DESIGN AND CONSTRUCTION OF BIPOLAR JUNCTION TRANSISTOR /DIODE TESTER

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DECLARATION

I.hereby solemnly declare that this project work was done out of my own personal effort. And wish to establish that it has never been presented elsewhere to the best of my knowledge in any form for the award of B tech in electrical computer Engineering.

Information derived from published or unpublished work of others has been acknowledged.

10/10/03

Salihu A Bala

CERTIFICATION

This is to verify that this project titled **design and construction of bipolar junction transistor/ diode tester** was carried out by Salihu A Bala with Mat. No 6153EE for the award of B. Eng. In Electrical Engineering, Federal University Of Technology, Minna

Mr. Jacob Tsado ....

Project supervisor   Signature &
Date

Engr. M. N Nwohwo ....

H.O.D Electrical computer   Signature & Date
Engineering Department

External Supervisor ....

Signature & Date

DEDICATION

I dedicate this project work to Allah (S.W.T), the most beneficent, and the most merciful.

ACKNOWLEDGEMENT

I wish to state my profound appreciation to Allah (S.W.T.) who has made the pursue of my undergraduate studies possible from beginning to end.

My appreciation to my dear mother (Hajiya Nana) for her maternal support and care, my elder brother (Umar Salihu) and Mallam Tanko A. Bosso for financial and moral backing during by course study in the university.

I will not forget to thank my project supervisor, Mr. Jacob Tsado and Engr. Mohammed they remains my mentor and guide in executing this project, it is your support and boundless academic and technical advice that makes this project yield its expectation.

I darely appreciate the assistance of Mr. Abraham Usman, Mal. M S Ahmed and Engr. Musa D. Abdullah for their encouragement. I also thank management and staff of logicgate ventures more especially Director (Engr. I. B Mohammed).

ABSTRACT

The enormous use of transistor in circuit design to accomplish new electronics fashion has made transistors an important device in design industry

Following the role transistors played in circuitry their workability is paramount to the users this has given the courage to embark on this project to design an instrument to be used in determining if a transistor is good or faulty and identify transistor's type, as either NPN or PNP, the collector, base and emitter pins. The instrument also tests diodes (linear).

Combinations of LEDs (light emitting diodes) are used to display the result of the device under test (DUT). Their **ON and OFF** states at particular situation help to determine and check the condition of operation of the transistor or diode being tested.

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CHAPTER ONE

1.0 INTRODUCTION

A transistor tester is a problem that requires a precise understanding of how a transistor works

Solving for a transistor's unknown detail using this project work means that a transistor operation and characteristic must be known and understood before any hardware construction for the circuit for the testing instrument can be started. Therefore a general description of the concept of operation of the transistor and theory of the transistor is needed to produce this understanding

A transistor is a three terminals (named, base, emitter and collector) semiconductor device which is made up of two pn-junctions. its output current, voltage and /or power are controlled by its input base current I_b. Transistors work on the principle that certain materials e.g. silicon, can after processing be made to perform as "solid state" devices any material is only conductive in proportion to number of free electrons that are available. Silicon crystals for example have no free electrons. If impurities (different atomic structure e.g. arsenic) are introduced in a controlled manner then the free electrons or conductivity is increased. By adding other impurities such as gallium, an electron deficiency or hole is created .as with free electrons, the hole also encourage conductivity and the material is called semiconductor. Semiconductor materials that conduct by free electron is called **n–type** material while materials that conducts by virtue of electron deficiency, is called **p–type** material.

In electronics, transistors are used as a high–speed electronic switch capable of switching between two states at an extremely fast rate. Another primary use of the transistor is for amplification, especially in communication systems.

A Transistor is a current controlled device, that is, the collector and emitter currents (I_C and I_E) are primarily determined by the base current, which is generally the lowest of all three currents.

There are two types of bipolar junction transistors **NPN** and **PNP.**

1.10 NPN AND PNP TRANSISTORS

The fig 1.0 below illustrates that the NPN transistor has n-type emitter and collector terminals and **p-type** base. Also, the PNP transistors are constructed in the opposite manner, having **p-type** emitter and collector and an **n-type** base. Therefore current directions are different for each type.

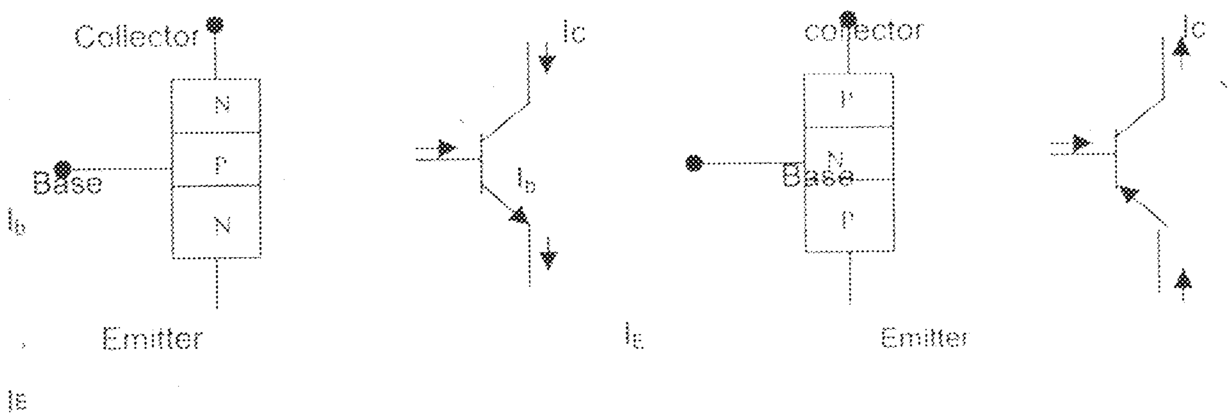


Fig 1.0 Current flow descriptions in NPN and PNP transistors

1.2 TRANSISTOR CHARACTERISTICS

The table below depicts transistor characteristics

Current direction	Does current flow NPN	Does current flow PNP
Emitter to Base	Yes	No
Base to Emitter	No	Yes
Emitter to collector	No	No
Collector to Emitter	No	No
Base to collector	No	Yes
Collector to Base	Yes	No

Table 1.0

Another explanation for the reason that current only flows when correctly biased is because of the resistance of the transistor type material. When forward biased the impedance across the base-emitter junction is low. When reverse-biased, the resistance in the junction is high.

Now, with these biasics of transistor one can determine if a transistor junctions are good and identify the type of transistor junction using logic Analysing circuit.

1.30 TESTING BIPOLAR JUNCTION TRNSISTORS

A transistor that is operated within its ratings with respect to voltage, power dissipation and temperature is normally expected to have an almost unlimited life. Failures in transistorized circuits are more often the result of damage or malfunctioning of some other components. This is particularly true when miniature transformer and electrolytic capacitors are employed. Despite the reliability of the transistor itself, failures occur due to **short** or **open** circuits in the bias circuitry, temporary overload, physical damage or even mishaps while servicing.

A good number of transistor testers and analysers are available. Some only check leakage and current gain, while others are capable of measuring all the transistor's parameters. From a servicing viewpoint, a few simple test are enough to reveal a great majority of troubles. These tests, to be described, reveal shorts, open, excessive leakage, and provide rough check of current gain. Fortunately, little components is required. Some of the tests require only an ohmmeter. The more elaborate check can be made with just a few additional components

1.3.1 TESTING THE JUNCTIONS OF BJT

The transistors (BJTs) contains two p-n junctions or diodes, most of the characteristics of the transistor are tied in with the behaviour of the junctions, while the rest of the device serve as connective material.

Damage to transistor, therefore, most always shows up as a malfunctioning of one of the rectifying junctions. The fault may be an **open** or **shorted** junction, or excessive reverse current (leakage).

A rough but useful check of the condition of the junction may be made with an ohmmeter. First, the forward resistance of each junction is measured, as shown in fig 1.1 in this figure, the connections for PNP transistors are shown. The negative terminal of the ohmmeter is connected to the base. The forward resistance of each junction is checked by touching the emitter and then the collector terminal in turn with positive lead. a high reading indicates an open junction. a normal unit should show a reading below 500Ω

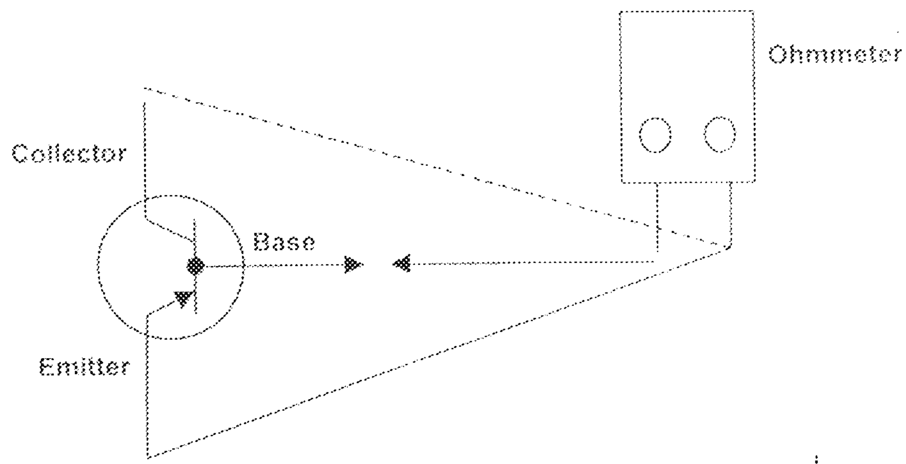


Fig 1.10 *Method of checking the forward resistance of both junctions Diagram*

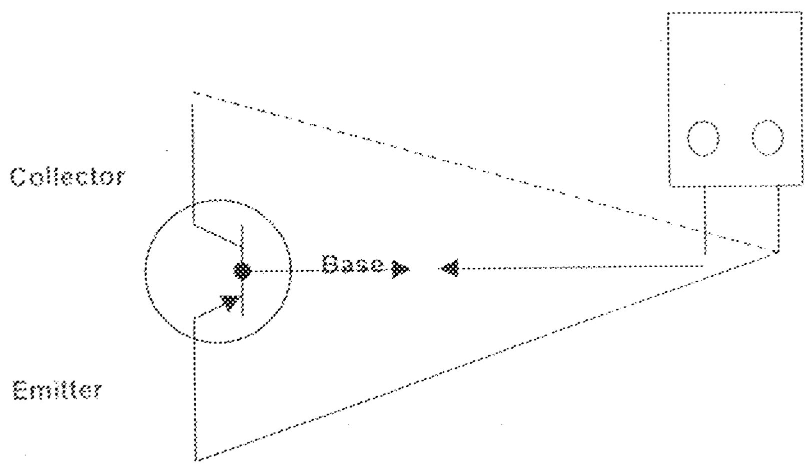


Fig 1.2 Method *of checking the reverse resistance of both junctions Diagram*

Typical readings taken with an ohmmeter on R x 10k scale are 700 kΩ to 1.5MΩ. Silicon transistors give much higher resistance readings. Power transistors have larger junctions and therefore greater leakage currents

Reverse-bias resistance reading should be 50KΩ or greater for power transistors.

Despite all the immediate or quick test available the accuracy is unpredictable, as such more accurate instrument is needed for testing of the transistors.

1.40 TESTING DIODES.

Because diodes and rectifies are non-amplifying devices, simple test for shorts, opens or excessive leakage are useful methods to determine if they are functioning properly. The forward resistance of a diode or rectifier is checked by connecting the positive and negative leads of an ohmmeter, preferably set to the R x 100 scale, to their respective positive (anode) and negative (cathode) terminals. A reading of about 500 to 600 ohms is normal for germanium types and for larger rectifiers (germanium or silicon). The resistance is somewhat lower than their respective diode types. Because the high voltage type may have several diodes in series, higher resistance readings can be expected. This way of testing of testing is generally not uniform and thus the need for instrument (meter) is required for accuracy and smartness in testing diodes. This clearly forms part of the basic reason for the design and construction of this transistor/diode tester.

1.50 AIMS AND OBJECTIVES

The basic aim and objective of this design and construction is to provide cheaper and less sophisticated instrument useful in testing the function or the workability of transistor or diode. This also includes identifying the polarity of transistor or diode.

1.60 LITRERATURE REVIEW

From the limited facilities/resources available, the observation stands that many people have carried diversified project works on similar testing instrument and have come up with enviable results.

Adam Fisher's transistor named after the inventor was designed to be used in determining if transistor is good or bad, identify the type of transistor and identify pins. Among all details about hardware components of his project, the most important chip is PIC/6F84 (Programmable integrated circuit) chip.

Jean-Bernard Guiot, D.C AG uschwil, switzland (2001) designed a pocket transistor tester without regard to such parameters as gain and frequency response. He use Two LEDs (light emitting diodes) connected in antiparallel configuration to display the result of the device under test (D. U. T)

IN-CIRCUIT TRANSISTOR/SCR/DIODE GO-NOGO TESTER By Frank V. Higher (1990s) is another similar instrument designed to test PNP and NPN transistors, diodes and SCRs (silicon control rectifiers). The circuit operation of this tester uses CD 4093 Cmos IC configured as square-ware oscilator of about $2H_z$. The square wave voltage are used as test supply Voltage to the D.U.T

Different fashions of transistor tester were also design and constructed by: Placentia, Calif. (2003), Philips (1980s) and Rod Elliot (ESP) among others.

However, the above development in transistor/diode testing instrument not withstanding, most roadside technicians, repairs shops, laboratories still rely on Multimeter for carrying out test on transistors and diodes. This is due to the complexity and cost of the already invented test equipments. Hence the need for transistor/diode tester which is simple, economical and reliable and will be of great help to the electronic designers and repairers, more importantly school laboratories.

1.70 PROJECT OUTLINE

The block diagram show in fig below illustrates the layout of this project.

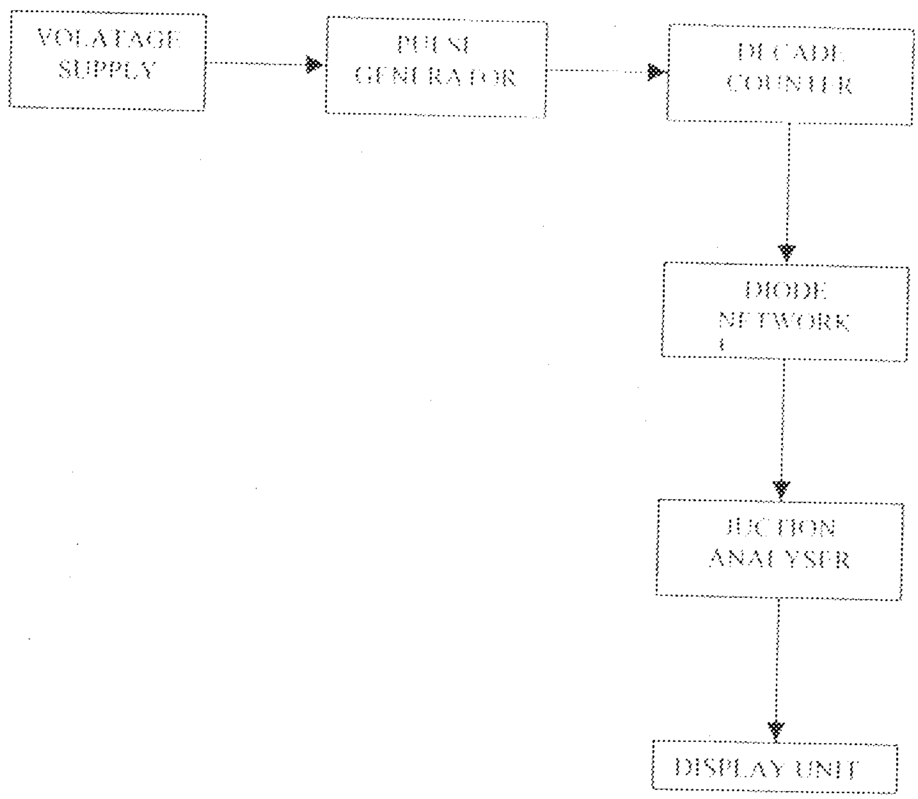


Fig 1.3 project layout

CHAPTER TWO

2.0 SYSTEM DESIGN AND ANALYSIS

The electronic components used all through this project work includes: 555IC-Timer, 9v-d.c battery linear diodes, decade counters (4017 cmosIC), Resistors, capacitors, quad Bilateral switch (4016 cmosIC), Light emitting diodes (LEDs), micro switch,4001 and 4011 CMOS ICs

2.10 OVERVIEW OF 555IC-TIMER

The 555IC-Timer are basically a two-stage amplifier or oscillator circuit that operates in two modes or states controlled by the external circuit conditions. These modes are monostable multi-vibrators and astable-multi-vibrator.

The top-view of 555IC- Timer is as shown in fig 2.0 the internal configuration of the 555IC-Timer, together with some few external components necessary for its monostable operation is shown in fig 2.1

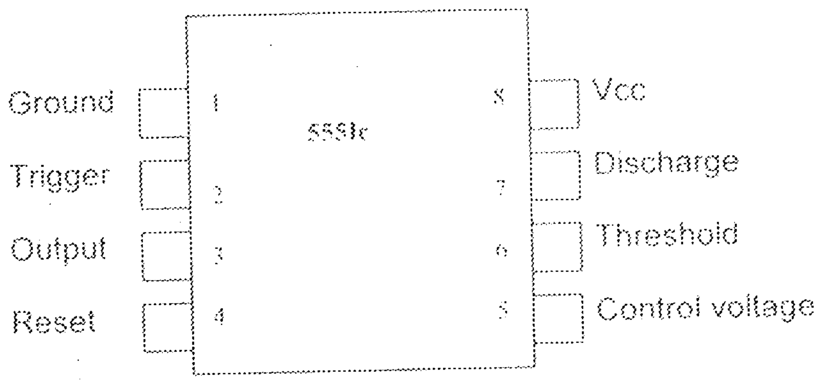


Fig 2.0 Top view of 555Ic timer

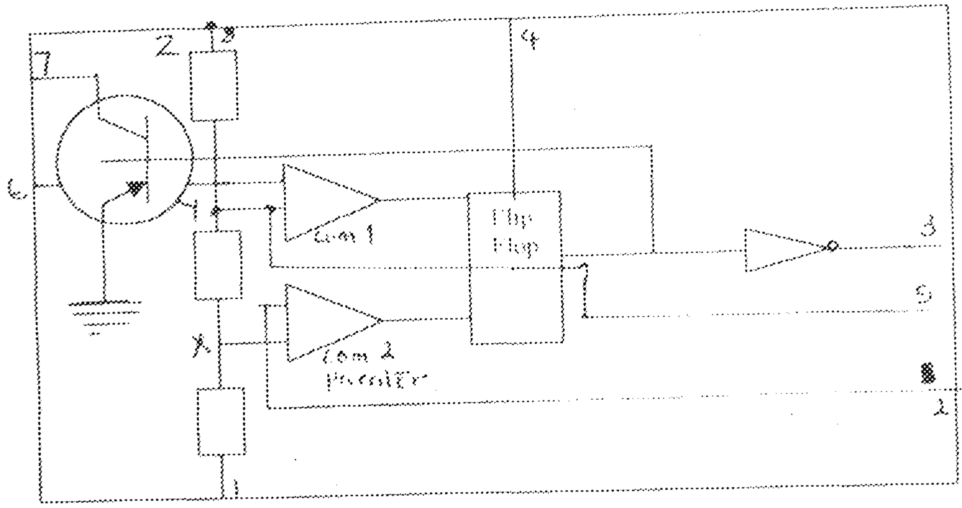


Fig 2.1 Internal circuitry of 555IC timer

The internal configuration of the 555IC-Timer shown in fig 2.1 the IC comprises a three resistor potential divider, two voltage comparators, a flip-flop, a transistor and an output buffer. The divider ratios are such that one-third of the supply voltage, (1/3Vcc) (i.e 3V of Vcc = 9V is set at 'X' on comparator 1 and two-third of the supply voltage (i.e 6V) is set at'Y' on comparator 2.

A 0.01PF filter capacitor is usually connected from the control voltage terminal; pin 5 is connected to ground. The capacitor helps in by-passing noise/or ripple voltages from the power supply to minimize their effect on **threshold voltage**. The control voltage terminal (pin 5) may also be used to change both threshold and **trigger voltage** levels by connecting a resistor between pin 5 and 8.

Still on fig2.1 considering the R-R-R potential divider between points Z-Y-Z-1, we note that point Z is the same as pin 8, and point Y is the same as pin 5. Only point 'X' cannot be reached externally. In other words, one can say that at pin 8 (i.e. at Z) the potential is V_{cc}, the potential at Y = 2/3 V_{cc}

and the potential at X = 1/3Vcc. Note that each 'R' in the potential divider is 5KΩ. Now, if a 5KΩ is connected externally between pin 5 and 8, it will change the potential divider ratios R//R – R – R or 1/2R – R – R As a result, the expected potential at Y is :

$$\frac{2R \times Vcc}{2R+R/2} = 0.8Vcc$$

The potential at X $= \frac{R \times Vcc}{R+R+R/2} = 0.4Vcc$

In other words, connecting a 5kΩ resistor between pin 5 and 8 changes the threshold to voltage 0.8Vcc and the trigger voltage to 0.4Vcc.

It was found that for the 555IC-Timer Vcc may be between +5V and +18V. This gives me the free will to choose 9V d.c battery for this project, because the 9V fall within the required range for Vcc.

2.2.0 OPERATION OF 555IC TIMER AS MONOSTABLE MULTIVIBRATOR

Monostable multi-vibrator is also called a single swing or one-short multi-vibrator it has one absolutely stable (stand-by) state and quasic stable state it can be switched to the quasic stable by an external trigger pulse but it returns to the stable condition after a time delay, determined by the value of external circuit components. It supplies a single output pulse of desired duration for every input trigger pulse.

When the trigger is taken from +9V to 0V (logic 1 to logic 0) the output will go high for a period determined by the values of R and C.

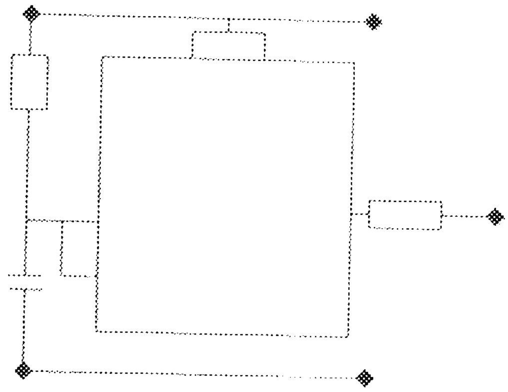


Fig 2.2 configuration of 555IC timer monostable multivibrator

When power is supplied to the IC, the output is at OV as is the discharge pin, so ensuring that the capacitor 'C' is fully discharged. When pin 2 receives a OV pulse, the output switches to positive for a time T.

Where T = 1.1R x C

During this time, the discharge pins is allowed by the IC to float. (i.e it is internally disconnected), so the capacitor 'C' begins to charge via R. the threshold pin monitors the voltage across the capacitor and at two-third of the supply voltage, the time period ceases. The output pin returns to zero Volt, as does the discharge pin. So reducing the charge on the capacitor to zero and then ready for next cycle.

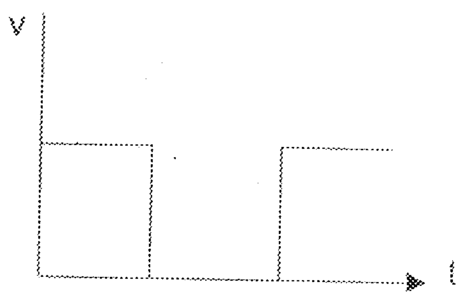


Fig 2.3 Output waveform of 555Ic timer

2.3 OPERATION OF 555IC AS ASTABLE MULTIVIBRATOR

It is also called free running relaxation oscillator. It has no stable state but only two quasi-stables (half-stable) states between which it keep oscillating continuously of its own accord without any external excitation.

In this circuit, neither of the two internal transistors reaches a stable state. When one is ON, the other is OFF and they continuously switch back and forth at rate depending on the RC Time constant in the circuit. Hence its oscillates and produces pulses of certain mark – to – space ratio, moreover, two outputs (180 out of phase with each other are available.

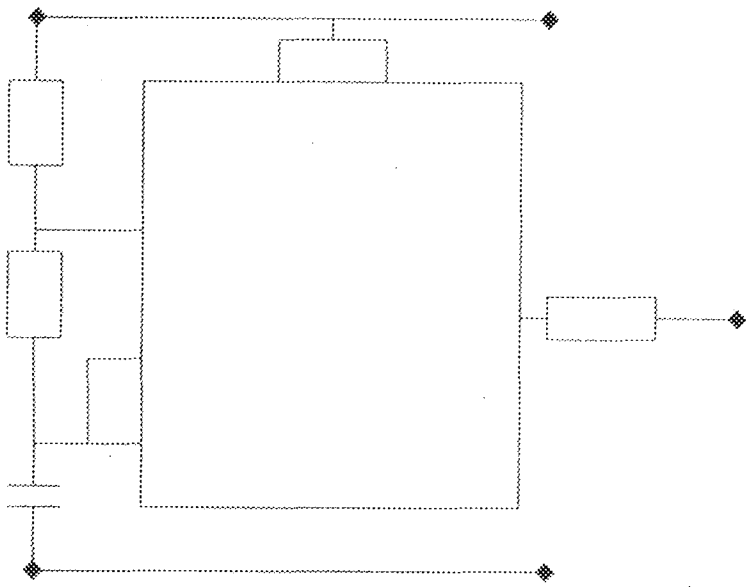


Fig 2.4 Configuration of 555IC timer as Astable Multivibrators

The 555 timer can be configured as an astable as shown above the resistors R_1 and R_2 along with C govern the overall frequency determining network.

2.3.1 HOW ASTABLE MULTIVIBRATOR WORKS

When voltage is applied, the lack of charge on capacitor C will trigger the IC and make its output shut to positive and IC on this make the discharge pin inactive, current flows through R_1 and R_2 to charge the capacitor when the voltage across C_1 is two-third of the supply the discharge pin fall to OV (output

= OV); and the capacitor discharges into the discharge pin via R_2. The trigger pin is connected to the capacitor, so when the voltage across C falls to one-third of the supply, the IC is triggered again and the cycle repeats as before. Notice that the capacitor charges via both R_1 and R_2 but discharges via R_2 – this explain the unequal/space ratio. If a more equal ratio is required then R_2 should be much higher in value than R_1.

2.3.2 CALCULATIONS

The fact that the mark/space ratio may be unequal complicates the calculation of the time periods and frequency.

Mark time = $0.7 \times C (R_1 + R_2)$

In this project work the values of resistors and capacitor used are:

$R_1 = 1K\Omega$

$R_2 = 4.6K\Omega$

$C = 2.2\mu F$

Mark time =, on time (logic 1)

$= 0.7 \times (2.2 \times 0.^{-6}) \times (1000 + 4.6 \times 10^3)$

$= 0.7 (2.2 \times 10^{-6}) (5.6 \times 10^3)$

$= 8.624 \times 10^{-3}$ Secs

= 8.624msecs

Space time = OFF time (logic 0)

$= 0.7 (2.2 \times 10^{-6}) (4.6 \times 10^3)$

$= 0.7 (0.01012)$

$= 7.084 \times 10^{-3}$ Secs.

7.084msecs.

Total period of oscillation

$T = 0.695 (R_1 + 2R_2)C$

$= 0.695 (1 \times 10^3 + 4.6 \times 10^3 \times 2) \times 2.2 \times 10^{-6}$

$= 0.695 (10.2 \times 10^3) (2.2 \times 10^{-6})$

$= 0.695 (0.02244)$

$= 0.0155958$ Secs

≈ 15.5958msecs

Frequency, $F = \frac{1}{T} = \frac{1.44}{(R1+2R2)C} = \frac{1.44}{(1+2x4.6)1000 \times 2.2\ 10^{-6}}$

64.1711 Hz (sec^{-1})

2.4.0 DECADE COUNTER (4017 CMOSIC)

The 4017 CmosIC can actually be used for many purposes in logic circuit designs such as counter and selectors among others but with respect to this project work, the 4017IC is used as decade counter to count the timing pulse fed into it from the 555IC timer circuit network.

The top view with pin description of the decade counter is as shown below:

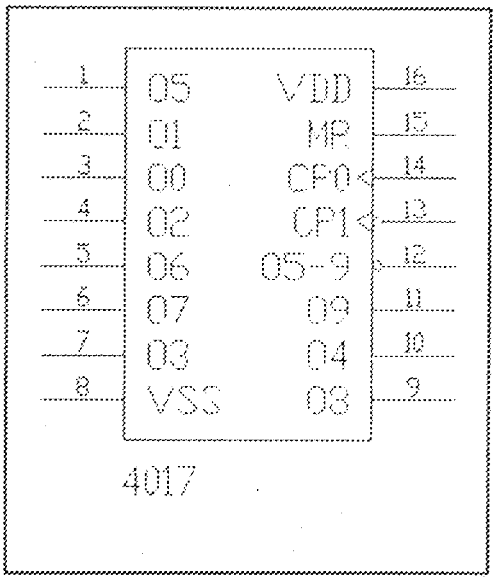


Fig.2.5 The Decade Counter (Top view) and pin description

As it counts from the first pulse it selects an output pin equivalent to the number of counts (of pulses) and put (set) it at high (1) volts while the remaining output pin remain at low (0) state.

The high state refers to the high voltage state which is almost equal to the V_{cc} while low or zero state refers to low voltage.

Among the 10 outputs available for the decade counter only 9 is used in this design (from pin '0' - '8') The first count i.e (output of pulse 0) resets all the memory calls of the outputs to zero.

The second pulse sets the necessary condition to test if the Device under test (D.U.T) is an NPN transistor with pin arranged in PNN order.

The third and fourth pulses are for testing if the D.U.T is NPN type with pins arranged in NPN and NNP order respectively.

The fifth, sixth and seventh pulse set the output of pins 10, 1, and 5 of decade counter 4017 respectively to produce necessary condition for PNP type transistor whose legs pins are arranged in PNP, NPP and PPN order respectively.

The eight pulse is to test a diode the ninth pulse at pin 11 of 4017 resets the 555IC and this marks the completion of one test cycles

2.6.0 DIODE ARRAY AND BILATERAL SWITCHES.

Diode array consist of diodes that links the outputs of the decade counter to the appropriate input pins of the bilateral switches (4016IC Cmos). Each group of diodes connecting an output pin of the counter sets a unique test condition on the series of the bilateral switches as the counter output pins goes high (i.e switches from low voltage of zero to high voltage of almost Vcc) while the other outputs pins remain at low state.

The bilateral switches are voltage driven solid-state switches that allow current flow in either direction. When the control pin of each gate is set high, the switch is in 'ON' state and current can flow in either direction across the two terminals of the switch. (i.e the inputs and output pins) and when the control pin is set low (i.e zero voltage is applied to it), the switch is in OFF state and a gap is created between its input and outputs terminal, hence the current can not flow in either direction.

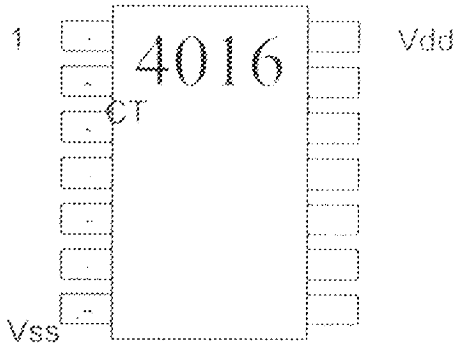


Fig 2.6 Quad Bilateral Switch

2.6.1 OPERATION OF DIODE ARRAY AND BILATERAL SWITCHES

Outputs labeled 'A' 'B' and 'C' on the 4017IC set the appropriate conditions to test the three terminal device that has been plugged in the test points (labeled 1,2,3) for an NPN-type device as follows.

OUTPUT A (**PNN**): if output A (pin 2) is high Diodes D_1, D_2, D_3 and D_4 are forward biased and communicate this high voltage to the input and controls pins of switch S_1, and to the control pins of the switch S_2 and S_3. The effect of this is that the high voltage on point A is relayed to test point 1 through 1KΩ resistor and the switch S_1 which is now on; test points 2 and 3 connected to the 0V potential via switches 2 and 3 respectively (both switches are on). The two switches communicate the zero Volts potential via the 5KΩ resistors that are at ground potential. Now if an 'NPN' transistor is inserted into the test points in such a way that the base pin is inserted into the test point 1 while the other two test points house the remaining legs of the transistor irrespective of their location, current will flow from base to emitter and collector as well, this condition set all the 3 outputs of the switches 1,2 and 3 to high. These outputs are fed into the network of **NAND** and **NOR** GATES used to display the result of the D.U.T

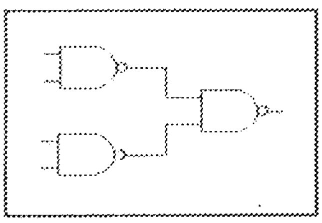
The output B and C (NPN and NNP) identifiers perform similar operation. In each case the output of the switches 1, 2, 3 are fed into the network of AND gate and NAND gates use to display the result of the D. U .T.

In contrast, output D, E and F (PNP, NPP, and PPN) requires only the output of switches S1, S2 and S3 respectively to be fed to the AND gates for display of the result

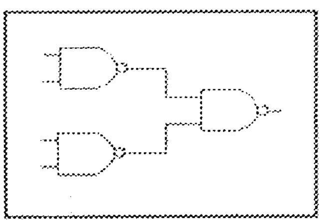
Conclusively, output G makes use of only switch S3 outputs to test for diode characteristics.

2. 7.0 DISPLAY UNIT

The result of LED used for display are solely determined by inputs of the **NAND** gate and **AND** gates. Logic circuit below shows details of how output of each **LED** is determined.



(i)



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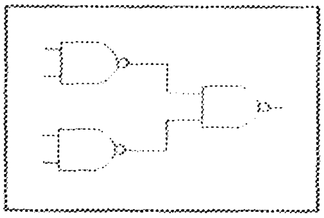

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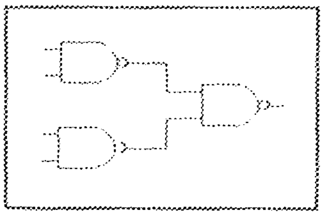

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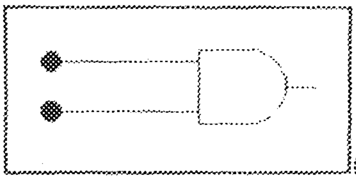

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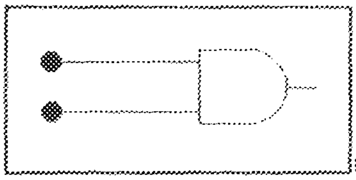

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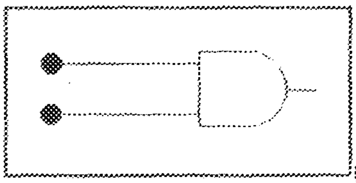
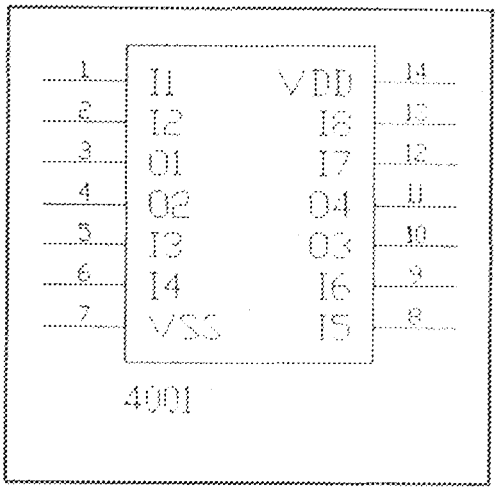


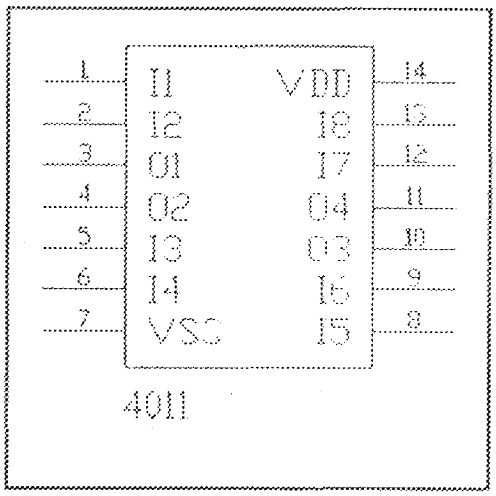
(vi)

Fig 2.90 *logic analysis of the output display*

The 4001 CMOS and 4011 were the ICs used for the display network. The following figures and table below shows the characteristics of the two ICs



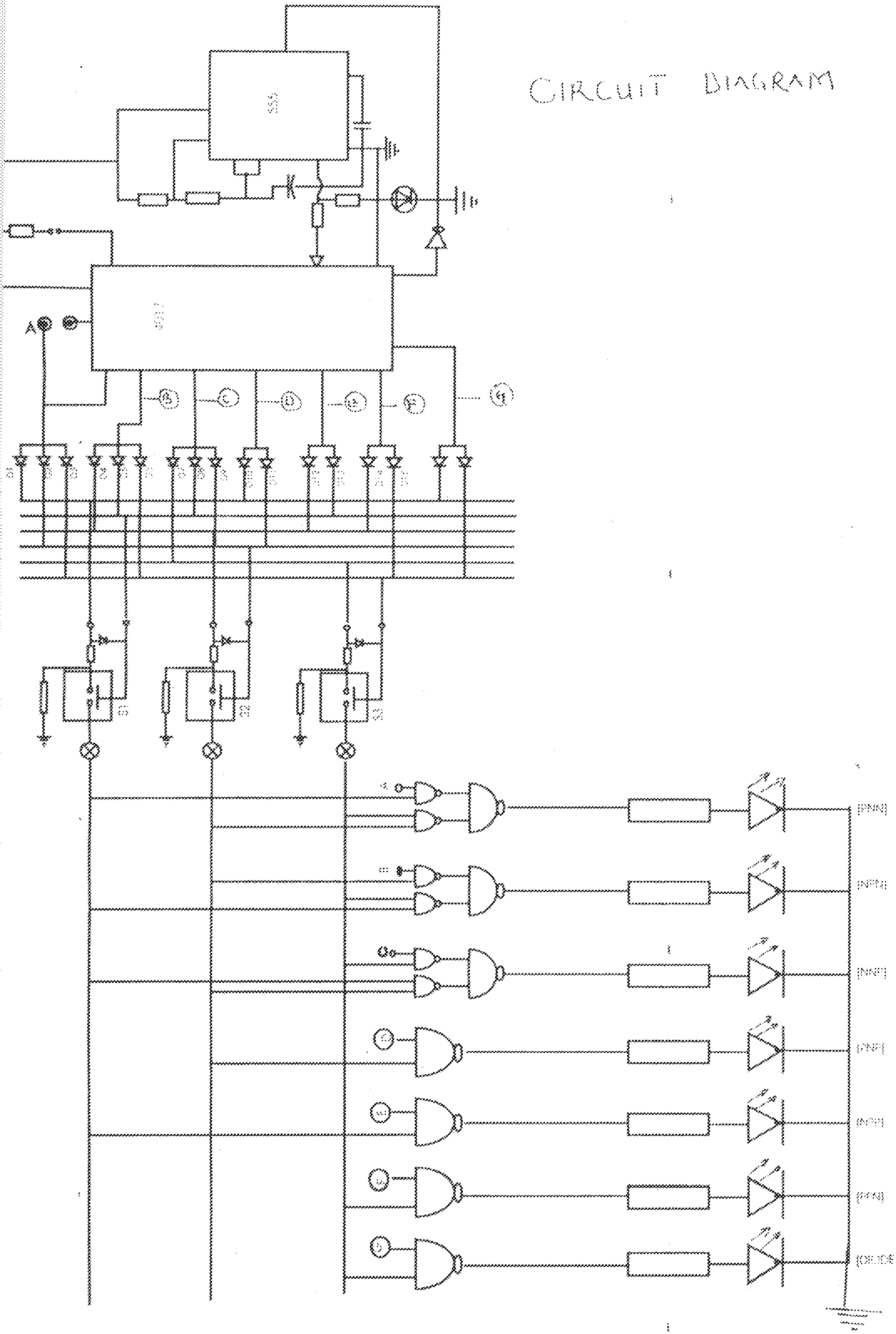
(a



(b)

fig 2.8 (a)Quad two input NOR gate.(b)Quad-bilateral Switch

CIRCUIT DIAGRAM



CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS

3.0 Construction

The construction of the circuit was first carried out on a breadboard. It was then tested for proper operation. After being certified, as designed it was then transferred to a Vero board.

A Vero board is a special kind of printed circuit board specially designed for practical operations. It has tiny holes, which are evenly spaced, through which components can be inserted and soldered. On one face of the board are copper strip and which run into rows such that all the components legs of a particular row are connected together The legs of each component are pushed through the holes from the top of the board and then soldered on to strip under the board. The orientation of the components on the board is such that they are only a few millimeter above board.

After a firm attachment was achieved, the excess wires were then cut off, for neatness and uniformity, using a long nose cutter.

However, the light emitting diode were not soldered directly on the board but rather, long wires were used to extend them out of the casing. This is because they perform external functions. Similarly, a hollow (hole) was provided externally the battery in order to allow quick access whenever the battery needs to be replaced.

The broken tracks in the Vero board were done with razor blade to discontinue signal flow to unwanted points and also to take care of blot between points that should be open.

3.1 PRECAUTIONS TAKEN DURING CONSTRUCTION

(i) The use of IC socket was implemented to prevent over heating of IC during soldering and also to make for easy maintenance when the need arises for them to be changed.

(ii) Re-checks were made to ascertain the right position of components and jumpers.

(iii) Soldering joints were proof against dry joint by making sure that the lead applied flowed well over the joints

(iv) The right polarities were carefully observed before soldering the polarized components such the electrolytic capacitor and LEDs. Also the ICs pins were ascertained for correct connection

(v) Off-target or stray solders were carefully removed to avoid short-circuiting.

(vi) The output of each stage was certified before final coupling of the entire system.

(vii) Being Cmos IC that are susceptible to static charges which destroys them. Great care was taken to avoid such.

3.2 RESULTS AND DISCUSSION

To affirm the function of each segment network in the entire circuitry the function of each was tested during construction stage and results obtained were as follows:

3.3 THE 555IC-TIMER CIRCUIT RESULTS.

The 555IC-timer was tested for frequency of oscillations. This was achieved by connecting light emitting diodes (LEDs) to the output pin (pin3), and results recorded were almost same as the calculated values. (Result = rate 'ON' and 'OF' states of the LED).

3.4 DECADE COUNTER

The output of 555IC was used as the input for the decade counter again the behaviour (outputs) was read. Using LEDS connected to the ten available output of the decade counter also the result obtained was satisfactory.

3.5 DIODE AND BILATERAL SWITCH

The cascade of the 555IC and the decade counter now connected to diode and bilateral switch were tested using LEDs connected to the outputs of the switch [note only 3 out of four outputs for the switch were used for this project but all the available four were tested.

3.6 TESTING

Finally, on completion of the circuit different BJT transistors and linear diodes were tested. Of all the tested transistors and diodes the results obtained were satisfactory within the limit of electronic components used and the design chosen.

4.1 RECOMMENDATION

Following the importance and of testing meter in workshops and laboratory, and the extent of success recorded in this project I wish to recommend that.

(i) The display unit be interfaced with microprocessor, though that will increase the cost of production.

(ii) A better oscillator circuit be used in place of 555IC multivibrator, this is because crystal oscillators are stable, better and more reliable at accurate pulse generation.

(iii) TTL (Transistor – Transistor logic) ICs should be avoided in case of improvement on this design, this is because they draw more current than Cmos ICs used in this project

4.2 CONCLUSION

The circuit was built using simple discrete components designed to perform logical operation. Economic consideration normally affects the implementation of many designs but for this project better and economical components were used. It was observed that during the testing of this project, there was a slight difference between theoretical and practical result.

Having tested all stages, to a large extent the aim of the work was achieved from the tests carried out, theoretical calculations at design stage agrees with practical results with little variation in the range of 10^{-1}(units)

4.3 PROBLEMS FACED

Major problems were encountered in the area of obtaining the precise pulse frequency using the 555IC timer, which makes the testing slower or faster than desired.

Components got burnt or failed completely at the cause of construction due to errors in connection or bridging of connecting wire (conductors). This wasted so much time as it was very difficult and costly to replace them.

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