DESIGN AND CONSTRUCTION OF A CONTINUITY/CUTPOINT DETECTOR

BY

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2001/11887EE

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

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DECLARATION

I, Abidoye Adekunle of matric number 2001/11887EE hereby declare that this dissertation is an original work wholly done by me under the supervision of Engr. A. M. Zungeru and submitted to the Department of Electrical Engineering, Federal University of Technology Minna. All works used in the preparation of this thesis have been duly acknowledged.

Abidoye Adekunle

23-11-2007

Date

CERTIFICATION

This is to certify that Abidoye Adekunle(2001/11887EE) carried out this research that it has been read and approved as meeting the requirements of the Department of Electrical and Computer Engineering, School of Engineering Technology, Federal University of Technology, Minna. for the award of Bachelor of Technology(B.Eng.) in Electrical Engineering.

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DEDICATION

To God Almighty, my help in ages past, my hope for years to come, my shelter from the stormy blast and my eternal home.

My Parents for their undivided support throughout my stay in School.

ACKNOWLEDGEMENT

My sincere and immense gratitude goes to Almighty God for his grace over my life, for the successful completion of this programme and for his protection and love for me.

I wish to tender my sincere and unreserved gratitude to my supervisor Engr. A.M. Zungeru for his great job and understanding. His contribution has made the completion of the project work a success. I acknowledge with my sincere appreciation, the effort and knowledge impacted on me by Engr. M. D. Abdullahi, I pray God Almighty reward you abundantly. I wish to acknowledge the contributions of Dr. Y A. Adediran, and the entire lecturers in the department, God bless you all.

I want to say a big thank you to my Darling and my beloved parents Engr & Mrs. S. B. Abidoye, for their love, undivided support and ceaseless encouragement. Your support and words of encouragement has brought me this far. To my wonderful sisters, Lola, Rolake and Tolu (you all have been my source of joy, thanks for being there for me). I will forever be grateful.

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I sincerely appreciate the contributions of my course-mates and others too numerous to mention.

ABSTRACT

This project aims at developing an electronic system for detecting continuity/cut point in an electrical system.

The continuity tester consist of five units which are the power supply unit, the transistor switch unit, the sensing unit, the multivibrator unit and the transducer/ indicator unit. These units are designed using ICs such as 555 timer, decade counter (CD 4017), transistors, resistors, light emitting diodes, a switch and a Speaker. A careful combination of all these units forms the continuity/cut point detector.

The aim of this project, which is to see that a sound signal is given when there is discontinuity in power supply, was achieved at the end of this project.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0 INTRODUCTION.

The past few decades has witnessed tremendous advancement in the field of science and technology anchored on the development in the electronics and computer world. In all of this, it is the duty of the engineer to ensure that these advancement are undertaken and maintained with the available minimum resources. Micro electronics is a form not far fetched. It entails the ability to miniaturise very complex electronic circuits to small chips. These chips are interconnected with other chips and discrete electronic component via the tracks of a printed circuit board. PCB is not a very expensive material, the cost comes from the chips placed on them.

The non-functionality or malfunctioning of an entire board can be caused just by a samples crack or cut on the copper tracks linking the chips or a (short circuit) between the pins of the chips among others causes . One of the solution of a problem of this kind is to discard the faulty board and replace it with an entire new one, but this will be tantamount to acute wastage of resources. On the other hand, a little troubleshooting would not be a bad idea. To do this, one very important test equipment is needed, a continuity tester.

Continuity in an electrical circuits means that there is a path of negligible or very small resistance for current to flow through, while an open (open circuit) stands for no path at all or path of very high resistance. Both continuity and opens are diagnosed by a continuity tester.

In the printed circuit boards, after a fault of an open (discontinuity) has been diagnose between two points, the actual point of cut or discontinuity can be detected by careful observation of the copper track between the two points. But in the case of an insulated cable or cabled buried in walls, plastic or ground. Much more than a continuity tester is needed. An electromagnetic enhanced cut point detector would both test for continuity as well as detect the cut point in such cable without making physical contact with the copper wire inside the insulated cables.

1.1 LAYOUT

The layout of the project is divided into three, and the block diagrams of the different layouts are shown in figure 1.1

1.1.1 P.C.B CONTINUITY TESTER

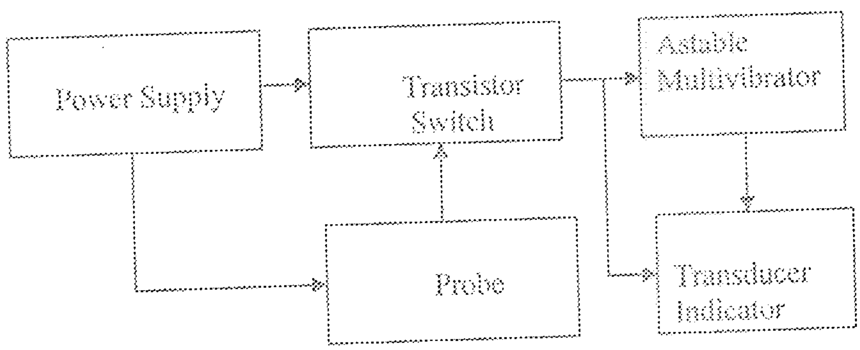

Fig. 1.1 block diagram of continuity tester module

The continuity tester can test for continuity in printed circuit boards and also between any two exposed parts of a circuit. It gives both an audible and visual indication for continuity and non for opens. This ensure that the user keeps the eyes fixed on the probe tip while working.

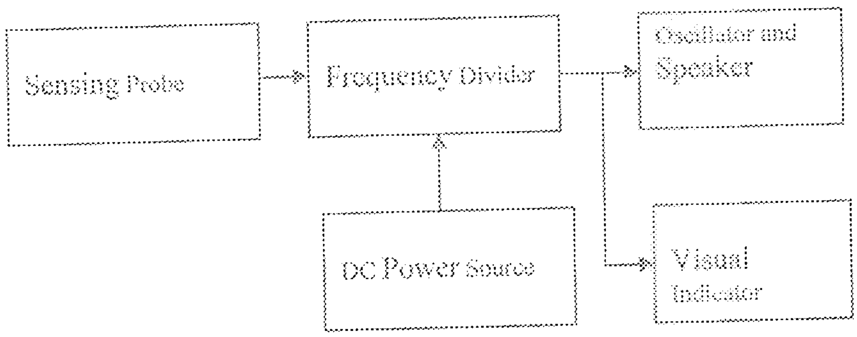

Fig. 1.2 block diagram of cut point detector module.

The cut point detector is used in testing for continuity in insulated cables and also detects the cut point in such faulty cables. It is required that the cables under test be powered with the live line of an AC power source. The cut point detector sensed the electromagnetic field around the powered cable through the probe. The frequency is divided by ten and then passed to the indicators which are both audible and visual.

1.2 OBJECTIVES OF THE PROJECT

The objectives of the project and other functions it can accomplish are:-

i) To test for continuity and opens in both analogue and digital circuits on a printed circuit board (PCB).

ii) To test for continuity in insulated cables or cables buried in plastic, ground or on circuit board (PCB)

iii) Detect high voltage in AC and the electromagnetic filed from such sources.

iv) Detect the cut point in faulty discontinuous insulated cables and buried cables

1.3 METHODOLOGY

The design of the cut point detector was first conceptualized and then continity tester. The construction was done based on modular construction in which each module of the project was constructed separately and then tested. The two main module are the continuity tester and the cut point detector modules each of the modules are further subdivided into smaller modules that define the principles guiding the operation of the project. After the operation of individual modules was confirmed to be working according to design and expectation, the two separate modules were joined together and packaged since they operate hand in hand and can powered from the same sources.

1.4 SCOPE

This inspiration of the project was born after having experienced and considered the high rate of wastage that occurs as a result of negligence in troubleshooting minor faults in electronic gadgets and also the trouble undergone when a cut occurs in an insulated cable.

In as much as the objectives of the project were achieved, there are still some limitations which are explained below:

1.4.1 CONTINUITY TESTING

In testing for continuity, small resistance values are regarded as continuous. This is because every conductor including the best conductor has a level of resistance which is proportional to its length, in other accommodate this, an amount of resistance was assumed as continues which can be varied by the user.

In testing for opens, high resistance values were regarded as opens. This is also because of the above reason.

1.4.2 CUT POINT DETECTION

In detecting the cut point in a faulty cable, the cable in question if not a power cable must be electrically isolated from the original circuits. This is because the cut point detection involves the powering of the cable with a high voltage alternating current which may be harmful to the circuitry in which the cable isolated.

In buried cables, the material covering the cable and the depth causes a limitation. This is because such materials can be act as a shield to the electromagnetic field generated by the alternating current flowing through the cable.

1.4.3 DETECTING HIGH VOLTAGE

The detection of high voltage AC and field from such sources are limited to AC sources which must be within the frequency range of 20hz to 200Hz. In as much as the circuit can detect beyond this range of frequencies, the indicators may not be both audible and visible to the user.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL BACKGROUND

The discovery of the light bulb by Thomas Edison and the DC battery by Alessamdro Volta provided a means of continuity indication. The circuit diagram below shows a simple methods of testing continuity using battery and the bulb.

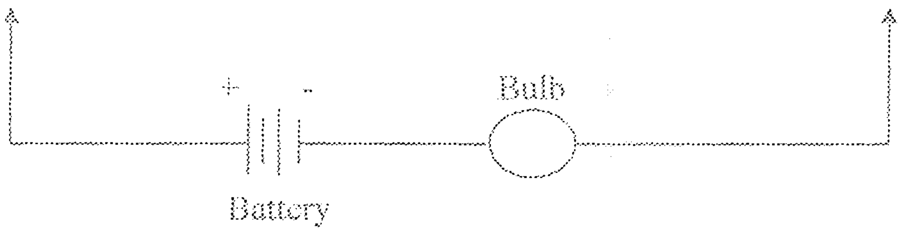

Fig. 2.1 the circuit diagram of a sample continuity tester [1]

In the diagram, when the two flying leads from the battery setup are connected between two points, the bulb will light indicating continuity between the points. If it doesn`t light then it indicates an open circuit (discontinuity) between the points. One of the disadvantage of such a circuit is that the current generated by the battery which may be up to few amperes depending on the battery type and bulb flows through the circuit under test. This large amount of current can be harmful to some electronic computers in the circuit.

As technology advanced, better bulb more suitable for this purpose were developed such as the light emitting diode (LED). This modified the previous circuit into a much better and safer continuity tester. The schematic diagram I shown below

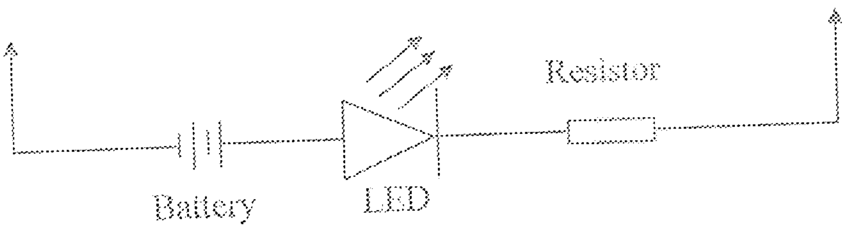

Fig. 2.2 continuity tester using light emitting diode I2I

In the above circuit, the problem of high current flowing through the circuit under test is minimized to about 20mA. This is achieved by using the appropriate resistor which limits the current depending on the voltage source.

For a voltage source of 6 volts, a voltage drop of 2.5 is requires across the LED and a current about 20mA.

$$\text{Series resistor value} = \frac{(6\text{-}25)V}{20mA} = 175\Omega$$

With the leads placed between two points the LED will glow if there is continuity between the two points.

The principle behind the operation of the two circuits discussed above is simple every circuit requires a complete path for current to flow, a continues circuit under test provides a path that completes the circuit, so that conventional current can flow all round from the battery's positive terminal through the LED resistor, circuit under test and back to the negative terminal of the battery. This flow of current causes the LED to glow. But fro an open circuit there is no complete path for current flow through, hence the LED doesn't glow.

The invention of basis electronic measuring instrument paved the way for better ways of continuity testing. This is done with the use of the ohmmeter which measures the resistance of the circuit under test. An ohmmeter works on the principle of ohm's law (V=IR) in which resistance is a ratio of the voltage and current.

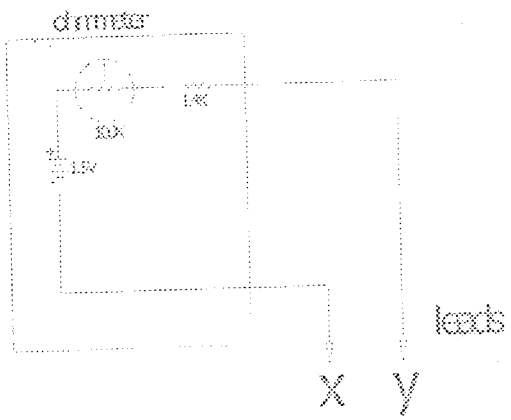

Figure 2.3 Basic meter movement used as ohmmeter

The circuit consist of the basic meter movement combined with a battery and a current limiting resistance as shown above[3]. the ohmmeter leads X-Y are connected across two points in the circuit under test after switching off the power in the a circuit . The ohmmeter battery provides the current for the meter movement which depend on the external resistance. For a continuous circuit the resistance is very small and so the meter pointer will indicate low resistance, but for the an open circuit the pointer indicates infinity some other multi-purpose meters called multi-purpose meters called multimeters operate based on the same principle and can be used to measure more than one electrical quantity by adjusting the selection, knob to the desired quantity of measurement . Example: Voltage, current, resistance, etc.

The digital multimeter is also used for continuity testing and operates the same principle as the analogue multimeter only that in this case it's not a pointer indicate the measurement value rather the actual digits are displayed on the meter screen. The basic layout of the digital multimeter is shown below.

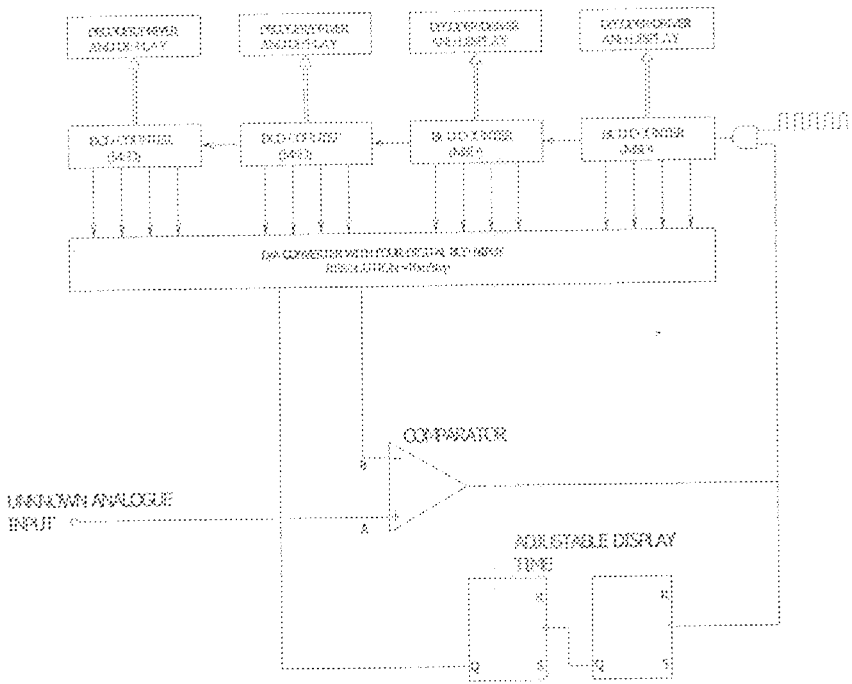

Figure 2.4 Simple Continuous Reading Digital Meter

The four cascaded BCD counters provides the digital input to a BCD type D/A converter. Each BCD counter feeds a decoder /driver and associated display. It follows that each digit of the count is continuously being displayed as the counter runs up from 0000 to 9999. when the counting has ended, the display is held for a time so that one we observe the changing display and normally the first effect we can observe is the steady display [4]

The clock pulses are gated into the counter along with the comparator output. As long as input A& B, the output of the comparator is 1(high) and the counter continues to receive pulse from the clock. With each clock pulse the counter advances a step and B goes up another 10m. Eventually B>A by not more than 10m, but this is sufficient to make the comparator output go to 0(low) and the AND gate is disabled. This prevent further clock pulses from entering the counter which therefore cannot advance further.

At this point. We have the counter holding data equivalent to the unknown analogue input A. As soon as the comparator output goes low 0. It also triggers a from of set-reset relay ready to repeat the cycle of events.

In using the digital multimeters to test for continuity, the selection knob is set to the resistance setting and the two probes are places across the two points to be tested . if there is continuity, it display the digit 0000 or the equivalent resistance value between the two points and for open it displays 1. some digital multimeters are equipped with an additional audible indicator that sounds a continuous high pitch tone indicate continuity and none (no tone) for opens. Another types of continuity tester is the latching continuity tester, which is used for continuity in vibration induced problems where shorts or opens are not maintained long enough for non latching continuity tester to respond[5]

Cut point/fault location in insulated cables and underground cables are done using so many hi-tech instrument that involve microprocessor operations. This include echometer, artificial neutral networks, which uses two main simulators. One with the EMTDC software using the Bergeron model for cable and the other MATLAB software using the Pi model: Dynatel ™ 965DSP units, which uses the integral resistance measuring bridge or a time domain reflectometer (TDR): 3M ™ 1342 Far End device II for detecting and diagnosing cable faults, and felicitates remotely controlled measurement termination at the other end of the pair being tested; DC Hi-pot Adapter , a very valuable tool for locating faulted cables in an underground loop [6]

Fault detected in fiber optical cables is not left out. The clause Fiber continuity tester provides you with a high intensity, long-lasting green LED light sources that transmit light instantly and accurately down the Fiber compatible with both single mode and multimode fiber, it can achieve a test distance of up to 2km in multimode fiber. Testing. OTDR (Optical Time Domain Reflectometer) is very fast producing a scan within one second of pressing the scan button. Among its many features is an easy to use zoom that enables the user to observe the entire link. Or zoom in on defects. Others include fiber optic video Microscope etc. all these are hi tech equipments whose principles of operations are based on digital signal processes not covered in the this work.

The continuity tester and cut point detector that have been constructed here is capable of testing for the continuity on the printed circuit board and insulated wires as well as detect or locate the cut point or fault point in such a cable. It gives an audible and visual indication in both cases. The working of the project is broken down into two main modules and the block diagram showing the basic make up of each module is show below

2.1 Continuity tester module.

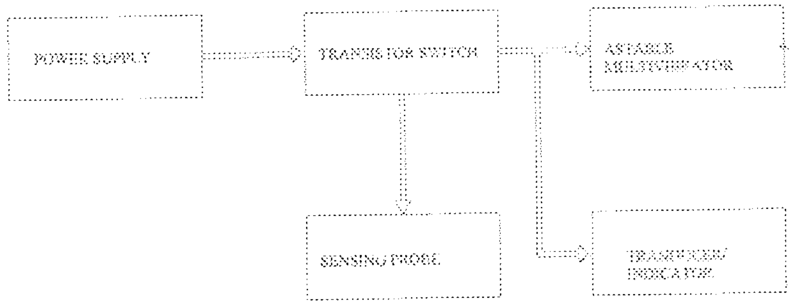

Figure 2.5 Continuity tester module block diagram

2.1.1 Power supply

The power supply is from a 6F22, 9 Volts battery which is a dry cell made up of primarily the positive and negative electrode and an electrolyte. It is a primary cells because the individual cells are connected is series (internally) and are capable of converting stored chemical energy in them into electrical energy through the process of electrolysis. The stored energy is inherently present in the chemical substance and doesn't need charging or recharging /3/. Although it can not be recharged. Its life spam some times can be long depending on the load that is connected to them and they supply constant current and voltage within this time. They also have the advantage of being small and light and as such can be carried in around portable equipments.

2.12 Transistor switch

The transistor is a PN junction component manufactured from a single piece of semiconductor crystal. The two junctions give rise to three regions called the emitter, Base and collector which provide the tree terminals of the component. Transistor switch is used in controlling a relative large current between or voltage across two terminals by means of a controlled current or voltage applied at a third terminal. It operates in the cutoff region where virtually no current flows through the transistor and in the saturation region where sufficient amount of collection current flows /8/. The basic operation of a simple BJT (bipolar junction transistor) switch is illustrated in fig 2.6

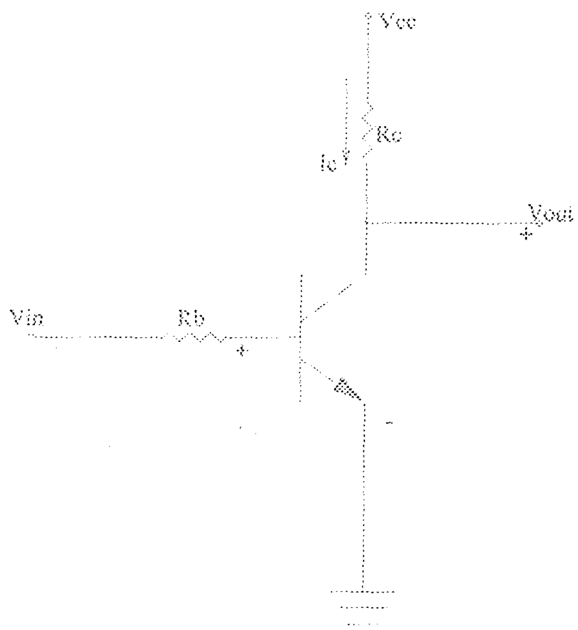

Figure 2.6 Simple circuit diagram of transistor switch

Considering the load-line equation all the collector circuit. We have

Vce = Vcc – IcRc and V_{out}=Vce

Thus, when the input voltage Vin is low (below 0.6V) the transistor is in the cutoff region and little or no current flows and.

Vout = Vce = Vcc

When Vin is large enough to drive the transistor (above 0.6V) into saturation region, a substantial amount of collector current will flow and the collector emitter voltage will reduce to the small saturation value, $V_{CE\ SAT}$, which is typically a fraction of a volt.

2.1.3 Testing probe

The testing probe is the part of the equipment that makes contacts with the circuit under test. It has a metallic conducting pointed tip which aids contact and conduction between the circuit and the equipment and also an insulted handle to isolate or protect the user from electrical contact which may otherwise be dangerous.

Astable Multivibrator

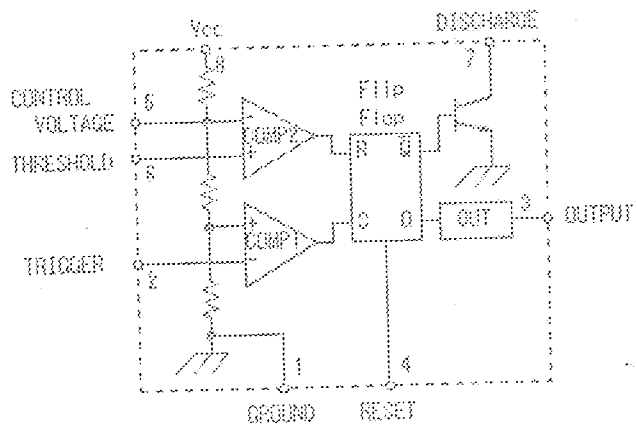

Figure 2.7 Block diagram of NE 555 timer

NE555 is composed of the voltage comparators, the flip-flop and the transistor for the discharge. Three resistors are connected with the inside in series and the power supply voltage(Vcc) is divided in 3. 1/3 of the power supply voltage is applied to the positive input terminal of the comparator (COMP1) and the voltage of 2/3 is applied to the negative terminal of the comparator (COMP2). When the voltage of the trigger terminal(TRIGGER) is less than 1/3 of the power supply voltage, the S terminal of the flip-flop (FF) becomes High (H) and an FF is set. When the voltage of the threshold terminal (THRESHOLD) is more than 2/3 of the power supply voltage, the R terminal of the FF becomes H and an FF is reset.

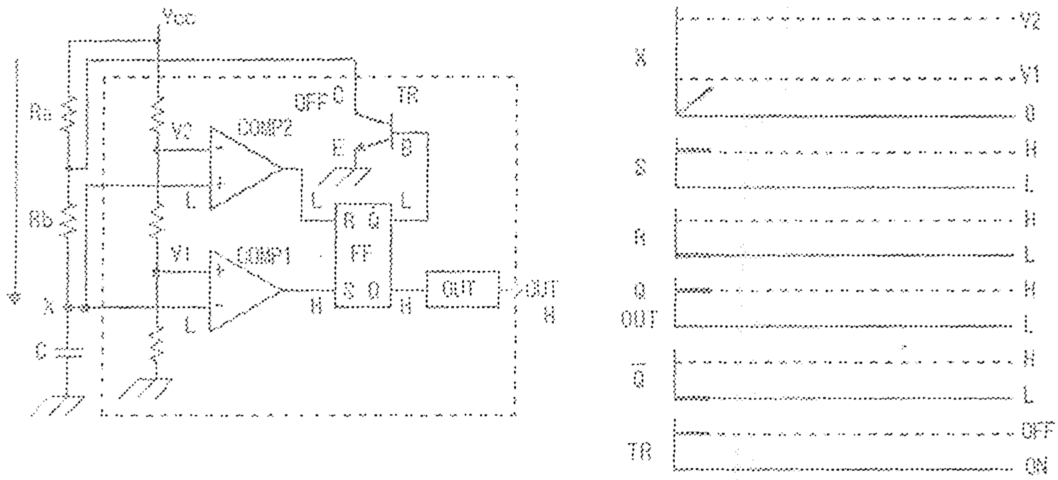

Figure2.8 **The condition immediately after the turning on**

Immediately after a power supply voltage is supplied, as for the FF, the Q becomes H and $\bar{Q}$ becomes L (low). Because $\bar{Q}$ is the L, TR is OFF and the electric current flows through the resistor of Ra and the Rb through the capacitor (C). Immediately after a power supply voltage is supplied, the voltage of the X point starts rising from 0V because the X point is lower than V1 of COMP1, the S terminal of the FF becomes the H condition. With this, the Q becomes H, $\bar{Q}$ becomes L condition but they are in the condition already. On the other hand, because the COMP2 (+) terminal is lower than V2, the output of COMP2 becomes the L and the FF is stable in this condition.

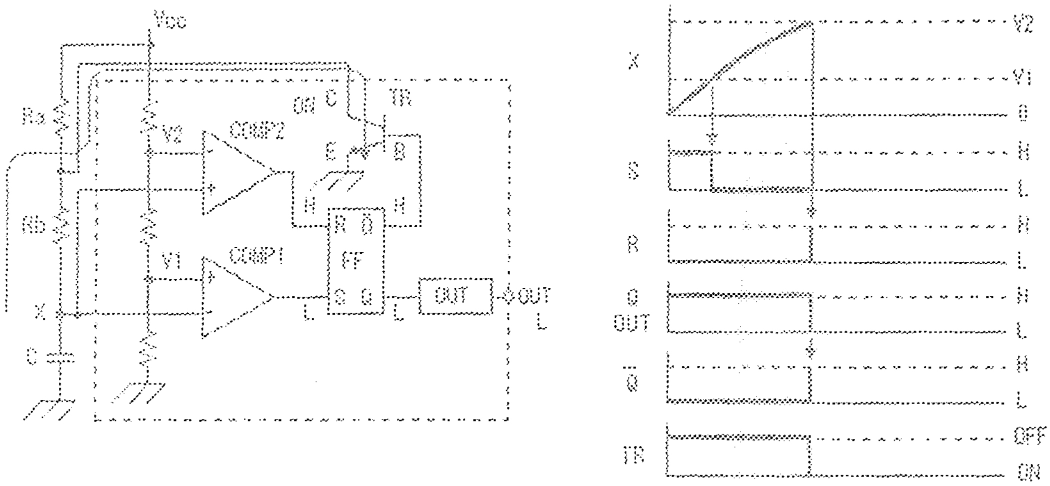

Figure2.9 **Output's reverse (1)**

When the voltage of the X point crosses V1 of COMP1, the output of COMP1 becomes L. However, this change does not change the condition of the FF. The output of COMP2 becomes the H condition when the voltage of the X point rises more and reaches V2 of COMP2. With this, the R terminal of the FF becomes H and the output state of the FF reverses. The Q becomes the L condition and $\bar{Q}$ becomes the H condition. At this time, OUT changes into the L from H. Because $\bar{Q}$ became the H condition, TR turns ON. Because the interface of Ra and the Rb becomes the grounded condition, the electric current which was flowing through C so far through Ra and the Rb gets not to flow through capacitor(C). The electric charge which was stagnant in capacitor(C) begins to discharge through the Rb and TR. Voltage of the X point begins to go down with this discharge. Because voltage of the X point goes down, the voltage of the COMP2 (+) terminal becomes less than V2 and the R terminal of the FF changes into the L condition from H. This change does not change the condition of the FF.

It is only in little time that the R terminal of the FF becomes H.

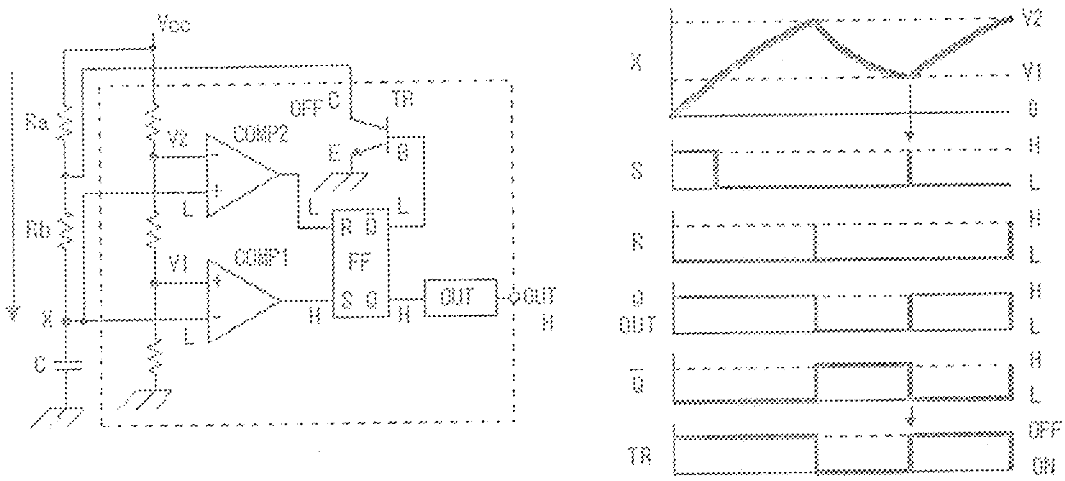

Figure 2.11**Output's reverse (2)**

because TR is ON, as for the electric charge of capacitor(C), it continues the discharge and the voltage of the X point falls. When the voltage of the X point becomes equal to or less than V1 of COMP1, the output of COMP1 becomes the H condition and the S terminal of the FF becomes the H condition. This changes the Q of the FF to H and $\bar{Q}$ changes into the L condition. Because $\bar{Q}$ became the L condition, TR becomes OFF and the discharge from capacitor(C) stops. The electric current flows through Ra and the Rb again in capacitor(C) and the electric charge begins to store up. When the electric charge begins to store up in capacitor(C), voltage of the X point begins to go up till the output of COMP1 becomes the L condition, this operation repeats and the signal of the square wave is the output.

When charging (accumulating the electric charge) capacitor(C), the electric current flows through Ra and the Rb and in case of the discharge (missing the electric charge), it passes only the Rb. So, the time of the charging and the time of the discharge are different. By making the Rb compared with Ra big, the difference of both becomes small but can not make the same at all.

Frequency of Oscillation

The oscillation frequency of this oscillator is fixed by the value of capacitor (C) and resistor (Ra) and resistor (Rb).

Roughly oscillation frequency can be calculated by the following formula.

The design formula is given as

f= 1.44/(Ra + 2Rb)C Unit f : Hz / C : Farad / Ra and Rb : ohm

2.1.5 Transducer

Transducers are devices that convert physical quantities or conditions into electrical signals and vice versa. In most instrumentation systems, the input or output quantities (such as temperature, force, displacement, luminosity, etc) are non-electrical. To use electrical methods of measurement, such non-electrical quantities require to be converted into the equivalent/corresponding electrical signal (such as voltage, current, resistance frequency. Etc) using transducers. Any transducer basically consists of two elements.

i) **Sensing element:** it is the part of the transducer which senses or responds to a physical quantity or change in physical quantity.

ii) **Transduction element:** this is that part of the transducer which transforms the response of the sensing element to electrical signal.

Some examples of transducers include audio transducers. (microphone, speakers, buzzers, etc. that operate based on principle of electromagnetic induction). Light transducers (bulbs, LED, LDR, etc) etc.

2.2 Cut-point detector module.

The cut-point detector module consist of a DC power source (battery) sensing probe. Frequency divider, oscillator, and transducer/indicator. The power source, oscillator and transducer/indicator are shared by he continuity tester module and cut-point detector module and are as explained above. The combination of the sensing probe and frequency divider form a magnetic field detector.

In Oersted experiment in 1820, he discovered that when a current carrying conductor was placed above a magnetic needle and in line with the latter. The needle was deflected clockwise or anticlockwise depending upon the direction of current [4]

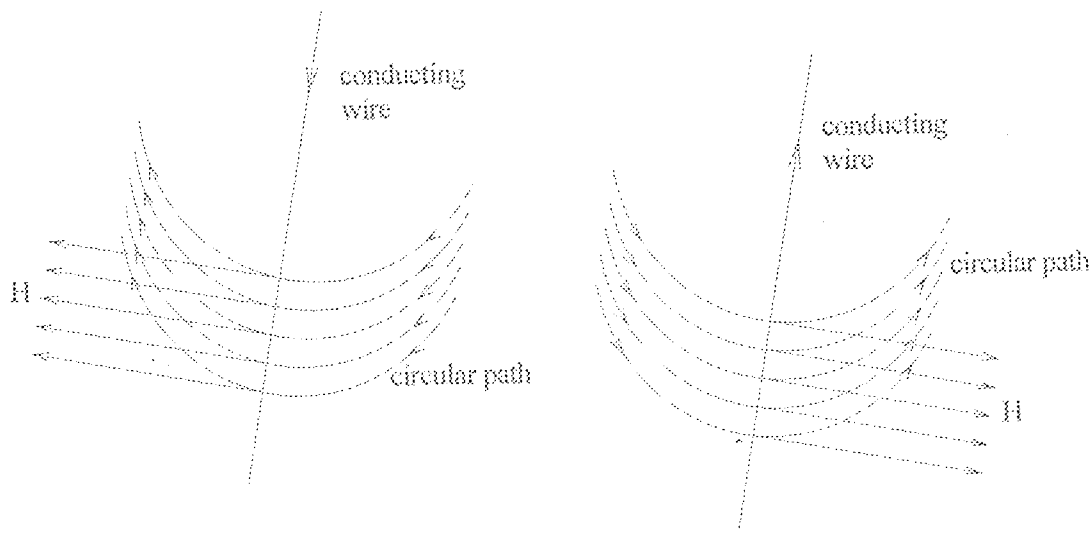

Figure 2.12 the right hand rule convention

The convention for showing the relationship between the direction of current flow and the magnetic: This is determining by the familiar right-hand rule. This rule states that if the direction of current I points in the direction of the thumb of one's right hand, the resulting magnetic field encircle the conductor in the direction the other four fingers would encircle it. Magnetic field intensity H is unaffected by the material surrounding the conductor but the flux density depends on the properties since $B=\mu H$. Thus the flux density round the conductor would be far greater in the presence of a magnetic material than if the conductor were surrounded by air /8/

The physical basis for the point detection is mutual induction between the faulty cable and the sensing probe of cut point detector linked by a common magnetic flux. If the faulty cable is connected to a source of alternating voltage, an alternating flux is setup around the cable as long as there is continuity. When the probe of the cut point detector is brought close to the cable, a path of high magnetic reluctance (air) is established which produces mutually-induced e.m.f (according to faraday's law of electromagnetic induction). This induced e.m.f which depends on the reluctance of the magnetic path is very small when compared to the alternating voltage in the cable, but is sufficient to clock the CMOS divide by ten counter IC which acts as a frequency divider. The output signal from the CMOS IC goes to a NAND gate and then to the oscillator for an audio and visual indication.

Chapter Three

Design and Implementation

The continuity tester and cut point detector was designed not only to indicate continuity in printed circuit boards (PBC) but with the capability of indicating continuity in insulated and buried cables. This was achieved using modular design and construction. The entire project is divided into two different modules: continuity tester modules and cut point detector module.

3.1 Continuity Tester

This module of the project is used for continuity indication between two exposed parts of a circuit. Fig 3.1 shows the entire circuit diagram of this module.

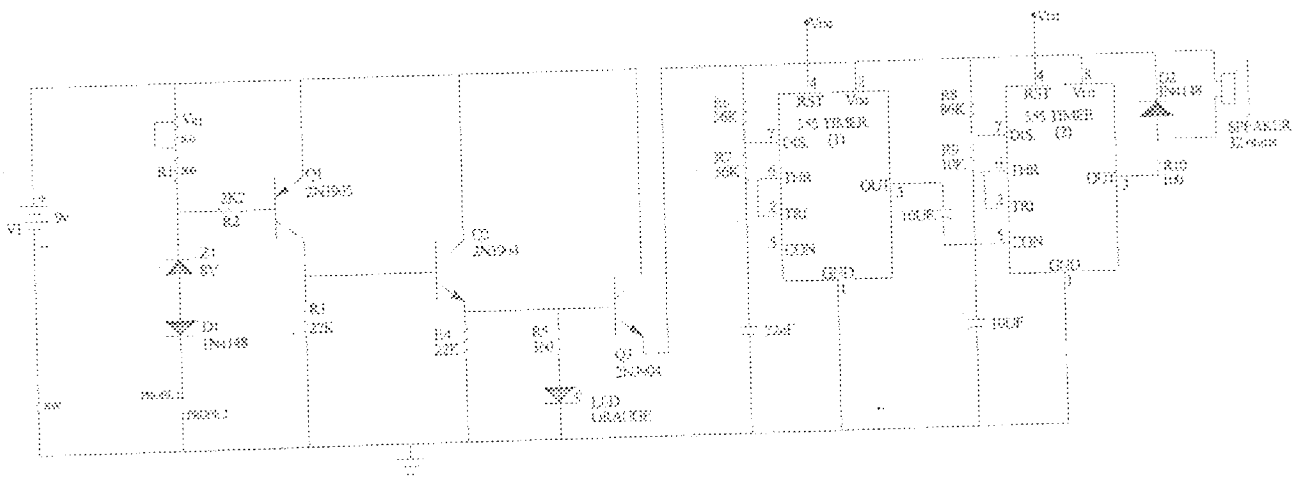

Figure 3.1 circuit diagram of continuity tester module

The above circuit gives both an audible and visual indication for continuity and non for discontinuity.

3.1.1 Power Source.

The power source for the circuit is a 9 volts alkaline battery. This was chosen because the continuity tester is a portable test equipment that consumes very little power and as such can be powered through a battery for a very long time.

3.1.2 Current Limiter.

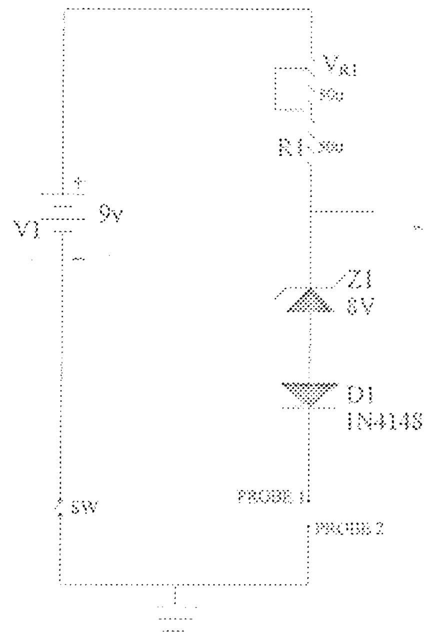

Figure 3.2 circuit diagram of current limiter

The series combination of the variable resistor VRL, R_1, zener diode Z_1, diode D_1 and the probes form a current limiter. This is to ensure that the maximum current flowering through the test circuit is very small (approximately 0.8mA).

Note: the diode D_1 wasn't part of original design. It was added because the voltage drop on Z_1 was found not to be 8.2V as expected but rather 7.5V as such adding a diode which has a forward voltage drop between 0.6 to 0.7V would add up to 8.2V Volts.

$$\text{Series resistance } R = \frac{(V1 - Vz)}{I}$$

$$= \frac{9 - 8.2}{0.8 \times 10^{3}}$$

Notes: V_Z is the voltage drop across the zener diode Z_1 and D_1

Series resistance $R = VR_1 + R_1$

Transistor Switch.

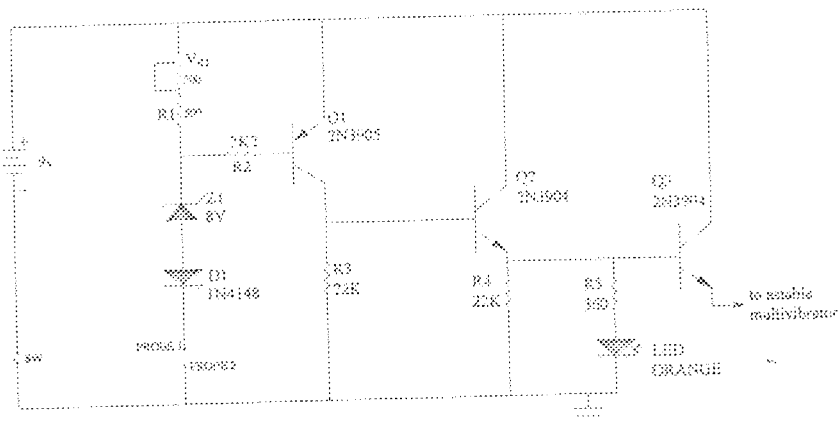

Figure 3.3 circuit diagram of transistor switch

Q1 is a silicon type transistor and the base-emitter voltage will need to be about 0.5 to 0.6 volt to forward bias the junction and initiated collector current with a maximum of 0.8 volt (9-8.2) available across VR_1 and R_1, it is seen that if a semiconductor junction or resistor is included in the outside circuit under test and drops more than 0.3 volt then there will be less than 0.5 volt remaining across VR_1 and R_1 barely enough to bias Q_1 into conduction. But this can also be variable by adjusting the preset variable resistor VR_1.

Table 3.1 absolute maximum rating of transistor 2N39006 (9)

Maximum collector current I_{CMAX}	200Ma
Collector Emitter Breakdown voltage V_{CEO}	40V
Base Emitter breakdown voltage V_{BEO}	5V
DC current gain H_{FE}	2000
Maximum operating frequency f	300MHz

Maximum base current $I_{BMAX} = \dfrac{h_{FE}}{I_{CMAN}}$

$$= \frac{200}{200} = 1mA$$

Minimum base resistor $R_B = \dfrac{V_E - V_B - 0.6}{1mA}$

$$= \frac{9-8.2-0.6}{1mA}$$

$$= 200\Omega \leq R_2$$

Minimum collector resistor RC = $\frac{Vcc}{I_{CMAX}}$

$= 9/200mA$

$= 45\Omega \leq R_3$

In order to minimise the current consumption of the circuit, much higher values were used.

Assuming that the probes are joined by nearly zero resistance, the voltage drop across VR_1 and R_1 is between 0.7 to 0.8 volt and Q_1 turns on. Its collector voltage rises positively to give nearly 9 volt across R_3, which biases Q_2 a 2N39004 NPN transistor causing its collector to conduct and its emitter thus rises to about 8.1 volt. This lights the LED and also biases the next transistor Q_3.

Table 3.2 absolute maximum rating transistor 2N3904

Maximum collector current I_{CMAX}	200mA
Collector Emitter voltage V_{CEO}	40V
Emitter base voltage V_{EBO}	6V
DC Current gain h_{EF}	300
Maximum operation frequency f	300MHZ

Maximum base current I_{BMAX} = $\frac{h_{FE}}{I_{CMAX}}$

$= \frac{300}{200m} = 1.5mA$

Minimum resistor R_5 = $\frac{V_R - 0.6}{5mA}$

$= \frac{9-0.6}{1.5mA}$

$= \quad 5600\Omega \leq R_4$

Minimum collector resistor Rc $= \dfrac{Vcc}{I_{CMAX}}$

$= \dfrac{9}{200} = 45\Omega \leq R_4$

$R_4 \geq 5600$ohms ≥ 45ohms, as such a far higher value of 22k was used to minimise power loss.

LED Resistor $R_5 = \dfrac{\text{Total voltage} - \text{LED voltage}}{\text{LED current}}$

$= \dfrac{8.4 - 3.0}{15mA} = 360$ ohms

Once the base of Q3 is biased, this causes current to flow from its collector to the emitter and to the astable multivibrator, which starts up a tone.

3.1.3 Astable Multivibrator

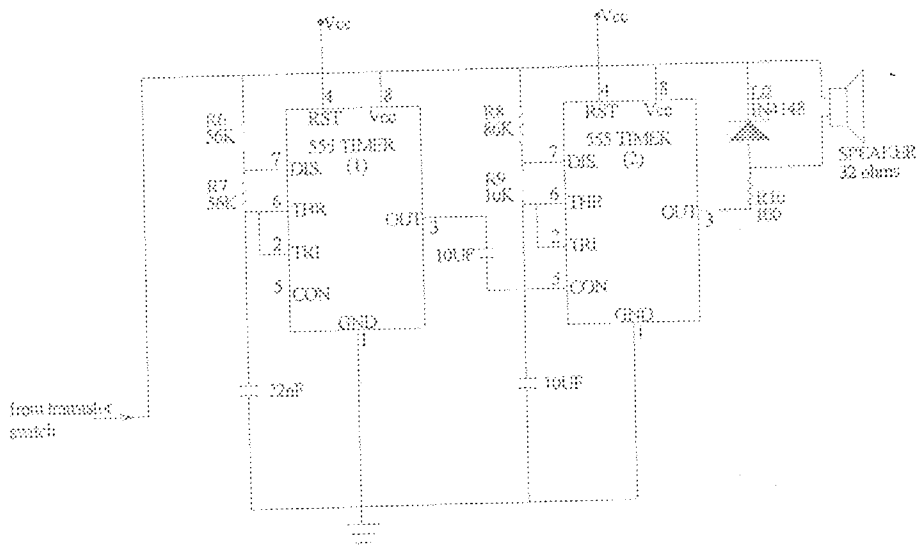

Figure 3.4 circuit diagram of astable multivibrator

The diode D2 is a protective (free wheeling) diode connected across the transducer since fast switching section of the oscillator circuit can produce a high back e.m.f across the coil and these high voltage might other wise lead to transistor damage of breakdown.

3.2 Cut Point Detect.

The principle behind the operation of the cut a point detector has been explained in chapter two (section 2.3.2). It is on this same principle that the transformer operates, however in this case there is high magnetic leakage.

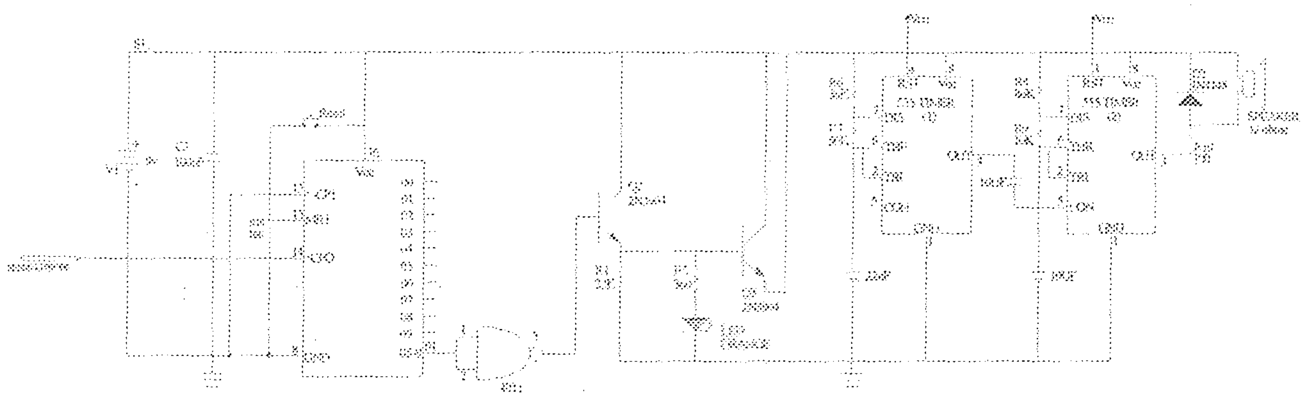

Figure 3.5 circuit diagram of astable multivibrator

3.2.1. CMOS Decade counters (1-of-10) CD4017

The CD4017 is a 5 – stage divide – by- ten Johnson counter with 10 decoded out puts and a carry out bit. Its counter is cleared to the zero count by logic 1 (high) on its reset line and it advance on the positive edge of the click signal. Being a Complementary metal oxide semiconductor CMOS IC, it has the following characteristics.

- ✓ Supply voltage is between 3V to 15V
- ✓ Very high input impedance
- ✓ Gate propagation time typically 30ns for a signal to travel through the gate
- ✓ Frequency up to 1MHZ.

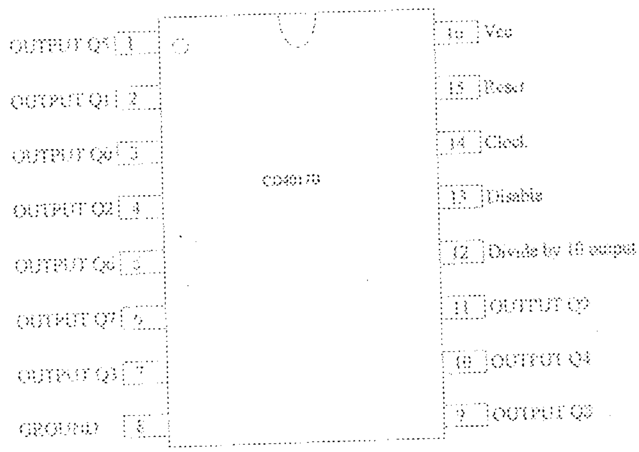

Figure 3.6 Pin configuration of CD4017

The disable input should be low (0V) for normal operation. When high it disables counting so that clock pulses are ignored and the count is kept constant. The divide by 10 outputs is high for counts between 0 and 4 and low for counts between 5 and 9 so it provides an output at one tenth (1/10) of the clock frequency. Due to the very high impedance of the CMOS IC's they do not affect the circuits in which they are part of. However, it also means that the unconnected input pins easily pick up electrical signals and rapidly change between high and low. This characteristic makes the CMOS IC useful in this project.

3.2.2. Quard Two Input Nand Gate CD4001

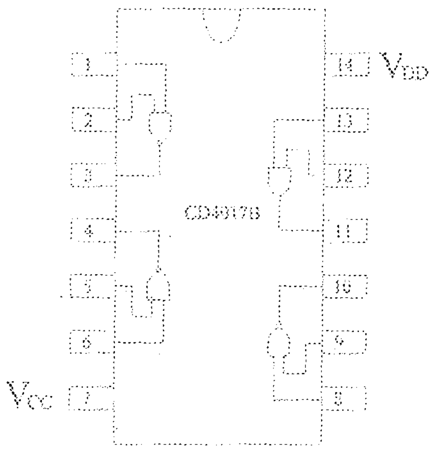

Figure 3.7 IC CD4011 showing its internal connections

The quard two input NAND gate CD4011 is a CMOIS IC and as such has all the characteristics of CMOS ICs as mentioned in above (section 3.2.1)[10]. It is used in the circuit to keep the output of the count low at a count of zero. This prevents the beep that would otherwise start when the cut point detector is switched on or when the reset button is pressed since the divide by ten input of the counter (CD.4017) is high at counts between 0 to 4.

The faulty cable under test is first powered from the live line of an AC 240V power source. This alternating voltage sets up an alternating magnetic flux amount the cable as far as the AC voltage can reach along the cable. Beyond the cut point there is no flux because there is no AC voltage. When the probe of the cut Pont detector is brought very close to powered cable, a magnetic circuit of very high reluctance is established which induces a very weak alternating voltage in the probe by mutual induction. This induced alternating voltage though weak is sufficient to clock the CMOS counter because of it very high impedance. As the

probe is moved along the surface of the powered cable, a point reached where there is no flux; hence no voltage is induced in the probe. This is the cut point.

Continuity is indicated by the continuous blinking and beeping of the LED (orange in colour) and the astable multivibrator circuit, for a visual and audio indication respectively.

Frequency of induced voltage (f) is equivalent to the frequency of alternating voltage source

$$\text{Frequency of LED blink} = \frac{f}{10}$$

since the cable is powered with AC mains voltage of frequent 50HZ then frequency of LED BLINK F_B can given as;

$$F_B = \frac{50}{10} = 5HZ$$

CHAPTER FOUR

TEST, RESULTS AND DISCUSSION

The conception of the project came having experienced some difficulties working with insulated cables, then came the design. As an engineer of the 21st century, computer simulation software such as such as multisim, circuit maker and tina pro were used to ensure the workability of the designed circuit at different level. Having confirmed it functionality, progress was made by purchasing the electronic components and implementing the circuit on breadboard, after which the components were placed on Vero board and soldering done.

TESTING.

This circuit worked perfect after some adjustments were made. The adjustments were due to some variations in the needed components and available components. This will be discussed later.

Various parts of the circuit were tested with different inputs and corresponding outputs were observed. The results gotten were recorded and are shown in the table below.

ITEM	INPUT	OUTPUT	DISCUSION
BATTERY	NILL	9.2 volts	This is a fixed value which may be a little Higher before initial use and reduces with time
Transistor switch	0V to 0.58V base emitter voltage 0.63V and above	Transistor in cutoff region Transistor in saturation region	These are standard with silicon type semiconductor with little or no fluctuations
Zener diode	1.5mA flowing through the zener diode	7.5V voltage drop across the zener diode	This is not what was expected, maybe due to manufacturing defects. Adjustments were made to correct circuit defects.

The preset variable resistor VR1 determines the value of resistance in the test circuit that the tested will regard as continuous and also determines the value or the test current that will flow through the test circuit.

Value of VR1	Current flowing in test circuit	Resistance considered as continuous
Maximun setting	0.8mA	405 Ohms
Center setting	1.04mA	300 Ohms
Minimum setting	1.6mA	202-Ohms

It was also observed that in cut point detection mode, the kind of metal used as the sensing probe or antenna determines the sensitivity of the cut point detector. Two different materials were used for testing and the results are.

MATERIAL	DISTANCE FROM CABLE (cm)
Aluminum	0.5
copper	2.0

This also determines the depth in the case of buried cables at which the tester can be useful. The length of the probe was also considered and found to vary proportionally with sensitivity.

CASING.

The casing was done with a wooden material. This was used considering cost. Availability and originality, which was intended from start to finish. The physical outlook of the project is as shown in figure 4.1

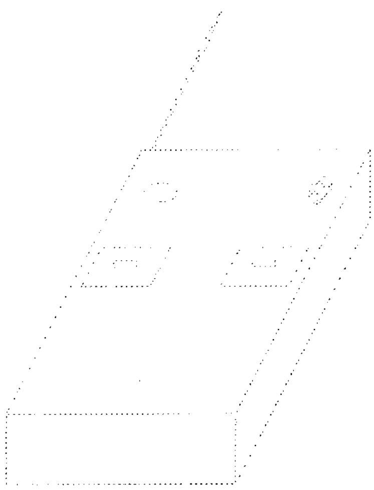

Figure 4.1 Project casing

CONSTRUCTION TOOLS USED.

Most of the instruments used were personal instrument which have been acquired over time. Others were bought for the purpose of the project, while yet others were borrowed. These are:

- Digital Multimeter
- Screw drivers and screws
- Soldering iron, suction tube and soldering lead
- Breadboard, cutter, blade and connecting wires
- Hammer and saw

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CHAPTER FIVER

CONCLUSION

The construction of a continuity tester and cut point detector has been completed, Tested and packaged. The aims right from the onset were actualised, all was achieved but one and further work could be done on this project.

Cut point detector requires that the cable under test be powered with the live line as an AC power supply. This mains power source is a very important requirement. With the high fluctuation in availability of mains power supply, an alternative AC power was to be part of this project, however due to cost and time this aspect of the work was not accomplish.

5.1 RECOMMENDATION.

The level of advancement in science and technology is somewhat appreciated by all. The ease and comfort it brings to life cannot be overemphasized. All this came to pass because men worked, "the height which great men attained and are kept was not by sudden flight, but they while men slept toiled` [11]. The long term aim of this project is to provide cheap but effective troubleshooting equipment and as such encourage troubleshooting.

It is thus recommended that:

- When further work is to be done on this project, an alternative AC power source be included to reduce the dependence on the mains power supply which will increase the operational availability of the equipment.
- The students should be introduce to practical works right from the onset to encouraged them perform practical more often as such develop better skills.
- The laboratory equipments should be made available to the students; this will inspire the students to make attempts at self proposed project which may bring room to new discoveries and create an enabling environment for engineering research works.

- Government should fund academic projects to encourage students whose projects are capital intensive.

Finally, the continuity tester and cut point detector would aid in fault diagnoses and as such should be mass produced and used in the departmental laboratory.

Reference:

[1] http://www/appliance111.com/info/

[2] http://www.kpsec.Freeuk.com/docs/simplet.pdf.

[3] B. I. Theraja, A.K. Theraja. The Textbook of Electrical Technology S. chand and Ltd New Delhi, 1999, pp; 283, 2080

[4] Edward Hughes, Electrical Technology, Addison Wesley Longman Limited. England. 1995.pp 131,744,776,777.

[5] www.uoguelph.ca/antoon/circ/latchingcontiunitytestr.html.

[6] www.solutions.com3m.com/wps/portal3m/en-EU/Telecommus Access.html

[7] www.tecratools.com/page/fiber/35535.html.

[8] Giorgio hill, principle of Electrical Engineering. McCraw Hill higher Education. -Ohio pp 2088, 17.4

[9] www.datasheetcatalog.com

[10] www.datasheetarchive.com

[11] www.greatquates.com.