise, the electrical signals it passes on for amplification and conversion back to sound by the output transducer (e.g. a loudspeaker) will not be identical, or nearly so, to the original sound. A schematic diagram of a microphone is shown in fig. 1.7

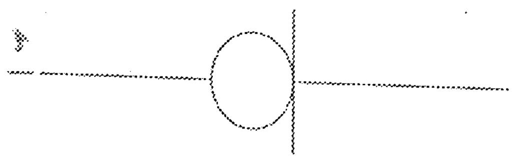

Fig 2.5: Schematic diagram of a microphone.

The carbon microphone are used in telephones. Sound makes the diaphragm vibrate and thus varies the pressure on the carbon granules between the front carbon block, which is attached to the diaphragm and the fixed one at the back. An increase in pressure squeezes the granules closer together and their electrical resistance decreases. Reduced pressure increases the resistance.

2.07 EARPHONE/SPEAKER OUTLET

Alternating current generated by the microphone is converted back into voice at the other end of the connection. The earphone/speaker outlet has a diaphragm with a piece of magnet inside a coil. The coil is supplied by alternating current produced by the microphone at the remote end of the connection. The current generates a variable magnetic field that moves the diaphragm that produces sound waves close to the original sound at the transmitting end.

2.08 OTHER PASSIVE COMPONENTS

Passive components are components that cannot amplify power and require an external power source to operate. They include resistors, capacitors, indicator LED, transformers, etc. Their application ranges from potential dividers to control of current (as in resistance), filtering of ripple voltage and blocking of unwanted dc voltages (as in capacitors).

They form the elements of the network circuit oscillator stages and are also used generally for signal conditioning in circuits.

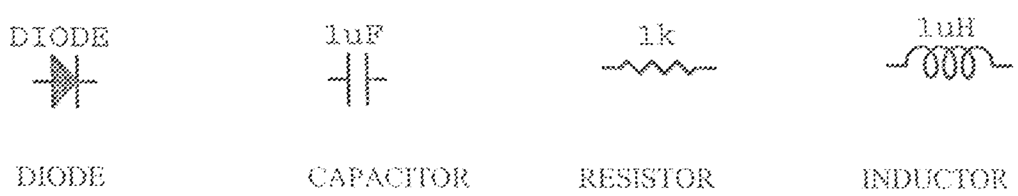

Fig 2.6: Passive components (showing typical values)

CHAPTER 3

3.0 DESIGN AND ANALYSIS

This chapter primarily deals with the major sections of this project Viz: the power supply, on/off hook detector, the switching subsection, the voice amplification unit, and the recording unit. This section elaborates on the principles, techniques, and analysis of each stage in a section.

The values in the calculations are as approximately close to those utilized in this project as possible.

3.1 POWER SUPPLY UNIT

In Nigeria, power supply to the mains is 240V, 50Hz sinusoidal voltage (ac). Moreover, most electronics components and circuits however, requires low current (dc) voltage of about 5-15V. The power supply stage is a linear power supply and involves a step down transformer, filter capacitor and voltage regulators.

A center tapped 240rms---15Vrms step down transformer is used to bring the mains voltage to 15V. The reduced voltage is however still an a.c voltage. Rectification is done to regulate this voltage to d.c voltage.

This design incorporates a full bridge silicon rectifier for rectification. Theoretically, it constitutes of four diodes arranged in such a way that, two diodes conducts during the positive half cycle and the other two diodes conducts during the negative half yielding a full wave rectification. The power supply circuit is shown in the figure below:

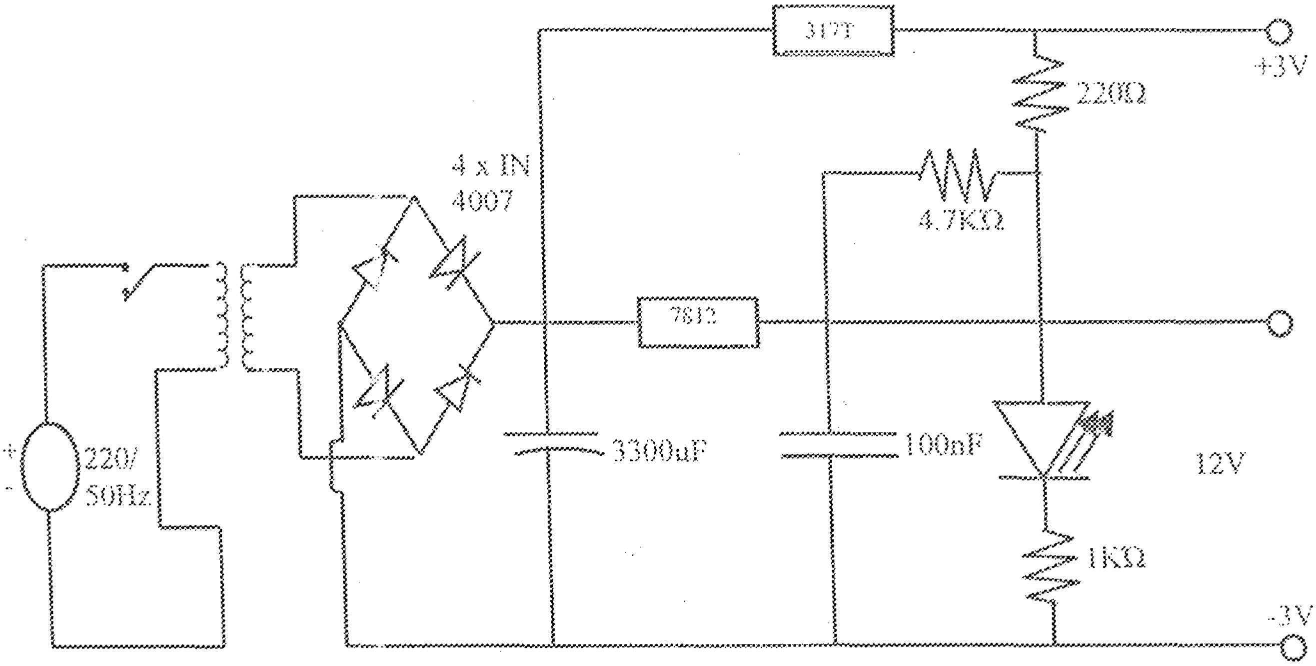

Fig 3.1 Schematic circuit diagram of a regulated power supply unit

Theoretically,

$$V_O = \frac{2V_s\sqrt{2}}{\pi}$$

Where; V_0 = output voltage

V_s = supply voltage = 15Vrms

$$V_0 \quad \frac{2x15x\sqrt{2}}{\pi} = \frac{42.4264}{\pi}$$

$$V_0 \quad = 13.5047V$$

The wave form generated at the ac mains of the transformer and the full wave output from the diode after rectification occurs is shown in figures below.

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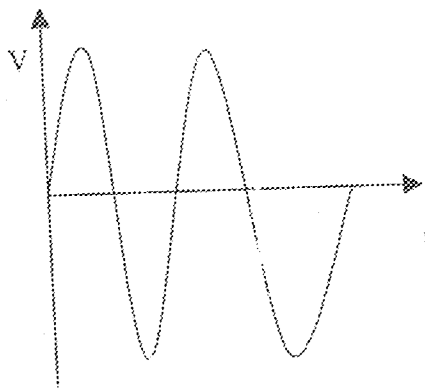

Fig 3.2 A/C mains output from transformer

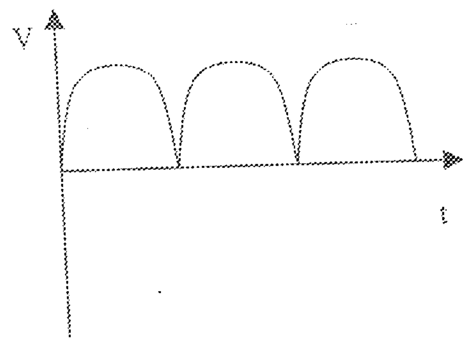

Fig 3.3 Output from diodes.

The resulting voltage after rectification still has some ripples, which might not be tolerated by some of the circuit components. These ripples are eliminated by a capacitor, a process called Filtration: which is the process of removing the unwanted ripples and pulses generated after rectification.

A filter capacitor is incorporated in this design to serve as soothing circuits. The capacitor used in this design have a rating of 3300µf, 50V, whose working voltage should double that of the rectifier output.

Moreover, the capacitor(C) is a filter capacitor and is inversely proportional to the ripple gradient of the power supply. The output from the capacitor still contain some little ripples although considerably reduce when compared to its input as shown below.

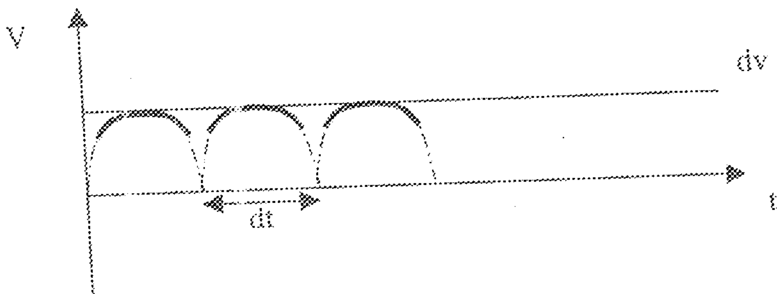

Fig 3.4 Output waveform from capacitor

Where dv is the ripple voltage for time dt, and dt is dependent in power supply frequency.

For an rms voltage of 15volts (from transformer)

$$V_{peak} = 15 \times \sqrt{2}$$

$$= 21.2V$$

Hence letting a ripple voltage of 15% makes dv = 3.18

$$\text{But } I/C = \frac{dv}{dt}$$

$$C = \frac{dt}{dv}$$

$$= \frac{10m/s}{3.1V}$$ (where is 10m/s for 50Hz)

= 3225.8μF (a preferred value of 3300μF was used in the design).

Most components in this design require level of 3V and 12V. The 13.507V unregulated d.c voltage must be regulated to 12V for the relay. An Ic-type regulator 7812 is used to maintain constant d.c supply.

Similarly, a voltage regulator LM 317T was used to maintain constant 3V supply for tape recorder using the 4.7k preset resistor to adjust to the 3V needed. Since an a.c supply voltage is not constant and the d.c voltage is directly proportional in magnitude to the value of the a.c supply, therefore, a constant 12V and 3V supply was maintained.

Light emitting diode (LED) with maximum rating of 4W is used as the power output indicator and this is connected to the output of the 7812 regulator in services with a current limiting resistor rating of 220Ω.

3.2 THE ON/OFF HOOK DETECTOR

This circuit detects and indicates when there is a voltage drop in the telephone line. When the handset is off-hook (i.e picked), the green LED serves as an indicator showing that the voltage in the line has changed and in turn the tape recorder switches on for recording.

It consists of a full bridge rectifier, comparator, transistors, LED, resistors and relay as its major component.

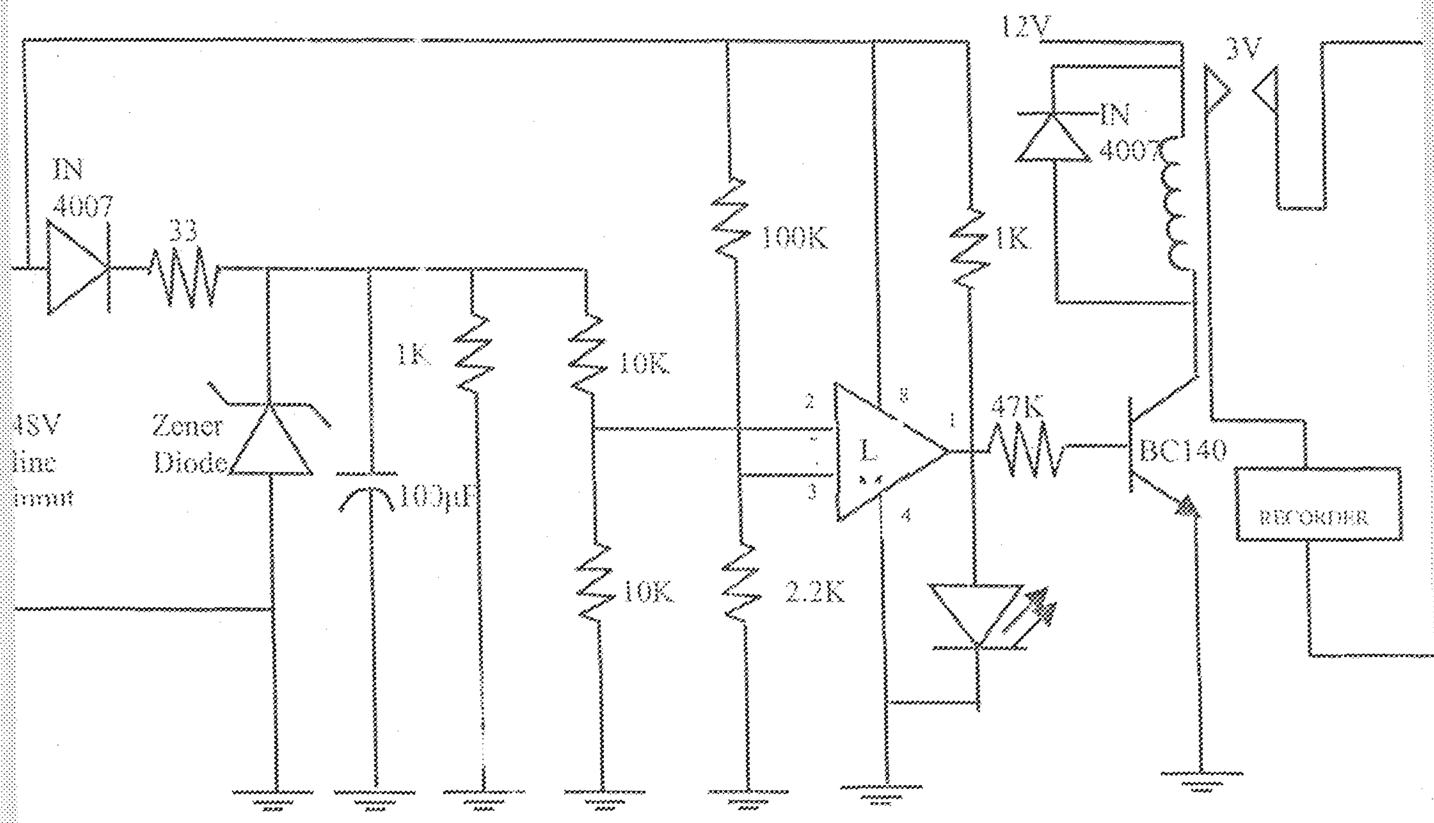

Fig 3.5 On/off hook detector circuit

The input voltage is d.c but the full bridge rectifier, rectifies any a.c signed found in the line due to voice. The silicon diodes cause a total drop of 1.4V when a d.c voltage of 60V and 12V flows across it.

The filter capacitor (100μF, 50V) achieves the filtration of the signal thus removing the ripples. It is also used for blocking the flow of d.c current.

The voltage in the circuit must be reduced to a level accepted by the comparator (LM, 393) using VOLTAGE DIVIDER.

The voltage divider constitute a 100kΩ resistor in parallel with 2.2kΩ resistor required to step down the voltage to an appreciable level. The voltage appearing across the 2.2kΩ resistor is fed to the "MIC-IN" socket of the tape recorder.

$V_{ab} = 1$

$V_2 = 1.4$

$V_{ab} = V_2 = V_i$

$$V_0 = \frac{V_i x R_2}{R + R_2}$$

Where,

V_{ab} = voltage across the line

V_2 = voltage drop across the diode

V_0 = output voltage

V_i = input voltage

When on-hook, $V_i = 60 - 1.4 = 58.6$

$$V_0 = \frac{(58.6)(100k\Omega)}{100k\Omega + 2.2k\Omega}$$

When off- hook, $V_i = 12 - 1.4 = 10.6$

$$V_0 = \frac{(10.6)(100k\Omega)}{100k\Omega + 2.2k\Omega} = 8.96V.$$

The function of the comparator is to compare two voltages and gives an output that determines if they are equal or unequal. It also compares the two input voltages and output a high (1) or a low (0), which depends on the input voltage differences. The truth table for a LM 393 comparator is shown in table 3.1.

V ref	V_i	V_0
0	0	0
0	1	0
1	0	1
1	1	0

Table 3.1:Truth-table for LM 393 comparator

The BC 140 transister switch acts so that the relay switches on both the tape recorder and the voice amplification circuit. A small current to the transistor enables a much larger current to flow to the relay. The figure 3.6 below shows the switching transistor stage for the relay.

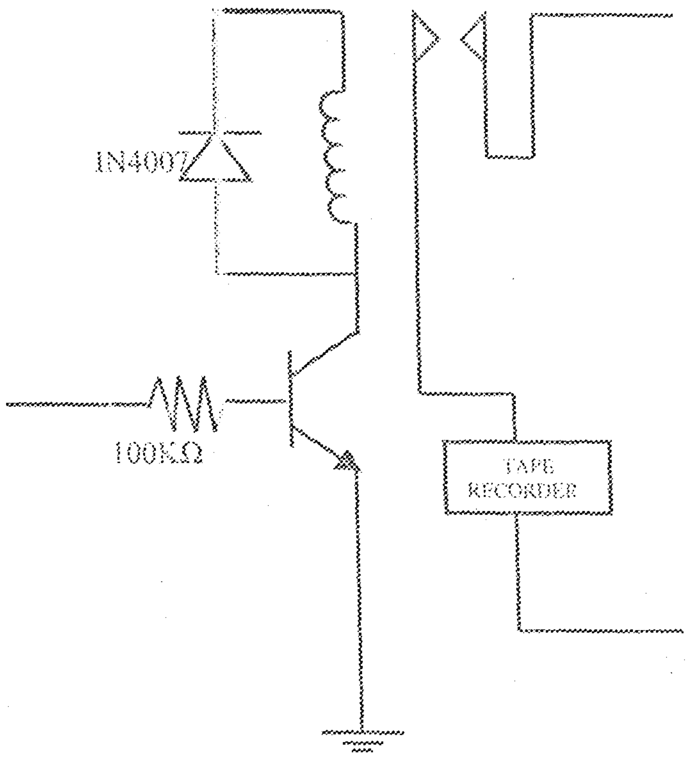

Fig 3.6 Switching stage for relay.

The switching transistor switches the relay, which energizes the tape recorder. The transistor as a switch operates in class A mode. The relay is switched on when the monostabe gives a HIGH input. A base resistor is required to ensure perfect switching of the transistor in saturation. The diode protects the transistor from back emf that might be generated since the relay coil presents an inductive load.

In this case. Rc which is the collector resistance, is the resistance of the relay coil, which is 400Ω for the relay type used in this project.

Hence, given that Rc = 400Ω (Relay coil resistance)

V+ = 12V(regulated voltage from the power supply stage)

Vbe = 0.6 (silicon)

Vce = 0V (when transistor is switched)

Vin = 58.6 or 10.6

Hfe = 300 (from data sheet for LM 393)

Since,

$V+ = I_cR_c + V_{ce}$ ....(1.0)

$Vin = I_bRb + V_{be}$ ....(2.0)

$\frac{I_c}{I_b} = hfe$ ....(3.0)

$Rb = \frac{Vin - Vbe}{I_b}$

Where,

I_c = collector current

I_b = base current

Vin = input voltage

Vt = supply voltage

V_{ce} = collector – emitter voltage

Hfe = current gain

From equation 1.0,

$12 = I_cR_C + Vce$

$12 = I_c(400) + 0$

and, $I_c = 30mA$

From equation 3.0,

$I_b = 30mA/300$

$= 100\mu A$

From equation 2.0,

$10.3 = 100\mu AR_b + 0.6$

$R_b = 9.7/100\mu A$

$= 97K\Omega$

$R_b = 100K\Omega$ (preferred value)

A transistor acting as a switch is shown in fig 3.7 In this mode of bias, the circuit is designed such that current flows without any signal present. The value of the bias current is either increased or decreased about its mean value by the input signal (if operated as an amplifier), or ON and OFF by the input signal if operated as a switch.

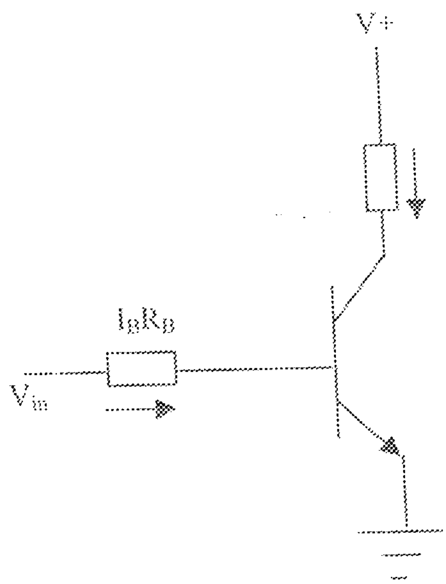

Fig 3.7 Transistor as a switch

For the transistor configuration, since the transistor is biased to saturation;

Vce = 0, when the transistor is ON, which implies that

$V+ = I_c R_c + Vce$ ....(1.0)

$V_{in} = I_B R_B + V_{BE}$ ....(1.1)

$Ic / I_B = hfe$ ....(1.2)

$R_B = \frac{Vin - V_{BE}}{I_B}$ ....(1.3)

Where:

Ic= collector current

I_B =base current

Vin =Input voltage

V+ =supply voltage

Vc_E =collector – emitter voltage

Hfe =current gain.

The relay is switch on when the comparator gives HIGH output. A base resistor is required to ensure perfect switching of the transistor in saturation.

The diode protects the transistor from back emf that might be generated since the relay coil gives an inductive load.

A green LED lights up only when the output voltage from the comparator is high i.e when the reference voltage is greater than the input voltage. The LED is grounded through a resistor to prevent large current that may damage the LED.

3.3 THE PRE-AMPLIFIER UNIT (AUDIO UNIT)

The voice amplification circuit dwells on the fact that a small signal only is needed to retrieve the voice via the speaker in order not to cause a voltage drop. It comprises of the tape in-built "MIC", speaker, transistor switch, resistor, capacitor and LM 386 comparator.

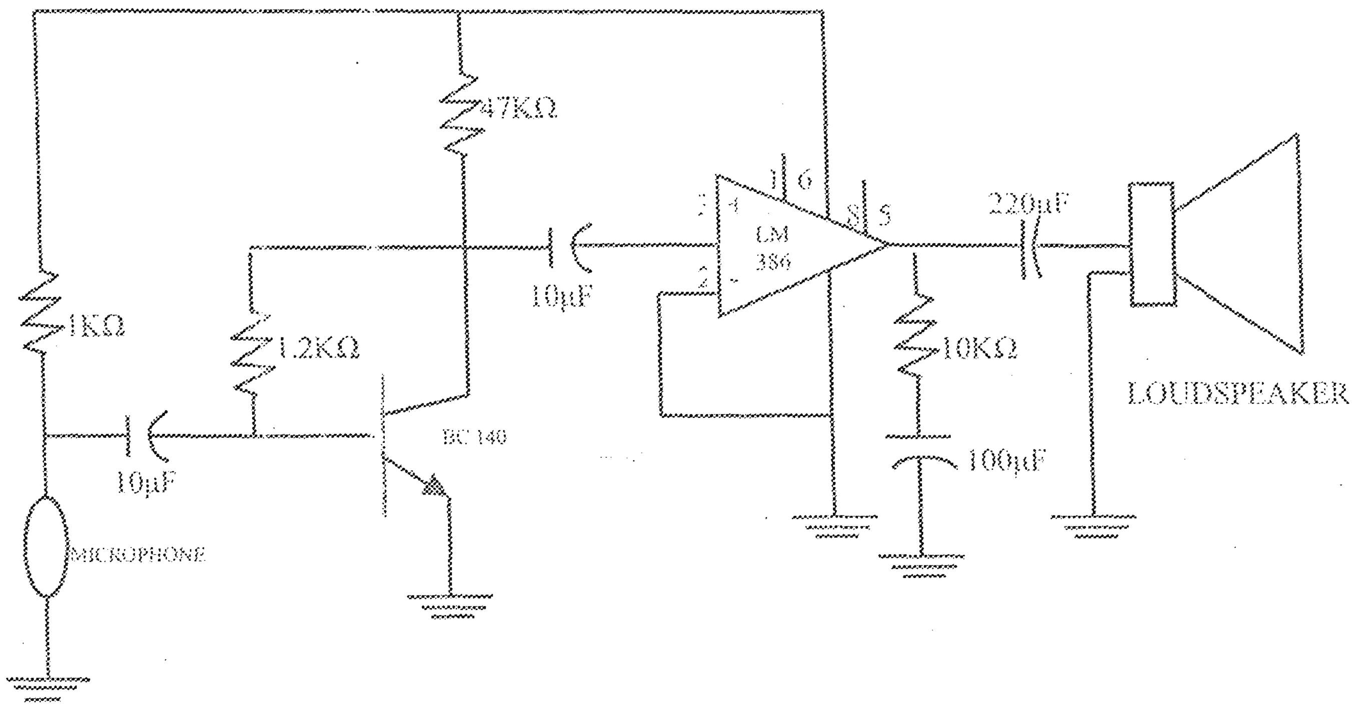

Fig 3.8 Voice pre-amplifier circuit

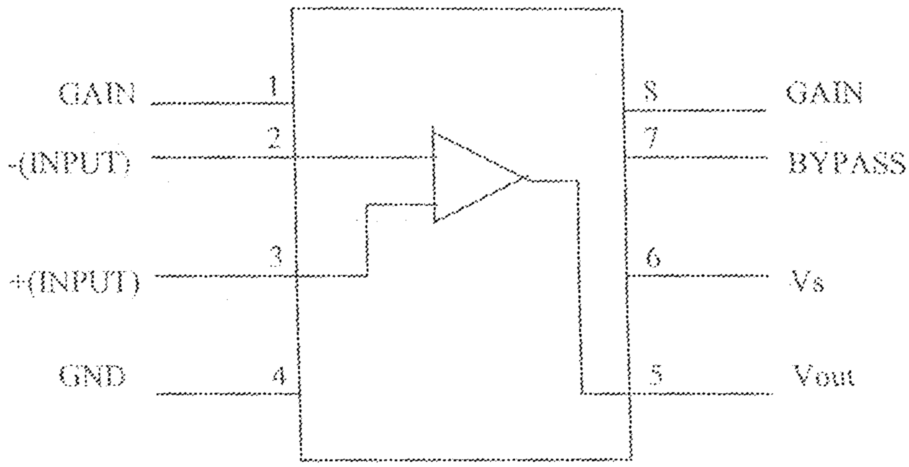

Fig 3.9 LM 386 Comparator

The LM 386 is a power or audio amplifier designed for use in low voltage consumer application. The gain is internally set to 20 and the input are ground referenced. Pin 5 is the output voltage, pin 2 and 3 are the differential inputs. Pin and 8 are for gain control while pin6 is the output voltage. The 10kΩ resistor is a variable resistor which is used to regulate the volume of the amplifier circuit.

The microphone pre-amplifier is designed to remove the following:

I. To remove the d.c offset from the microphone output.

II. To remove the signals and

III. To band limit the signals to the voice band (300-3400Hz)

The current flowing through the circuit ranges between 20-200mA when it is off-hook depending on the telephone set.

3.4 HOW THE AUDIO INTERFACING IN THE CIRCUIT WORKS

The audio interfacing works considering the circuit in parallel with the telephone line or in series with telephone line. These two conditions are considered below.

3.4.1 CIRCUIT IN PARALLEL WITH TELEPHONE

The audio interfacing is usually done by connecting the audio recording circuit to telephone line in parallel with telephone. The audio circuit is designed so that it shows high impedance to the line, but picks enough signals to feed the tape recorder microphone input. Because the circuit is of high impedance and does not pass any d.c current, it can be always connected to the telephone line and does not disturb the normal operation of the telephone.

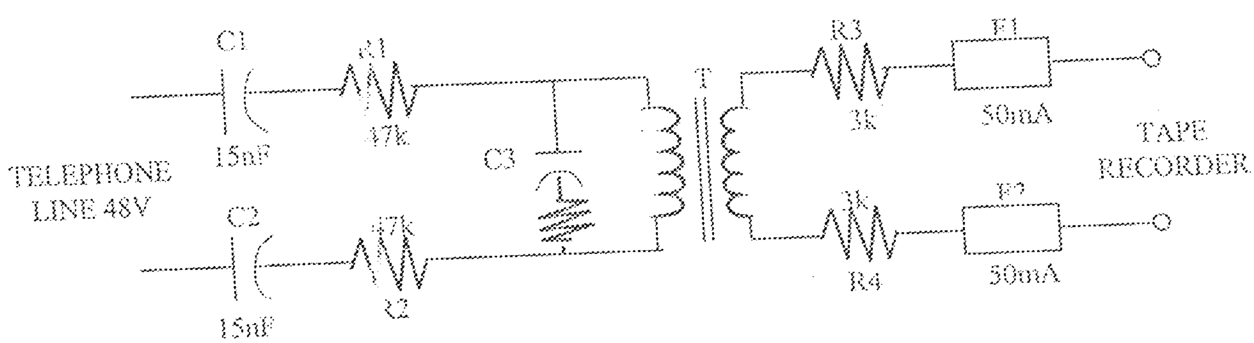

Fig.3.10 Interfacing circuit.

The capacitors C1 and C2 make sure that no d.c current passes the circuit, but the audio goes through the current. Resistors R1 and R2 provides high impedance and attenuation to the audio signal. Audio isolation transformer provides isolation between telephone line and tape recorder.

is pulled low and cut off and the relay is not energized.

When the telephone line is off-hook, the telephone takes its operation current from line and the voltage drops to about 12V. The transistor gets forward biased via the resistor, which energized the relay. The tape recorder gets switched on and recording begins.

The tape recorder is kept loaded with a cassette with the record button pressed down to enable conversation to be recorded as soon as the handset is lifted.

The capacitor C2 ensures that the relay is not switched on-and-off repeatedly when a number is dialed in pulse dialling mode.

The tape recorder gets switched on-and-off due to the LM 393 comparator, which compares 2 voltages.

$V^+ > V^- = 1$

$V^+ < V^- = 0$

With the condition above, when $V_{out} = 1$, the tape recorder starts recording.

When $V_{out} = 0$, the tape recorder stops recording i.e when the line voltage falls back to zero.

3.6 SIGNALING FUNCTION

The microphone generates the electrical current that carries voice information, and the earphone/speaker produces the voice at the receiving end of the speech circuit. The telephone network provides a dialed up or switched service that enables the subscriber to initiate and terminate calls.

3.7 TONE DIALLING

Modern telephones include an electronics circuit that makes the implementation of better means for signaling feasible. Digital exchange does not require high power pulses to drive the selectors like old electromechanical switches did.

However, subscriber lines are still, and will be, supplied by a –48V or –60V battery to make operation of telephones independent from the electric power supply. Electronics telephones use 50 to 500μA current all the time to supply power to their electronic circuitry, which is needed for number repetition, abbreviated dialing and other additional features of modern telephone sets.

In modern telephones, there are usually 12 push buttons (keys A to D are not included in an ordinary subscriber set) for dialing, each generating a tone with two frequencies. One frequency is from the upper frequency band and the other from the lower band.

All frequencies are inside the voice frequency band (300HZ to 3400HZ) and can thus be transmitted through the network from end to end when the speech connection is established.

This signaling principle is known as DTMF (dual-tone multi-frequency) signaling.

The advantages of tone dialing are:

I. Quicker dialing of all digits takes the same time.

II. Less dialing errors

III. Operation of end-to-end signaling

IV. Additional push buttons *, # (A, B, C, D) for activation of so-called supplementary services.

3.8 OP-AMPS AND COMPARATORS

An operational amplifier is a differential amplifier with an extremely high open voltage gain. They are of most important simple linear integrated circuits and they perform a wide variety of linear and non-linear signal processing functions. Negative feedback circuits are employed in Op-amps to control the gain when precise gain values are needed.

The Op-Amps and comparator used in this design have the following ideal characteristics:

Infinite voltage gain

Infinite input impedance

Infinite bandwidth

The comparator is an operational amplifier without a feedback. Hence, it is controlled by open loop voltage gain. The simplest form of comparator is a high gain differential amplifier made either with transistors or with an Op-amp.

Generally, they have more flexible output circuits than Op-amps. Whereas, an ordinary Op-amp uses a push-pull output stage to swing between the supply voltages (±13, say, for a 411 running from ±15v supplies), a comparator chip usually has an "open – collector" output with grounded emitter.

The function of the comparator is to compare two voltages and give an output that determines if they are equal or unequal.

CHAPTER FOUR

4.0 CONSTRUCTION, TEST AND RESULT

The physical realization of the project is vital. This is where the fantasy of the whole idea meets reality. The design and construction of a telephone conversation recorder was not just seen on a paper work but also on a finished hardware.

The project was implemented and tested to ensure it's working ability after carrying out all the paper design and analysis. The design specification of each component was followed strictly except in cases of non-availability of components. In such cases, slight changes in design specialization was inevitable and was finally constructed to meet desired result.

The process of construction, testing, and implementation involved the use of some equipment below:

4.01 BENCH POWER SUPPLY: This was used to supply voltage to various stage of the circuit during the breadboard testing before the power supply in the circuit was constructed. Also, during soldering on the Vero board, the power was still used to test various stages of the circuit.

4.02 OSCILLOSCOPE: This was used to observe output waveform (ripples) in the capacitor and power supply. This was carried out to ensure that all waveforms are correct and their frequencies are accurate. The output waveforms of the pre-amplifier and the power amplifier stages were also observed on the oscilloscope.

4.03 DIGITAL MULTIMETER: This basically measures voltages, resistance, current, frequency, transistors etc. The process of implementation of the design on both breadboard and Vero board required the measurement of parameters at various stages. The digital multimeter was used to check the various levels, power supply voltage, the analog input, and the various output to the ports.

4.1 HARDWARE CONSTRUCTION, IMPLEMENTATION AND RESULT.

The implementation of this project was done on breadboard. The power supply was first gotten from a bench power supply in the electrical lab. This was done to confirm workability of the circuits before the power supply stage was soldered on Vero board.

Stage by stage testing and implementation was done according to the block diagram of the circuit, on the breadboard before soldering of the components commenced on the Vero board. The various circuit stages were soldered in tandem to meet desired workability of the project. These stages are explained in details.

4.1.1. POWER UNIT

This unit consists of a 240/15V center tapped transformer, a resistor, light emitting diode (LED), a bridge rectifier, ON/OFF switch and main socket.

The primary winding of the transformer was connected to the 240AC main supply, the output measured from the DC was 15V, which was soldered on the Vero board. A capacitor was soldered across the rectifier output. The AC input terminal to the bridge rectifier was soldered in contact with the output of the transformer.

A 7812 voltage regulator and LM 317T using a preset variable resistor was used to achieve after rectification, the required voltage needed for the circuit for both the relay and the tape recorder respectively. Heat sinks are fixed to both regulators to prevent heat dissipation to the circuit before being soldered to the Vero board.

The regulator output when measured by a digital multimeter gave a output of 11.95V and 2.96 for the relay and tape recorder respectively. A red light emitting diode (LED) was connected to the output which serves as indicator when power switch is ON from the circuit.

4.1.2. ON/OFF HOOK DETECTOR.

This consists of various components but the major ones are LM 393 comparator, a Zener diode, resistors used as voltage divider, the 10A, 12V relay. A telephone line dc voltage of 48V and ground voltage of 0V was passed through the input while the output was monitored through a green LED connected to the output via a resistor.

The comparator compares two voltages and outputs high or low depending on the difference between the voltage inputs. The greed LED acts as an indicator to show high or low i.e. during on/off hook condition.

The transistors and the relay were also connected and tested to verify they both switch as required before soldering on the Vero board.

A multimeter was used to measure the output voltage across the resistors used as voltage to ensure that the voltage correspond with the required voltage.

4.1.3 VOICE PRE-AMPLIFIER CIRCUIT

This consists of a carbon microphone, transistor, LM386 operational amplifier, capacitor, 4Ω speaker. The microphone was connected in series with the 1KΩ resistor and a capacitor of 10μF, which serves as a filter was soldered across the output. The 10μF capacitor was connected to the base of the BC 140 transistor while the emitter was connected to the 47KΩ resistor and its collector pulled to the ground.

The LM 386, which acts as an amplifier was connected in series with a 10KΩ resistor. The output from the amplifier is capacitive coupled to the 4Ω speaker and soldered on the Vero board.

4.1.4 RECORDING UNIT

This consists mainly a 3V cassette player recorder. The LM 317T voltage regulator using a preset variable resistor was used to supply 3V DC to power the tape recorder. The tape recorder is switched on automatically when the handset is lifted. And its gets switched off when the handset is replaced.

The signals are suitably attenuated to a level of which voice can be recorded using the "MIC –IN" socket of the tape recorder fixed at the speaker outlet of the telephone box.

The tape recorder is kept loaded with a cassette and the record button remained pressed down to enable it record the conversations made. As soon as the handset is lifted, the relay sensing the voltage across it gets energized and the tape recorder switch on and the recording starts automatically.

4.2 SOLDERING

The following are some of the precaution taken during soldering:

I. Heat sinks were used to ensure that heat is conducted away from active components during soldering.

II. It was ensured that temperature of soldering iron was not too high in order to prevent damage by overheating.

III. Proper contact was ensured by using little but enough soldering leads for the joints.

IV. Easier and proper soldering was ensured by thinning the leads of the components.

4.3 CASING

The circuit after final soldering on the Vero board was coupled to a metal casing. The casing material being a stainless steel designed with special preparation and vents to allow for easy dissipation of heat. Holes were drilled for easy access to switches, LED, and the tape recorder buttons.

Nevertheless, for proper understanding of how the system operates and to allow for troubleshooting, the pin configuration of the IC and other active components are shown below.

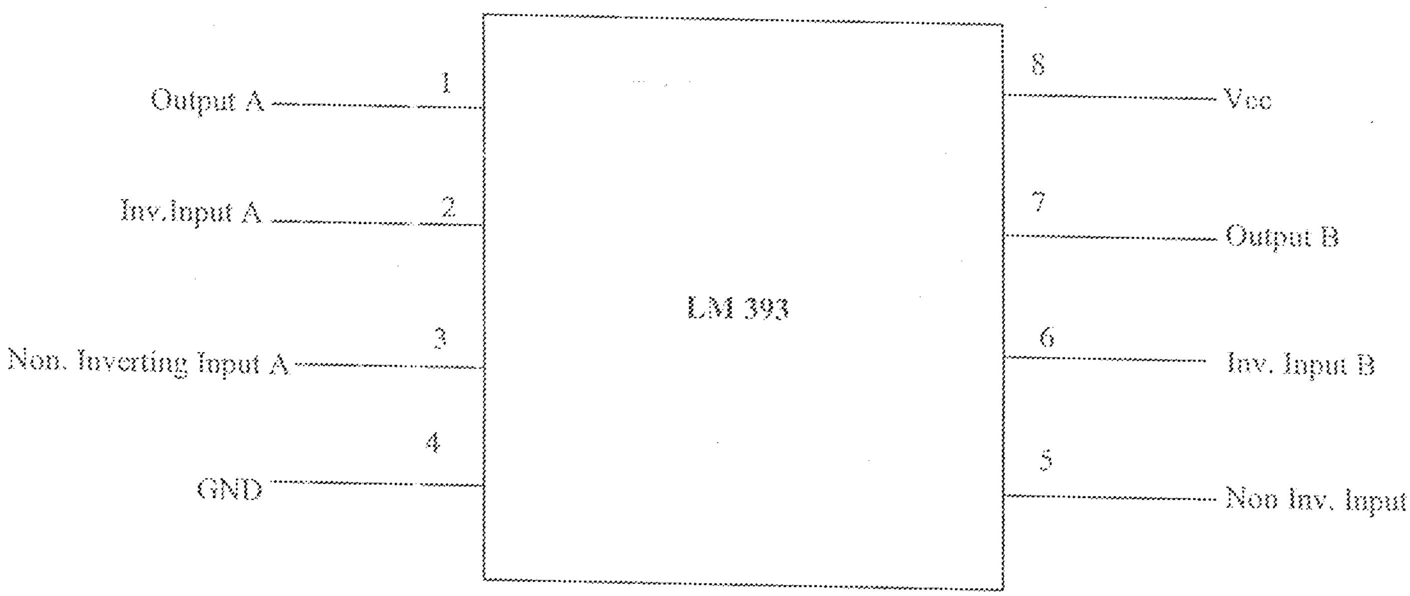

Fig: 4.1 LM 393 Dual Op-Amp Pin-Out Configuration.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The design and construction of a telephone conversation recorder was achieved, though very tasking and challenging. It was designed considering some factors such as economy, availability of components, research materials, efficiency, compatibility, portability, and durability. The performance of the project after testing met design specifications and the experience gained is invaluable.

The general operation of the project and performance is dependent on the user who is prone to human error when trying to use the system to record conversations.

The system is designed to be installed far from the telephone set. The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user, should there be any system breakdown.
Financial constraint was also one of the challenges faced but ingenuity was applied to make judicious use of what was available to obtain the desired result.

The project has really exposed me to digital electronics and practical electronics generally, which is one of the major challenges I shall meet in my field now and later in future.

However, like every aspect of engineering, there is still room for improvement and further research on the project as suggested in the recommendation below.

5.2 RECOMMENDATION

I. I strongly recommend that any student who will likely carry out a further work on this project should venture on making more research so that the device can work as both telephone conversation recorder and a telephone answering machine.

II. Private firms and other interesting parties should be involved in sponsoring some of these projects so that bigger projects might be undertaken in order to eradicate student limitations to project work due to financial constraint.

III. Internet facilities should be provided on campus to enable serious research work to be carried out.

IV. I also still recommend that any research on this project should venture on making available a battery backup incase of power failure.

V. Finally, it is necessary that the department have a departmental library to acquire more research-oriented books. Also, sales and availability of components in the laboratory to make enough materials available for students to use.

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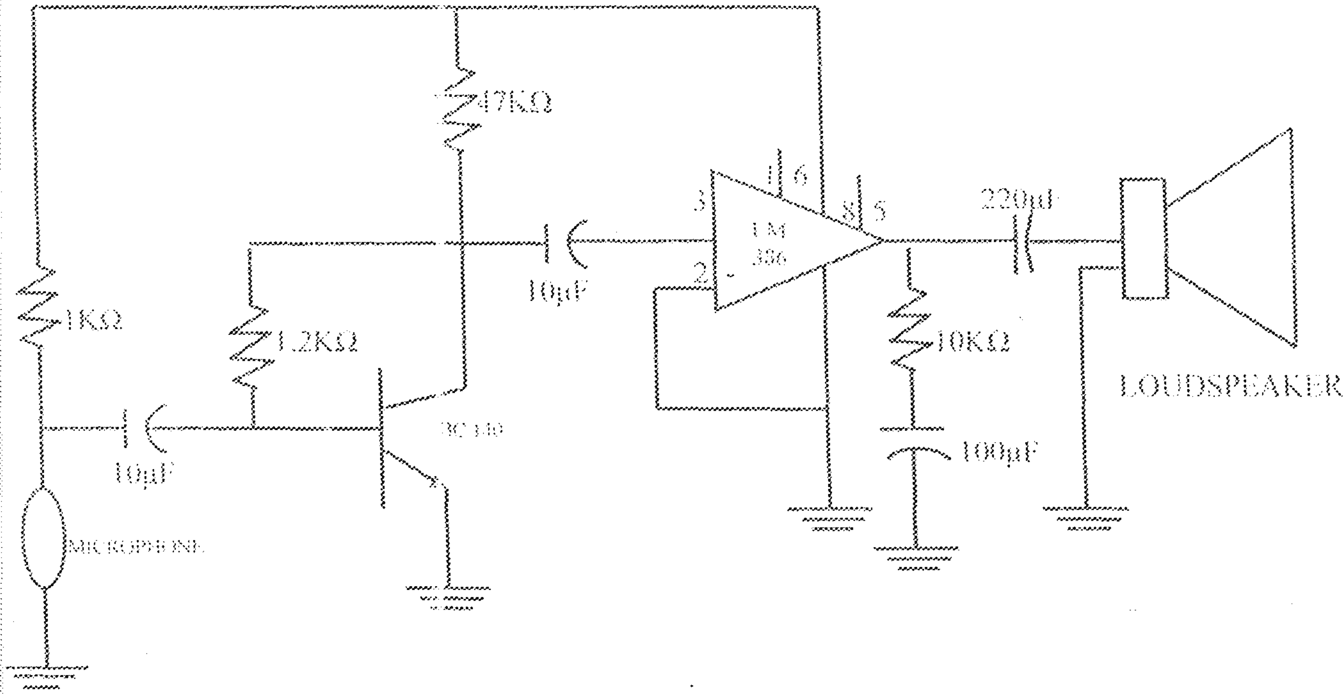
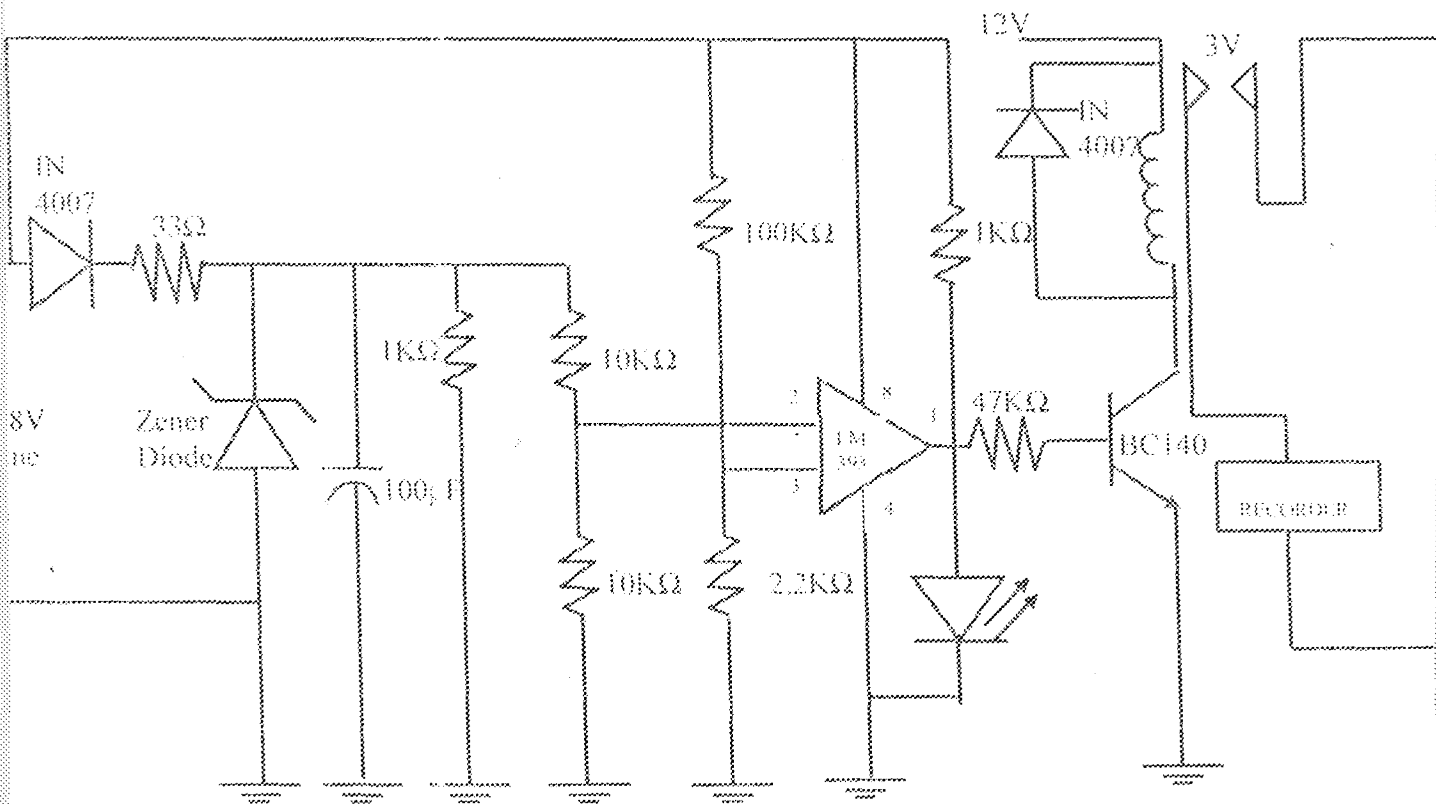
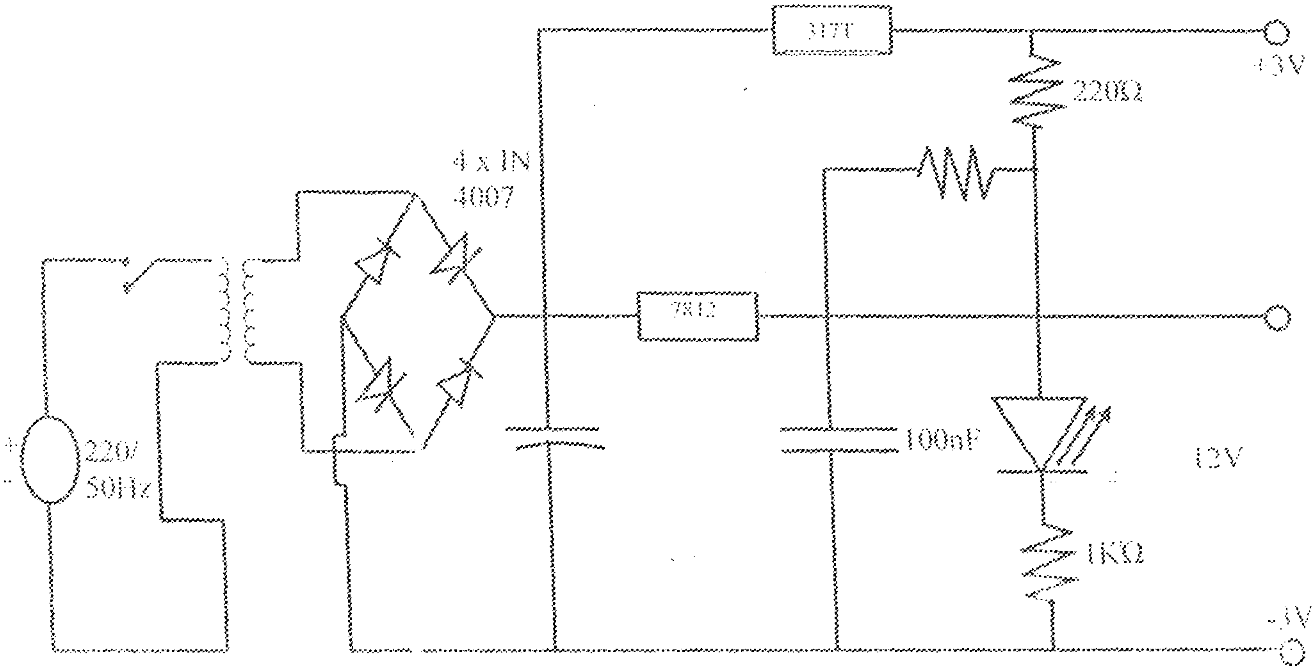


47KΩ
1KΩ
1.2KΩ
10μF
10μF
3
2
1
6
8
5
LM 386
220μF
10KΩ
100μF
LOUDSPEAKER



12V
3V
IN 4007
IN 4007
33Ω
100KΩ
1KΩ
1KΩ
10KΩ
Zener Diode
100μF
47KΩ
BC140
10KΩ
2.2KΩ



317T
220Ω
4 x IN
4007
7812
220/
50Hz
100nF
12V
1KΩ