DESIGN AND CONSTRUCTION OF VOICE OUTPUT METAL DETECTOR

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DEDICATION

I make my dedication to God Almighty, for His grace, mercy, strength, and wisdom to meet this academic challenge.

I also dedicate this work to my Mum, Mrs. Inalegwu Comfort Omegwu and my loving dad, Late.Mr. Inalegwu Paul Edo

DECLARATION

I, Inalegwu Collins Ogbole declare that this work was done by me and has never been presented elsewhere for the award of a degree of Bachelor of Engineering. I also hereby relinquish the copyright to the Federal University of Technology, Minna

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ABSTRACT

This project presents the design and construction of a voice output metal detector for use in shops, office entrance, airports and security buildings, to check against crimes and to make the search for weapons and other metal objects easier. The design is based on the principles of electromagnetic induction and the heterodyning action. When the search coil which is made up of copper wire is brought close to a metal object, the copper coil opposes the external magnetic field and thus oscillates. Also the colpitt's oscillator is signaled and oscillates at its frequency too, thus producing a second frequency component, both frequency components are mixed and modulated to generate a single heterodyned frequency which then triggers the detecting and amplifying unit of this device to respond to the presence of a metal and the subsequent activation of the voice output unit. The test procedure as conducted shows that the device provides a high sensitivity in the detection of metals within a short range.

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CHAPTER ONE

1.0 INTRODUCTION

Metal detectors are fascinating machines. They have become so necessary in our present day for checking the increasing rate of crime in banks, companies and even shops, and the need to protect lives and properties. The need for metal detectors has become more as there effectively and efficiently curb out criminal intentions even before it is initiated by checking these individuals for guns, knives and metallic sheets before entering the buildings. Other useful application of this machine is seen in landmine detection by the military and exploration by companies. Metal detectors help miners to detect metallic objects buried deep in the ground. Archeologist also uses this machine in their exploration for artifacts, geologist are also not left out since they continually use this machine in search for metallic minerals [3, 1, 7].

For this device, the mode of operation is based on the principle of electromagnetic induction. Though engineers and technologist have arrived at different means of achieving this which is seen in the different technologies listed below [4];

i. Magnetometer technology

ii. The Beat Frequency Oscillator (BFO) technology

iii. The Pulse Induction (PI) technology

iv. The Very Low Frequency (VLF) technology

But even with these technologies, many advancement and development are being made. The first effort was reached by English geologist and mining engineer R.W. Fox in

1830 after He first discovered that electricity will flow through metallic ores as well as metallic objects. This device in 1870 was modified by Circa [6, 1].

The challenge today is to build a metal detecting device using electronic components that will provide an efficient circuitry and will effectively function in;

*Geological survey

*Security purpose

*Demining (the detection of landmine)

*Detection of foreign objects in food materials

*Item recovery

. Certain metal detectors are able to even distinguish between the types of metals; an example is the Expendable Metal Detector (EMD) [5].

1.1 OBJECTIVE OF THE PROJECT

The objective of this project is to design and construct a hand held metal detector that will effectively locate metallic materials on human bodies, in hand bags, and in food substances.

1.2 METHODOLOGY

The methodology employed an initial paper design, followed by simulation using electronic workbench software. The circuit was then implemented on a breadboard to allow for placement and adjustment and then the actual soldering on the veroboard.

1.3 SCOPE OF WORK

This project is to construct a metal detecting device that functions in detecting metals placed on human bodies or bags but at a distance of 2-5cm, its short sensitivity range is to prevent interference of other external metallic object signals from nearby individuals also. The technology adopted to achieve this is the Beat Frequency Oscillator (BFO) technology which compares two frequencies and produces an output when both frequencies are not the same (this is when a metal is within its sensitivity range).

The metal detectors can also detect anti-personal landmines, examples are; German S-mines, US M16 mines and Italian SB 33-mines that are usually buried at 10-20mm below the ground [10].

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 THEORITICAL BACKGROUND

Metal detectors are use in a wide range of applications, from security in bank and companies, land mine detection, safety in airport, office buildings or schools. They can be useful around the house to help locate coins, jewelries, keys and gas lines.

Metal detectors help archeologist in the discovery of precious artifacts and coins that were once the everyday items of use by our ancestors. Today metal detectors provide millions of hobbyist around the world with opportunities to discover hidden treasures, providing relaxation, excitement, the thrill of discovery and profit to those who construct and design them [2],[3].

2.2.0 BLOCK DIAGRAM REPRESENTATION

The basic operation of this device and how it is achieved is illustrated in the block diagram shown in fig 2.1.

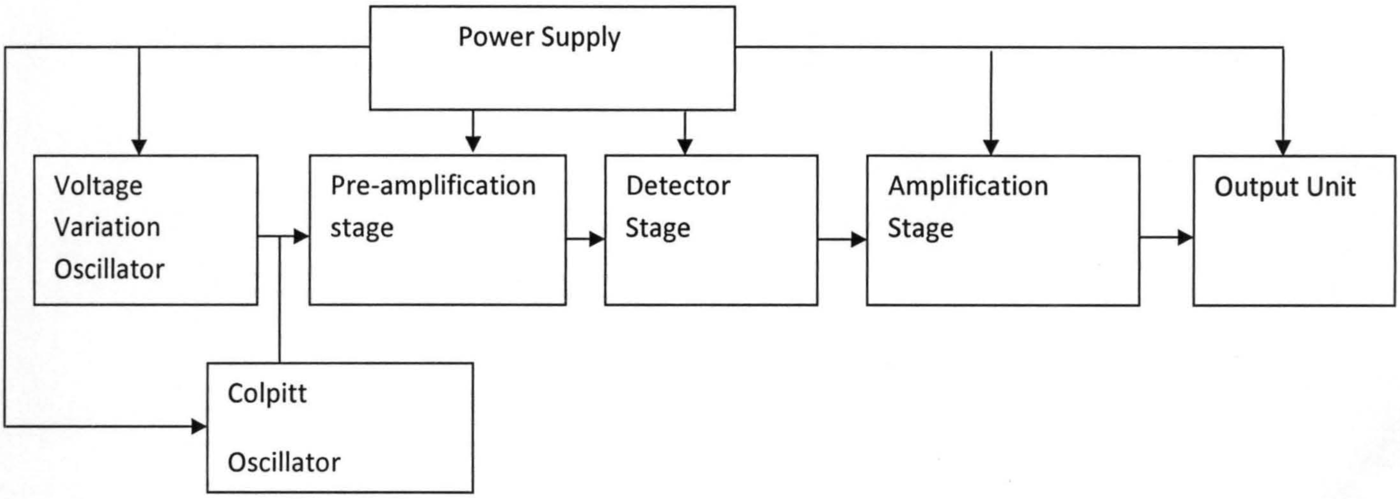


Fig 2.1 Generalized block diagram

This device work using basic electronic components.

2.2.1 OSCILLATORS

The oscillator is a circuit which generates an AC output signal without requiring any externally applied input signal. It keeps producing an output signal so long as the DC power source is connected [9]. Fig 2.2 shows a simple operational illustration of an oscillator.

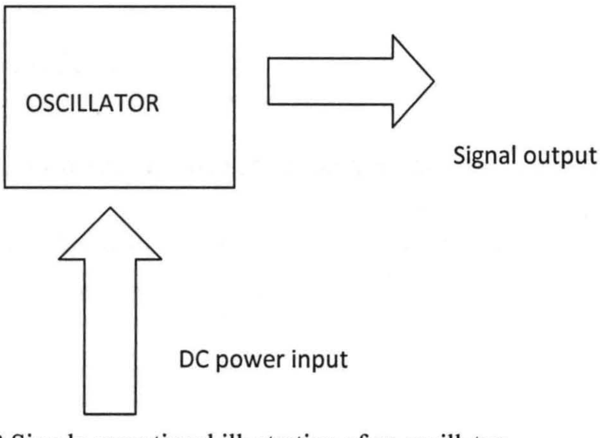


Fig 2.2 Simple operational illustration of an oscillator

2.2.1.1 VOLTAGE VARIATION OSCILLATOR

This is a source of energy that generates a particular high frequency. It is called an oscillator because it provides its own output signal via the feedback network and produces an output frequency that has been predetermined. The circuitry is such that

β A=1 at that fixed frequency only [11].

β =feedback ratio

A=amplifier gain

$$\text{Feedback ratio } (\beta) = \frac{\text{Feedback voltage } (V_t)}{\text{Output voltage } (V_0)}$$

This conduction $\beta A=1$ is satisfied both in magnitude and in phase for a voltage variation oscillator.

2.2.1.2 THE COLPITTS OSCILLATOR

This a special kind of oscillator with feedback supplied capacitively. The oscillator consists of a capacitor which provides a feedback path and an inductor which is a frequency determining network. Shown in fig 2.3 is a simple AC equivalence colpitts oscillator

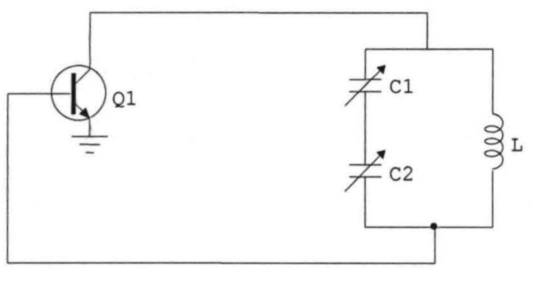


fig 2.3 An AC equivalence colpitts oscillator

The f2equency of the output signal is determined by the inductor and capacitor as illustrated by the formula shown.

$F = 1/2\pi\sqrt{LC}$

Where L=inductance of the inductor

C= capacitance of the capacitor

Thus, an increase in the inductance reduces the frequency of oscillation while a decrease will increase the frequency [9].

2.2.2 THE MIXER

The mixer in this context refers to a modulator. This modulator works in a principle of heterodyning action, this action is the process of combining two AC signals of different frequencies in order to obtain a new frequency. Suppose we have a carrier signal of frequency Fs it can be heterodyned with another signal of frequency Fo, the two additional frequencies will be produced which are;

(i) Fo + Fs- the sum component

(ii) Fo - Fs- the difference component [9]

2.2.3 THE AMPLIFIERS

This electronic circuit functions in providing gain. This gain could either be in voltage or current depending on the signal at the input.

Amplifier types like the op-amps are available in integrated circuit (IC) packages in several forms [13]. Fig. 2.4 shows a typical op amp package.

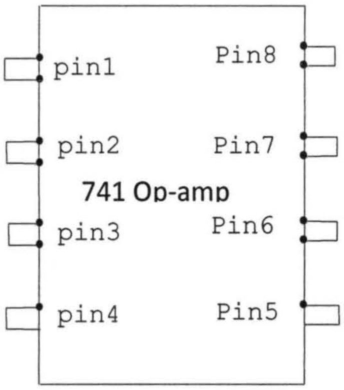


Fig 2.4 An Eight pin Dual In-line package (DIP) 741 Op-amp

These OP-amps are seen to have pins from pin1 to pin8 with the following label

Pin1- the balance

Pin2- the inverting input

Pin3- the non inverting input

Pin4 - the ground (V^-) or negative power source

Pin5- the balance

Pin6- the output

Pin7- the positive power supply (V^+)

Pin8- No connections

To achieve the amplification of signals, a pattern of arrangement of the resistors, transistors, capacitors and diodes in the IC package is adopted. For amplification the gain (G) has to be greater than 1, G>1.

2.2.4 THE MICROCONTROLLER

The microcontroller or programmable logic controllers (PLC) is a device built around microprocessor and its functions are determined by a program which it stores. The program can be fairly readily changed, but generally, once they have been established, the program is set to operate and left to perform on its own. For example having set a microcontroller to trigger a voice output (audio tone) from a voice IC when a metal object is brought close to the metal detector which, it would be switched on 24 hours a day ready to respond to any call. Microcontrollers are relatively cheap, flexible, can perform sequencing, timing, monitoring and counting on their own [11].

An example of a microcontroller single chip is the AT89C2051.

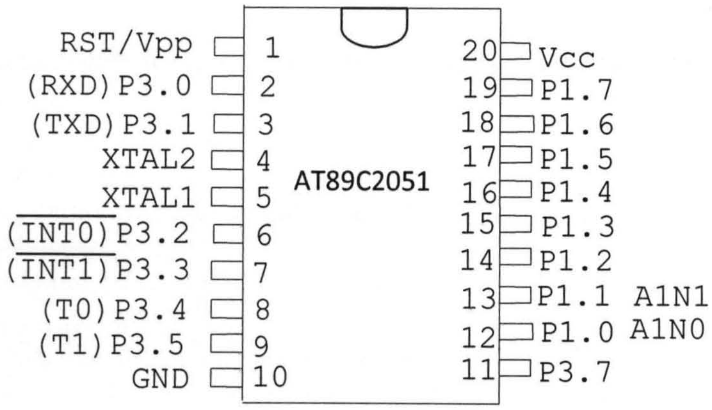


Fig 2.5 Pin configuration for AT89C2051 microcontroller IC chip

The pin descriptions are;

Vcc- pin20 is the supply voltage

GND-pin10 is the ground

Port 1- pin12 to pin19 are used for internal and external pull-ups, and are also used as inputs when 1s are written to them.

Port 3- pin2,3, 7, 8,9,11, these are I/O pins, there can also be used as input pins when 1s are written to them.

RST- pin 1, Reset input. All I/O are reset to 1s as soon as RST goes high.

XTAL1- pin5, input to the inverting oscillator amplifier and input to the internal clock operating set.

XTAL2- pn4, output from the inverting oscillator amplifier.

2.2.5 THE VOICE IC

The design and construction makes use of the Wisbonds ISD2500 chip corder series, particularly ISD25120 which is a single chip, Record/Playback solution for 0-120 second applications. This CMOS device includes an on chip oscillator, microphone pre-amplifier, automatic gain control, antialiasing filter, smoothing filter, speaker amplifier, and high density multi-level storage array. In addition, the ISD25120 is microcontrollable compatible, allowing complex messaging and addressing to be achieved. Recordings are stored into on-chip non volatile memory cells in their natural form which enhance high quality, solid state voice reproduction [14].

It's a 28pin single chip as illustrated in figure 2.6

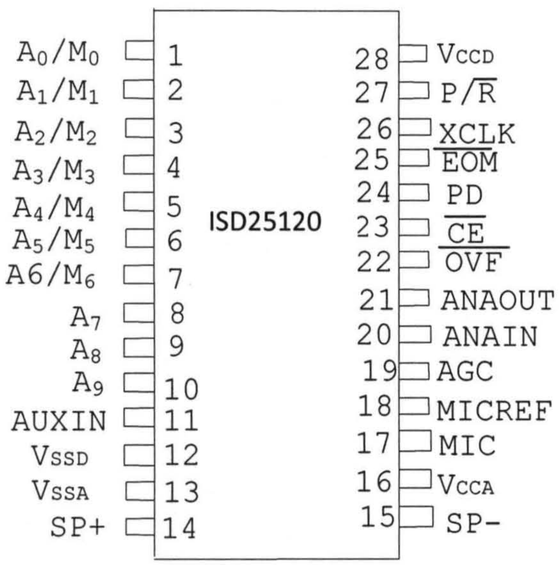


Fig2.6 Pin configuration for ISD25120 Voice IC chip

The Ax/Mx- pins 1-10 are addressing modes

AUX IN – pin11 is the auxiliary input that is multiplexed through ton the output amplifier and speaker output pins.

VSSA, VSSD - pin 13 and 12, these are the ground pins.

SP+, SP- -pins 14 and 15; these are the outputs to the speakers.

VCCA , VCCD – pin 16 and pin28; these are the supply voltage pins

MIC –pin 17; this is the microphone pins transfer input signals to the on chip pre-amplifier.

AGC – Automatic Gain Control

ANA IN – pin20; analog input

ANA OUT –pin21; analog output

$\overline{\text{OVF}}$ -pin22 The overflow pin

$\overline{\text{CE}}$ - pin23; Chip Enable pin

PD - pin 24; Power Down Pin

$\overline{\text{EOM}}$ - pin25 End of Message pin

XCLK -pin26; external clock pin

P/$\overline{\text{R}}$ -playback/record pin

2.2.6 THE POWER SUPPLY

The power unit is an essential part of every electronic. All electronic are 'dead' if there is no power supply to it. Power could come in different forms, could be from natural sources; solar, wind, hydro, or it could be from electrodes an electrolytes used in dry cells or wet cells e.g 9V dry cell batteries. Some devices makes use of alternating current (AC) sources and with their inbuilt rectifiers, this AC power supply is converted to Direct current (DC) which is used to operate the device. Some device are able to use both Direct current (DC) source e.g batteries and also the alternating current (AC) sources supplied by transmission cables down to the socket outlet at our homes. This unit is very essential as without it the amplifier, transistors, oscillators, microcontrollers and IC's will not operate.

The DC power supply unit converts the standard 230V, 50Hz AC available at all socket outlets into a constant DC voltage. The DC voltage produced by power supply is used to power all types of electronic circuits, such as television receivers, computers and laboratory equipments. A typical DC power supply consists of five stages as shown in fig. 3.1. Thus, the ICs and other components used run on a power supply of 5V and 12V, hence the supply must be regulated to prevent fluctuation in voltage level.

Fig. 2.7 A typical dc power supply block diagram

These blocks can be briefly explained as follows:

(i.) **Transformer:** its function is either to step up or (mostly) step down the AC supply voltage to suit the requirement of the solid state electronic devices and circuits fed by the dc power supply.

(ii.) **Rectifier:** it is a circuit which employs one or more diodes to convert AC voltage into pulsating DC voltage. A rectifier can be either a half-wave rectifier or full-wave rectifier. In this design a full-wave rectifier was employed.

(iii.) **Filter:** the function of filter of this circuit element is to remove the fluctuations or pulsations (called ripples) present in the output voltage supplied by the rectifier. This is done by connecting a capacitor filter to the rectifier.

(iv.) **Voltage Regulator:** Its main function is to keep the terminal voltage of the DC supply constant even when the AC input line voltage to the transformer, or the load varies.

(v.) **Load:** the load block is usually a circuit for which the power supply is producing the DC voltage and load current.

2.3.0 TYPES OF METAL DETECTORS

2.3.1 VERY LOW FREQUENCY (VLF) DETECTORS

They are detectors designed to combined frequency from two balanced coils. The outer coil acts as a transmitter using alternating current to create a magnetic field that is distorted by metallic objects and the inner coil acting as a receiver, reading the secondary magnetic field created by the conductive object. This magnetic field is amplified and converted to an audio tone [8]. They operate at very low frequencies (below 30 KH_Z) and this is the reason for their name. Examples are;

Heathkit Groundtrack GR-1290 VLF metal detector

Minlab Excalibur 1000, Fisher CZ 20 [10]

2.3.2 PULSE INDUCTION (PI) DETECTOR

The PI inductor works by sending repeated pulse of electrical current to the search coil, producing a magnetic field. The coil transmits pulse towards the ground , in the absence of a metallic object the pulse will delay at a uniform rate and time it takes to fall to zero is measured. In the case where a metallic object lies in the path of the sent pulses, a small current will flow in the metal and the time for the voltage to fall to zero would be increase. The sampling circuit will notice the difference in time and then responds by triggering the audio tone [3, 6, 10].

Pulse inductors are able to detect objects buried deep underground. Example is the white surfmaster pulse induction metal detector.

2.3.3 THE BEAT FREQUENCY OSCILLATOR (BFO) DETECTORS

The basic beat frequency metal detector employs two radio frequency oscillators which are turned near the same frequency. The first is called the search oscillator and the other is called the reference oscillator.

The outer of the two Oscillators are fed into mixers which produce a signal that contains the sum and different frequency components. As long as the two oscillators are tuned to the same frequency, the output will have no signal. When a metallic object disturbs the magnetic field of the search coil, the frequency of the search oscillator shift slightly and the detector will produce a signal in the audio frequency range, which could be heard with an earphone [10].

2.3.4 MAGNETOMETER DETECTORS

This technology of metal detector detects only ferrous metals (Iron/Steel) but at long ranges. It works by detecting small abnormalities in the earth's magnetic field. They are usually rugged in use and their detection range is not affected by the medium between the metal detector and the metal target and also their performance does not change whether detecting through air, water, sand or solid coral. It is also an old technology in metal detecting and cannot be used in some applications like treasure hunting and security purpose [3] [4].

Before now, they have been many attempted works on metal detectors in the department of Electrical and Computer Engineering, Federal University of Technology Minna, designed and constructed by students but none with a voice output.

This project uses the electromagnetic induction principle as its basis, the metal detecting technology adopted to achieve the output response is the Beat frequency oscillation (BFO) technology. If a metallic object is brought close to the search coil which has a direct connection to the second oscillator (Colpitts oscillator), there will be an increase in the current which is as a result of the magnetic induction on that pat of the circuit, thus varying its frequency from that of the first oscillator (reference oscillator). The two oscillator frequencies are mixed, and the beat frequency (the different frequency) output from the mixed frequency is fed to the detector stage. At this stage the signal is modified, and then pass through an amplifier before it is sent to the micro controller output stage.

The microcontroller controls a voice IC connected to it. This stage has to be maintained at a supply voltage of +5V as any increment of decrement beyond 0.1 V will blow the microcontroller circuitry. The voice IC contains the recorded voice tone " Caution: A metal has been detected" which comes up when a metal object is detected.

CHAPTER THREE

3.0 DESIGN AND CONSTRUCTION

3.1.0 SYSTEM DESIGN

The design procedure for this device follows the block diagram illustrated in figure 3.0 below

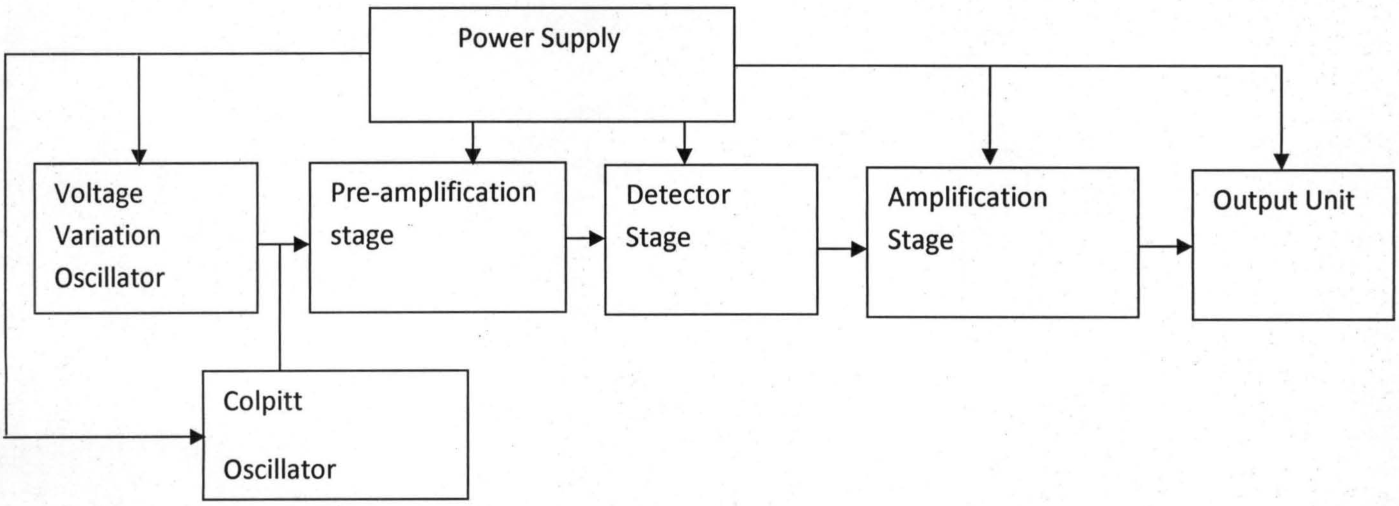


Fig. 3.0 Generalized Block Diagram

3.1.1 VOLTAGE VARIATION OSCILLATOR UNIT

The voltage variation oscillator unit comprises a fourteen pin integrated IC and a search coil. This construction uses a 40106IC which is designed to transmit signals to the colpitt oscillator by the inbuilt inductance capacitance (LC) circuitry.

Table 3.1Parameters of 40106 IC

TECHNICAL INFORMATION	40106 IC
Category	Integrated Circuits
Package/ Case	14- DIP
Voltage Supply	4.5V – 15.5V
Operating Temperature	-40°C – 125°C
Current Rating	2.4mA

A schematic representation of this unit is shown below.

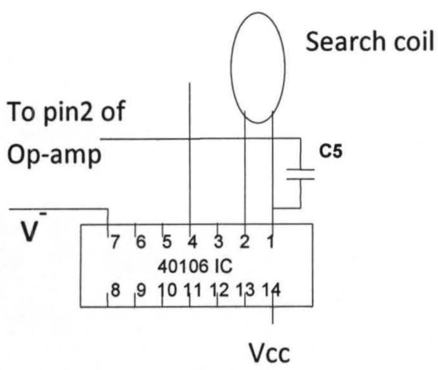


Fig 3.1 Voltage variation oscillator with coil connection

This stage is also composed of large number of coils with 70 numbers of turns and with an area of 8cm^2, this was done to generate a high radio frequency and the inductor which is being made up copper will now exert a diamagnetic characteristic.

A diamagnetic material is a material that opposes the field of an external magnetic field to induce its own eddy current to generate an internal field. Therefore, since the search

search coil is made up of copper wires which is diamagnetic, the coil will experience excitation in a case of introduction of a metallic object, in so doing it creates its own fields and sets the domain in the metal on excitation, which in turn exert their own magnetic field. By this action eddy current is induced which tends to oppose the external magnetic field, at this point a voltage is induced in the coil.

When the coil is moved along the metallic object the voltage will be variated within the copper. The varying voltage will be received by the 40106 IC which is a Hex Smith Trigger IC with six buffer, it amplifier this voltage tand signals the colpitt oscillator, the signal at this point is a negative voltage signal and this action occurs only when a metal is brought close by.

3.1.2 COLPITTS OSCILLATOR

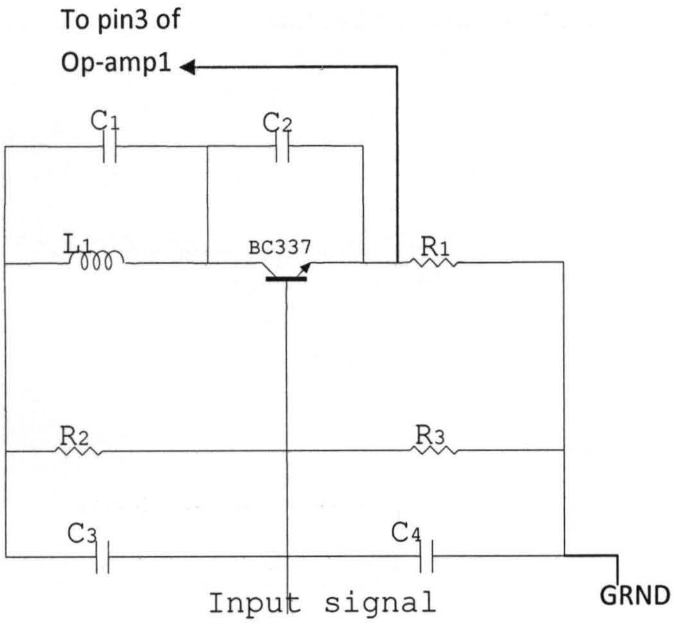


Fig3.2 The Colpitts Oscillator

The colpitts oscillator is an oscillator that can generate high frequency up to radio frequency. The colpitt oscillator is composed of the tank circuit, the positive feedback capacitor, a voltage divider and the decouple capacitor.

The tank circuit is the part that contains the LC circuit with capacitor of capacitor of capacitance (C_1=InF) and inductor (L_1=0.5Mh). the frequency of the tank circuit is

$$f = \frac{1}{2\pi\sqrt{LC}} = \text{frequency of the tank circuit}$$

$$L_1 = 0.5\text{mH} = 0.5 \times 10^{-3}\,\text{H}$$

$$C_1 = \text{Inf} = 1 \times 10^{-9}\text{F}$$

$$f = \frac{1}{2\pi\sqrt{0.5\times10^{-3}\times1\times10^{-9}}}$$

$$f = \frac{1}{2\pi\sqrt{0.5\times10^{-3}\times1\times10^{-9}}} = \frac{1}{4.443\times10^{-6}} = 225.06 \times 10^{3}\text{Hz}$$

$$f \approx 225.06\text{KHz}$$

This frequency of oscillation of the tank circuit is as a result off the conversion of electrical energy to magnetic energy inside the inductor coil.

The frequency signal generated (225.06kHz) changes in the tank circuit whenever it comes into contact with a metal. This change in frequency at the output of the colpitt oscillator is as a result of the metal interaction with electromagnetic wave generated by the coil (interference).

Also the frequency of the colpitt oscillator is expressed as

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

Where, $L = L1 = 0.5 \times 10^{-3}H$

$$Ceq = Cequivalence = \frac{C_1C_2}{C_1+C_2}$$

$$C_1 = InF = 1 \times 10^{-9}F$$

$$C_2 = 100pF$$

$$C_{eq} = \frac{1\times10^{-9}\times100\times10^{-12}}{1.0\times10^{-9}+100\times10^{-12}} = \frac{100\times10^{-21}}{1.1\times10^{-9}}$$

$$C_{eq} = 90.91 \times 10^{-12}F = 0.0909InF$$

$$f = \frac{1}{2\pi0.09091\times10^{-9}}$$

$$f = \frac{1}{2\pi\sqrt{0.045455\times10^{-13}}} = \frac{1}{2\times3.142(0.2132\times10^{-6})}$$

$$f = 745.44KHz$$

This gives the frequency generated at the out put of the colpitt oscillator. The feedback capacitor (C_2) provides the link for feeding back the output frequency to the input to continue regeneration of the frequency as to avoid damping of the frequency.

The voltage divider is a parallel connection of $R3 = (10k\Omega)$ and $R_2 = (27k\Omega)$ so as to share the voltage across the transistor to keep itself biased.

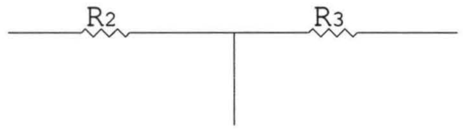


Fig3.3 The voltage divider Resistors

The two capacitors (C_3 & C_4=2.2nF) functions as decoupling capacitors. This capacitors network isolates the frequency from the input to the ground.

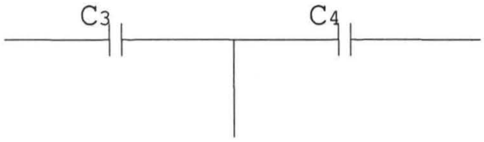


Fig 3.4 The decouple capacitors

3.1.3 PRE-AMPLIFIER STAGE

The stage is made up of two 741 operational amplifiers. There are differentiators designed to respond to low frequency and also amplify the signals.

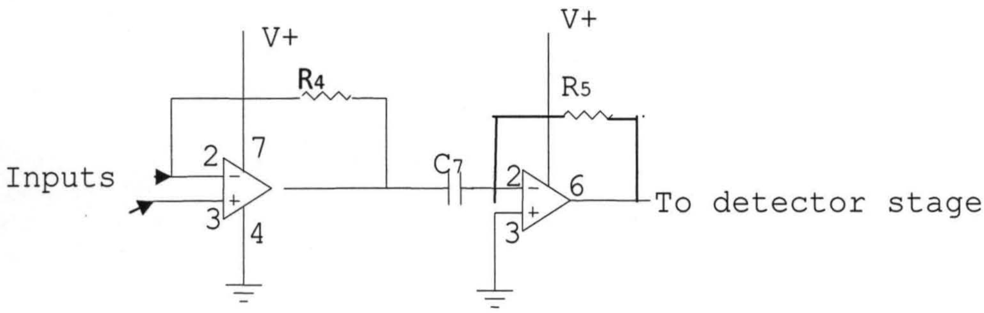
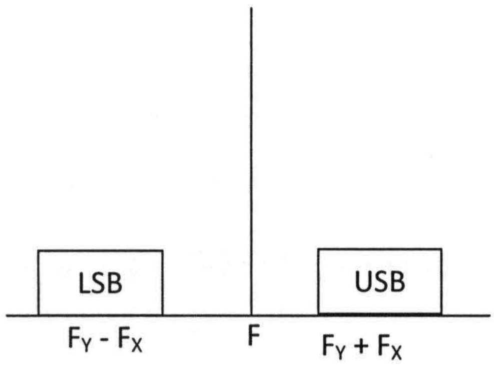


Fig3.5 The pre-amplification unit

At this stage also the variable voltage oscillator unit signal is mixed with that from the colpitts oscillator and at this point the modulation of the two frequencies occur.

The frequency from the voltage variation oscillator is referred to as Fx and the frequnecy of the colpitts oscillator as Fy. Therefore the sum frequency $(F_x + F_y)$ is termed the upper side frequency $(USB = F_x + F_y = 740KHz + 745kHz = 1485\ kHz = 1.485\ MHz)$ and the difference frequency $(F_y - F_x)$ is termed the lower side frequency$(LSB = F_y - F_x = 745KHz - 740kHz = 5kHz)$.



LSB = Lower side band

USB = Upper side band

Fig. 3.6 illustration of frequency bands

Thus, as the 5KHz and 1485KHz approaches the input of the differentiator (the first 741 op-amp), this differentiator already designed to respond only to lower frequencies will accept the 5kHz and gives an out put at pin 6 which goes to the second op-amp for amplification.

3.1.4 THE DETECTOR STAGE

The detecting part comprises of two diodes and a capacitor. At a constant frequency of the pre-amplifying stage, the first diode helps in detecting the signal and thereby rectifying it. The action here gives a positive polarity for the capacitor to charge, so at this point the capacitor is charging to its maximum thus, immediately there is a variation of voltage which comes as a negative peak voltage the first diode will block, the connection is blocked by the first diode which now acts as a valve. At this point the capacitor begins to discharge in reverse direction and the second diode can now conduct and complete the path to the amplifier.

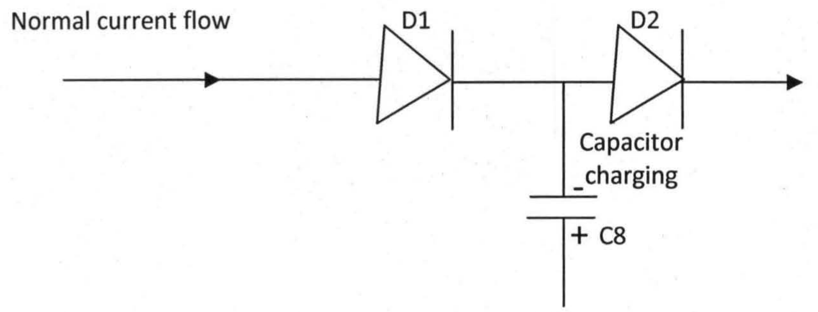


Fig3.7a Illustration of the charging capacitor

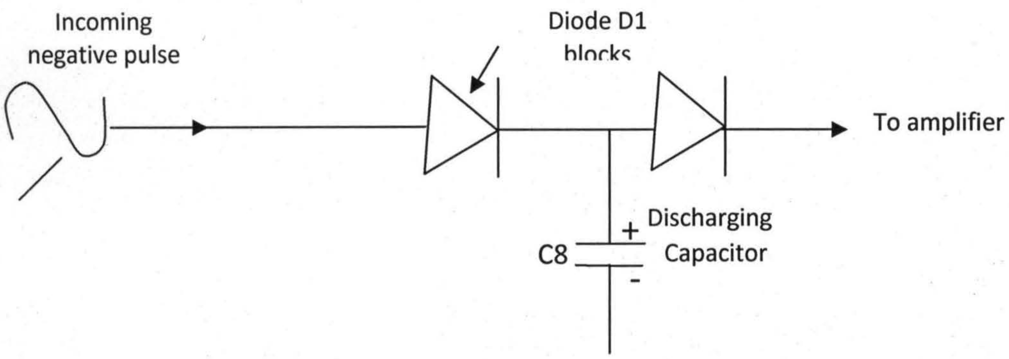


Fig3.7b Illustration of discharging capacitor

3.1.5 THE AMPLIFIER STAGE

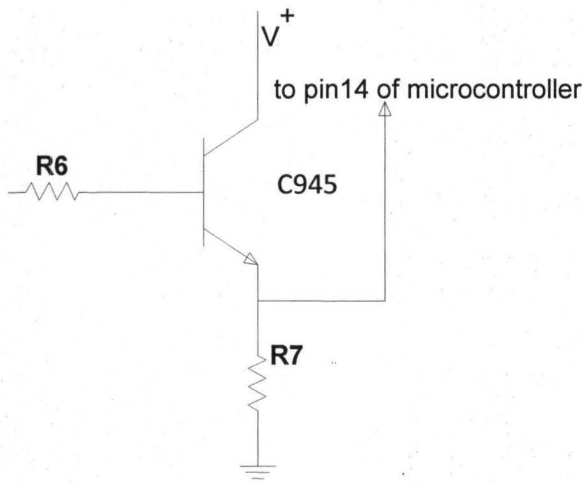


Fig 3.8 the amplifying unit

The amplifier stage is made up of a common collector transistor (C945) with a voltage gain less than 1, high input resistance with a preferable current gain.

Its operation is; when the capacitor starts charging, it will cause a negative potential which will make the transistor to completely cut off from the saturation point thereby given no output but immediately there is no output from the first diode, the capacitor will begin to discharge thereby making the input of the transistor to be positively biased, it is at the point that the transistor will begin to conduct. Current now flows across the collector to emitter, thereby dropping as voltage across the resistor at the emitter line, this gives out an output that goes to the microcontroller in the output unit.

3.1.6 OUTPUT STAGE

This unit comprises the micontroller IC(AT89C2051), the voice IC (ISD25120) and the speaker.

3.1.6.1THE MICROCONTROLLER

This design uses the AT89C2051 microcontroller which has 20 pins. It is a low voltage, high performance CMOS 8-bit microcontroller with 2K bytes of flash programmable and erasable read only memory (PEROM).

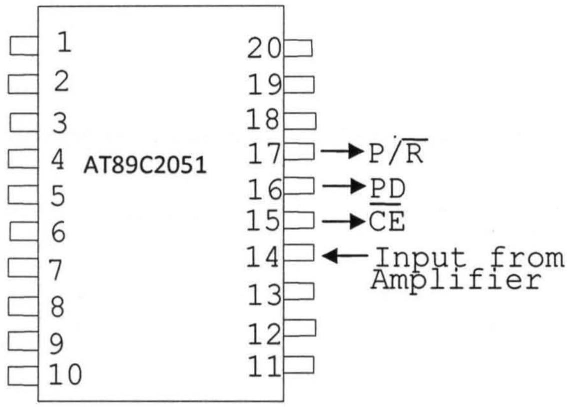


Fig3.9 pin connections for the microcontroller IC Chip

This device is compatible with the industry standard MCS-51 instruction set. Its pin 14 connected to the output from the amplifying transistor with the pin 15,pin 16 and pin 17 connected to the Chip Enable (CE) pin, the Power Down (PD) pin and the Playback/Record (P/R) pins respectively of the voice IC chip.

3.1.6.2 THE VOICE IC

This unit is comprised of the voice IC which is a 28 pins single IC chip with model number ISD25120. The voice IC is able to record and play voice recordings up to 120seconds. The recorded voice is heard through the speaker connected, these connections are made to the pin14 and pin15 of the voice IC as shown.

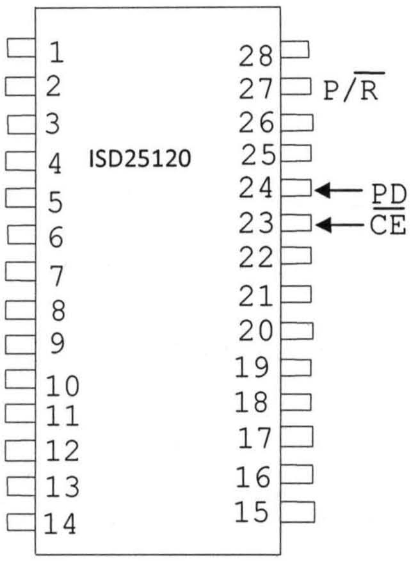


Fig3.10 pin connections for the voice IC Chip

Pin23 which is the Chip Enable ($\overline{CE}$) pin receives signal from the pin15 of the microcontroller, pin24 is the Power Down (PD) which is connected from the power down pin of the microcontroller and the pin27 which is the Playback/Record pin is connected to the pin17 of the microcontroller. With proper connections, the device thus far was able to play the recorded sound "Caution: A metal has been detected"

3.1.7 THE POWER SUPPLY UNIT

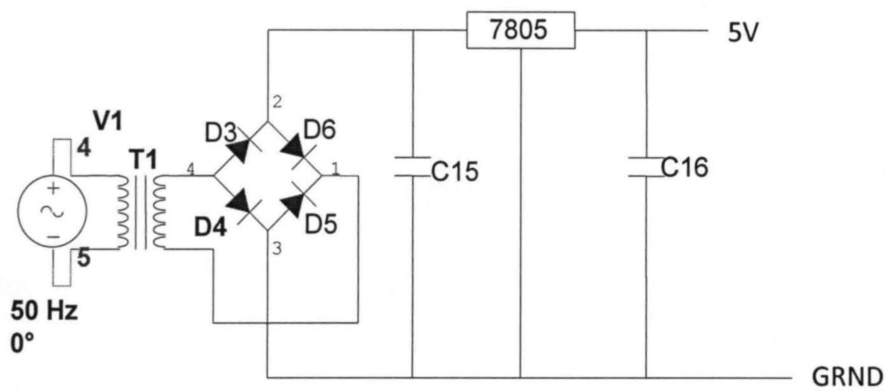


Fig3.11 power supply unit

The power supply unit consist of a transformer with rating of input voltage 220v and output voltage of 15v (220/15V) a full wave rectification unit of four diodes (D_3, D_4, D_5 & D_6 =IN4001) with the output DC being fed to a 5V voltage regulator. The capacitors C16 & C17 are to filter the power signals.

3.2 HOW THE SYSTEM WORKS

The operation of the metal detector is based upon the principle of electromagnetic. The design involves the comparison of signals from two sources, the colpitts oscillator and the voltage variation oscillator unit. In the absence of a metal there will be no output to the microcontroller unit since the capacitor at the detector unit will now be charging.

However, when the search coil of the metal detector is brought close to a metal, there will be an induced voltage which now leads to variation of frequency and this will make the first diode at the detection unit to block and second diode conducts and connects the detection unit to the amplifying unit which is a common collector transistor (C945).

This unit transfers the signal to pin 14 of the micro controller which receives this signal and triggers the voice IC connected to it through pin 16 to play the recorded audio voice.

This voice is heard by the help of a speaker connected to pins 14 and 15 of the voice IC.

CHAPTER FOUR

4.0 TEST, RESULT AND DISCUSSION

4.1 TEST AND RESULTS TABLE

The following test were performed and the results tabulated.

Tabe 4.1a Test result for Power Supply(AC)

Vcc		
Designed value (V)	LAB Value (V)	Preferred Value (V)
5.0	4.9 – 5.1	5.0

Table 4.1b Test result for Power Supply(DC)

Designed value(V)	LAB Value (V)	Preferred Value (V)
12	10V – 11.5	12

Table 4.2 Sensitivity of search coil in percentage

Distance (cm)	Efficiency (%)
1-2	80
3	75
4	60
5	50

Table 4.3 Voice output range as regards strenght of battery

Battery strenght (V)	Voice out put range (m)
10.0	10
10.5	15
11.0	25
11.5	30

4.2 DISCUSSION OF RESULT

From the test and results, it is seen that the sensitvity of the device depend on the strenght of the battery and the closeness of the test metal object. In some of the test instances it was also observed that there were delays in the response from this device and this could be that the frequency distortion from the metal was not strong enough to give an output signal.

4.3 LIMITATIONS

Metals at great depth inside the ground were not able to be detected by this device, this is as aresult of the design which made use of electronic component with small ratings and strength, also the small diameter of the search coil contributed to this, though larger diameter would have resulted in less sensitivity to small objects.

4.4 BILL OF ENGINEERING QUANTITIES

The bill of engineering quantity for this project design is seen in the table below

Table 4.4 Cost Analysis

S/N	Desciption	Quantity	Amount	Total amount(N)
1	Transformer	1	230	230
2	Diodes	6	10	60
3	Capacitors	17	20	340
4	Breadboard	1	60	60
5	Veroboard	1	100	100
6	Copper coil	1	300	300
7	741 Op- Amps	2	50	100
8	Inductor	1	10	10
9	Transistor	2	10	20
10	Regulator	1	50	50
11	40106 IC	1	100	100
12	Microcontroller	1	1500	1500
13	Voice IC	1	1500	1500
14	Speaker	1	150	150
15	Wires	1	100	100
16	Casing	1	1200	1200
17	Total	37		5,820

4.5 CONSTRUCTION DETAIL

The construction involves the the design of the various units (power supply, metal detecting unit and the output unit) initially onthe breadboard and later trasnfer to the veroboard.

For the power supply unit the step down transformer (230/12V) was used as the first component, the secondary end of the transformer was connected to the two legs of the bridge rectifier block which consist of four IN4001 diodes that were also soldered on the veroboard. All other coponents; the regulator (7805), the capacitors, the IC's, resistors and inductors were all soldered following the circuit arrangement.

During the construction process, care was takent toensure that the right components were correctlyconnected in their right polarities. All excess wires were neatly clipped and all solder connections properly made. The components were laid out on the vero board with enough spacing to give room for replacement of fault components , ventilatin and troubleshooting.

After all soldering and placement, a plastic casing was constructed to house the device.

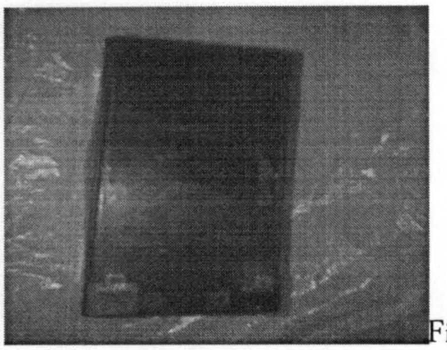


Fig 4.1 12V DC Battery

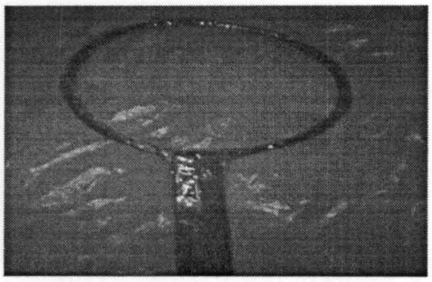


Fig 4.2 the search coil

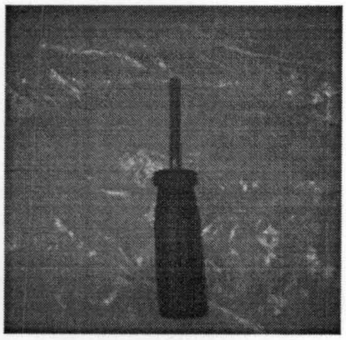


Fig 4.3 Metal object for test

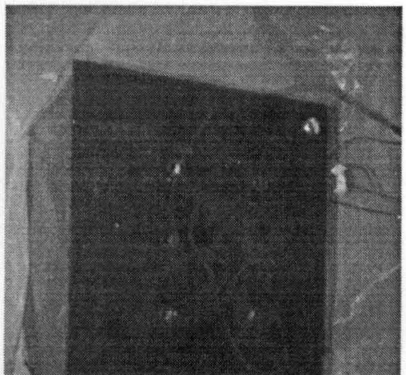


Fig 4.4 Metal Detector for test

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The metal detector was found to be sensitive to change in frequency which is due to the use of oscillators and transistors based on the super heterodyne principle as can be noticed in the interferrence with the radio frequencies.

Furthermore the aims of the project as stated earlier in chapter one was achieved, which is designing an effective and fast means of detecting objects made of metals at a reduced cost using electromagnetic induction principle with the super heterodyne principle.

5.2 PROBEMS ENCOUNTERED

Some of the components were not readily available in the local market. This result in the use of their equivalents. Due to the use of alternative components the sensitivity was not that effective as it should be.

Also for the microcontroller unit it was very difficult to properly regulate the voltage as the device only needs a voltage input of 5V with only a 10% variation as an increase or decrease in the output voltage greater than the specified can completely damage the microcontroller.

The voice IC ISD25120 was not able to give out a perfectly clear audio output, though the response “Caution: A metal has been detected” could be heard but not clearly by those who are at about 10metres away from this device.

In the course of soldering on the veroboard certain components were burnt and this led to replacement of such components which incurred extra cost.

5.3 RECOMMENDATION.

I recommend that advancement on this project should involve frequency discriminators so as to be able to differentiate between different types of metals.

I also recommend that this construction be put to application at the department entrance door, the lab and offices, so that student would appreciate and see the need for creative reasoning and to challenge them to their own innovations.

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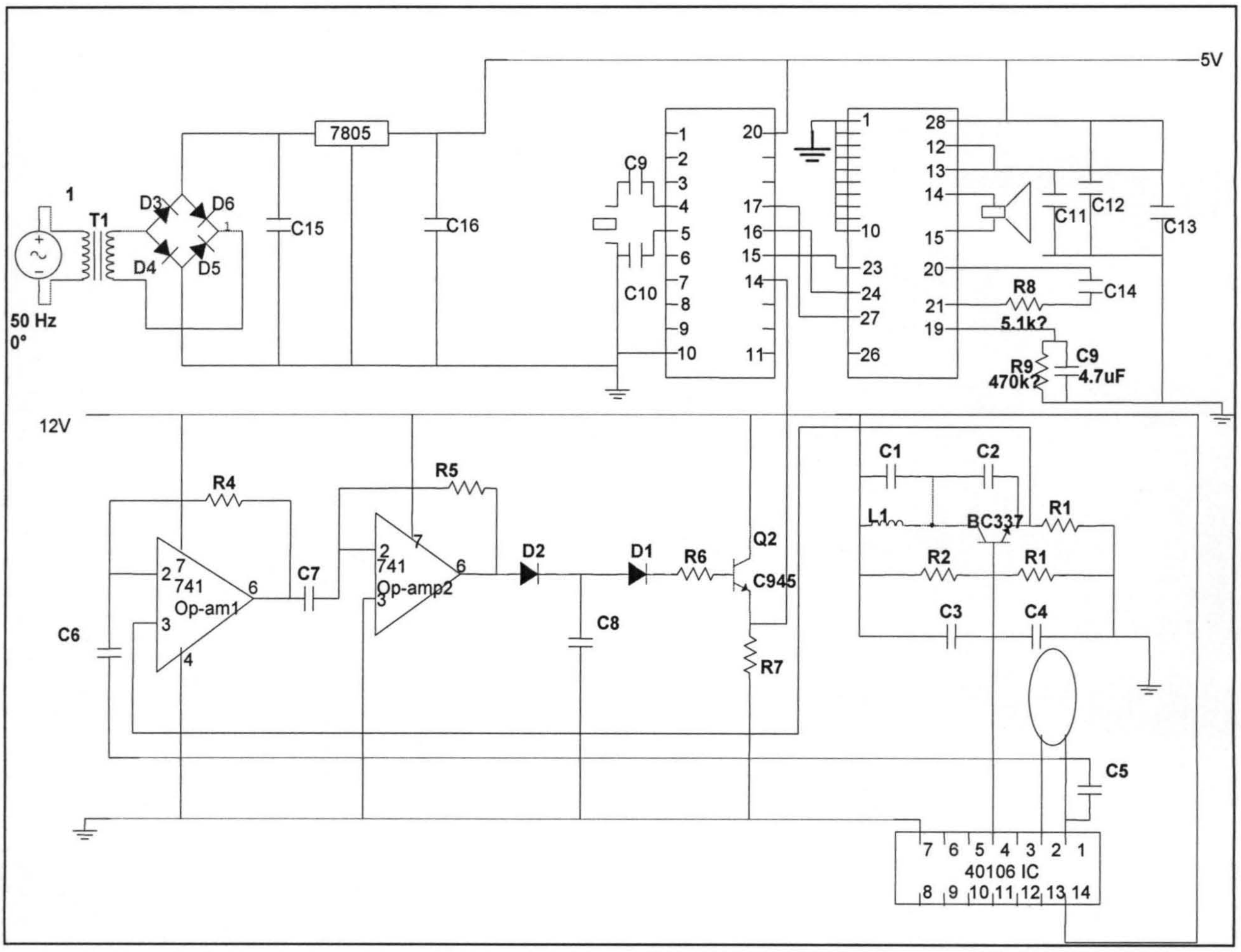
APPENDIX

FULL CIRCUIT DIAGRAM



COMPONENT VALUES

R1= 1K	R5= 1M
R2=27K	R6= 1M
R3= 10K	R7= 1K
R4= 1M	R8= 10K

C1= 1nF

C2= 100pF

C3= 2.2nF

C4= 2.2nF

C5= 100nF

C6= 0.1uF

C7= 1uF

C8= 1uF

L1= 0.5mH

D1= IN4148

D2= IN4148

D3= IN4001

T1= 220/15V

C9= 33pF

C10= 33pF

C11= 0.1uF

C12= 0-1uF

C13= 2.2uF

C14= 0.1uF

C15= 4.7uF

C16= 100uF

C17= 100uF

D4= IN4001

D5= IN4001

D6= IN4001